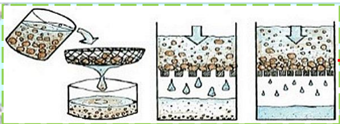
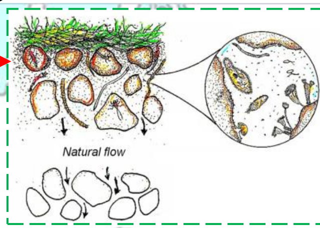
# Ecological Purification System (EPS)

*Treatment System for Safe Water by Wise Use of Natural Phenomena*

An English invention of Slow Sand Filtration to make artificial spring water for safe drinking water is re-defined in Japan as Ecological Purification System.



*Slow Sand Filtration*




*Ecological Purification System*

Nov. 7(Tue). 2023, am 10-12, pm 13-16.
Hiroshima City Waterworks Bureau:
JICA-Hiroshima training on: Operation and Maintenance of Urban Water Supply System (Water Distribution and Service) from Oct.29. to Nov. 30.,2023 都市上水道維持管理（給・配水）


*EPS in Nagano, Japan*


*EPS for Fiji village*


*EPS is to make artificial spring water.*


NAKAMOTO Nobutada,
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Dr. Science cwscnkmt@yahoo.co.jp
中本信忠　信州大名誉教授、理博


## 生物浄化法

自然仕組みで人工的に湧水をつくる

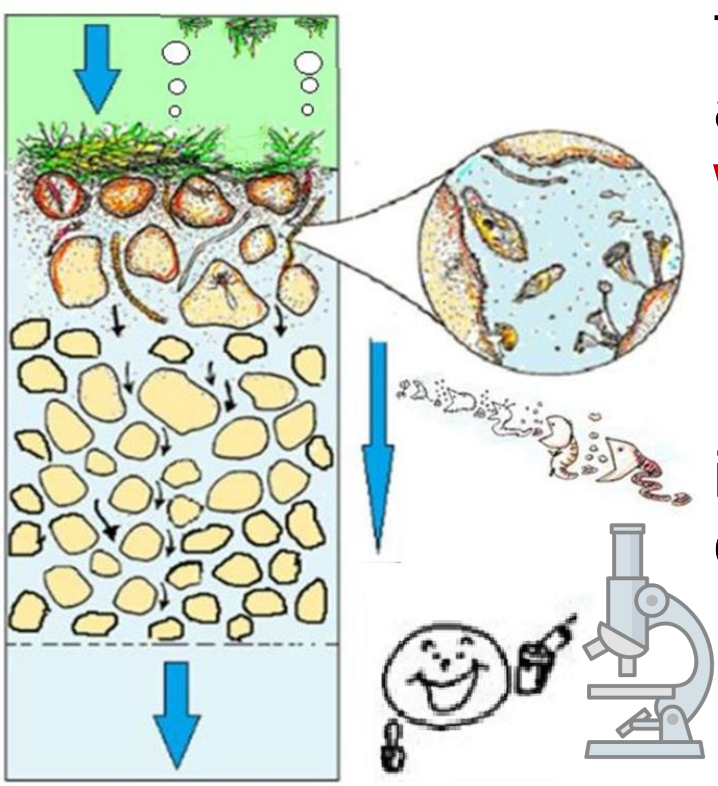
英国生まれの緩速ろ過技術を日本で生物群集による浄化技術と新たな技術と認識された。日本発の生物浄化法は世界中に広まりだした。

# Quest for Safe and Delicious Water

English Invention of Slow Sand Filter to make safe drinking water has been misunderstood by the name in the world.

*This is Wise Use of Natural Purification System to make artificial spring water.*

Microorganisms trap and decompose dirt in water near the surface of the sand layer of slow sand filter.



The filtrate is clean and delicious water without chemicals.

I proposed Ecological Purification System instead of the name of *Slow Sand Filter*.

6 CLEAN WATER AND SANITATION

*Chemical Free*
*Eco-friendly*

# *Ecological Purification System (EPS)*


0. Introduction: Phytoplankton, Reservoir study, Meet Slow Sand Filter, Importance of Ecological point. JICA training
植物プランクトン、貯水池研究、緩速ろ過、生態学の視点、JICA研修へ

*1-17* **17**

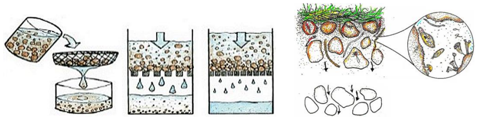
1. Water cycle, Safe water, Acceptable risk.
水循環、安全な水、許容できるリスク

*18-26* **9**



2. Key of purification in nature is food chain.
Refocus to Slow Sand Filter.
浄化は食物連鎖が鍵、緩速ろ過の再認識

*27-51* **25**




3. Algae and animals in Slow Sand Filter.
緩速ろ過池の藻類と動物

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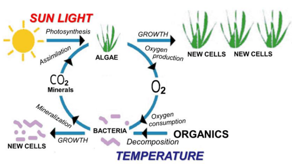

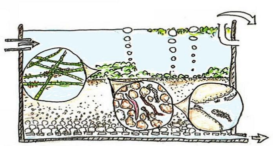

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濁り対策で上向き粗ろ過、モデルで解説

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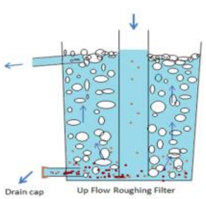


5. From JICA training in Miyako-jima, Okinawa to Samoa
宮古島JICA研修からサモアへ

*101-116* **16**



6. Safe water for rural people by EPS in Fiji
フィジーの展開：生物浄化法で地方給水へ

*117-138* **22**



7. Aerobic condition is essential for EPS.
生物浄化法は酸素が必須

*139-148* **10**



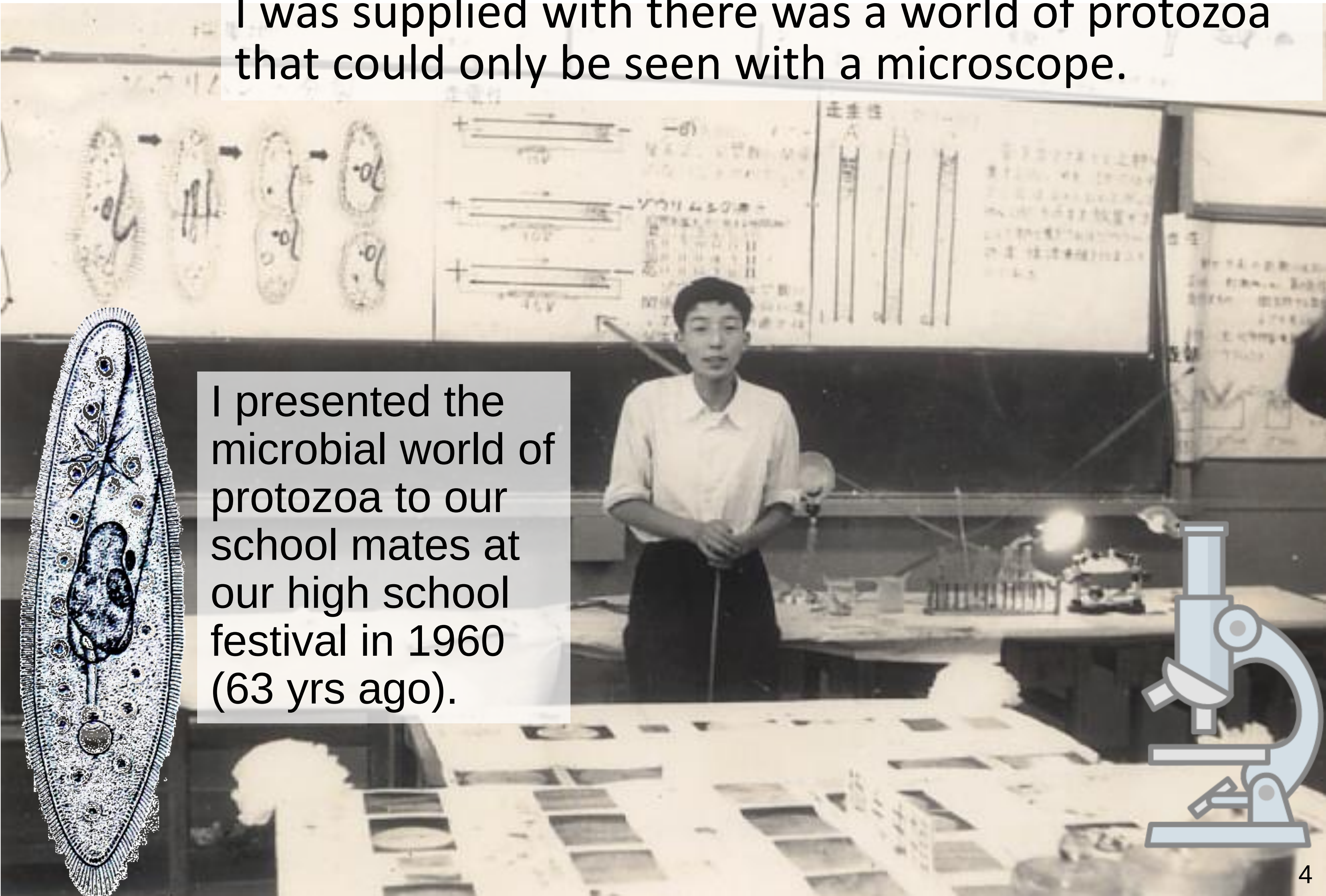
8. Confirm by yourself. Don’t believe commercial.
Trust your true sense. 自分で確かめよう。

*149-163* **15**



# It all started with the biology club in high school.

I was supplied with there was a world of protozoa that could only be seen with a microscope.



I presented the microbial world of protozoa to our school mates at our high school festival in 1960 (63 yrs ago).

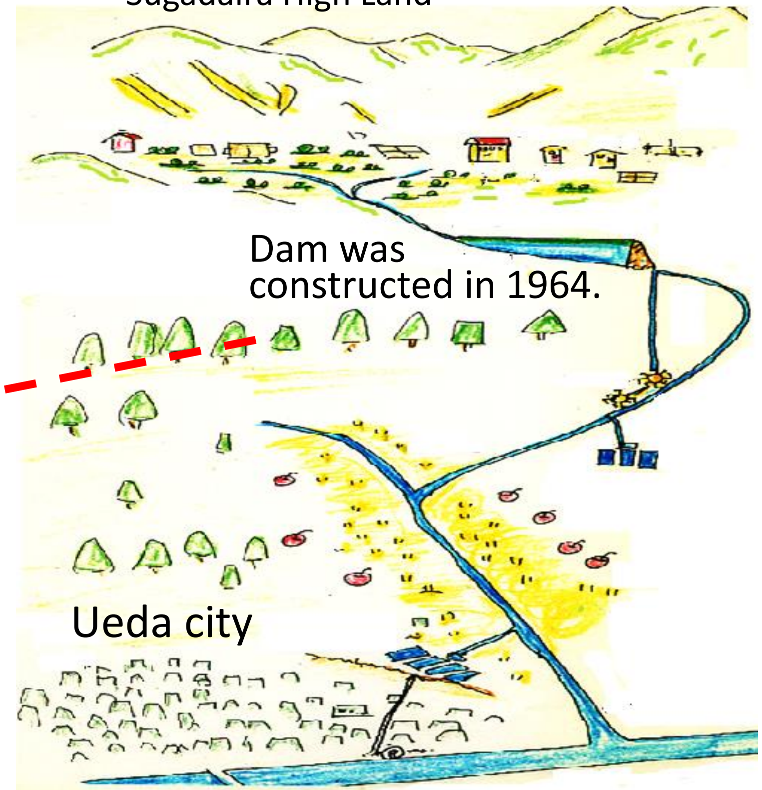

I entered Tokyo Metropolitan University to study biological science. I studied phytoplankton ecology in graduate school.

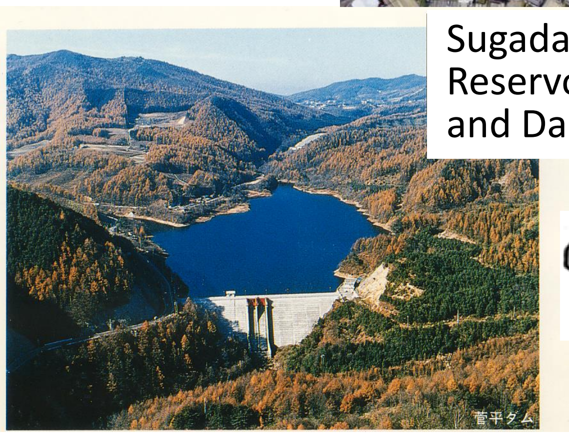
Marine surveys were also conducted in the Pacific and Atlantic Oceans.

Plankton in all regions in the ocean was same species and in hungry condition.

I also studied plankton in reservoirs in Japan and in Brazil.

From 1975,
I worked as a teaching staff of Shinshu University at Ueda Campus.



Sugadaira Reservoir and Dam

1964 Algal bloom in reservoir

Odor problem in tap water


Heavy Algal bloom in a slow sand filter pond

Delicious tap water

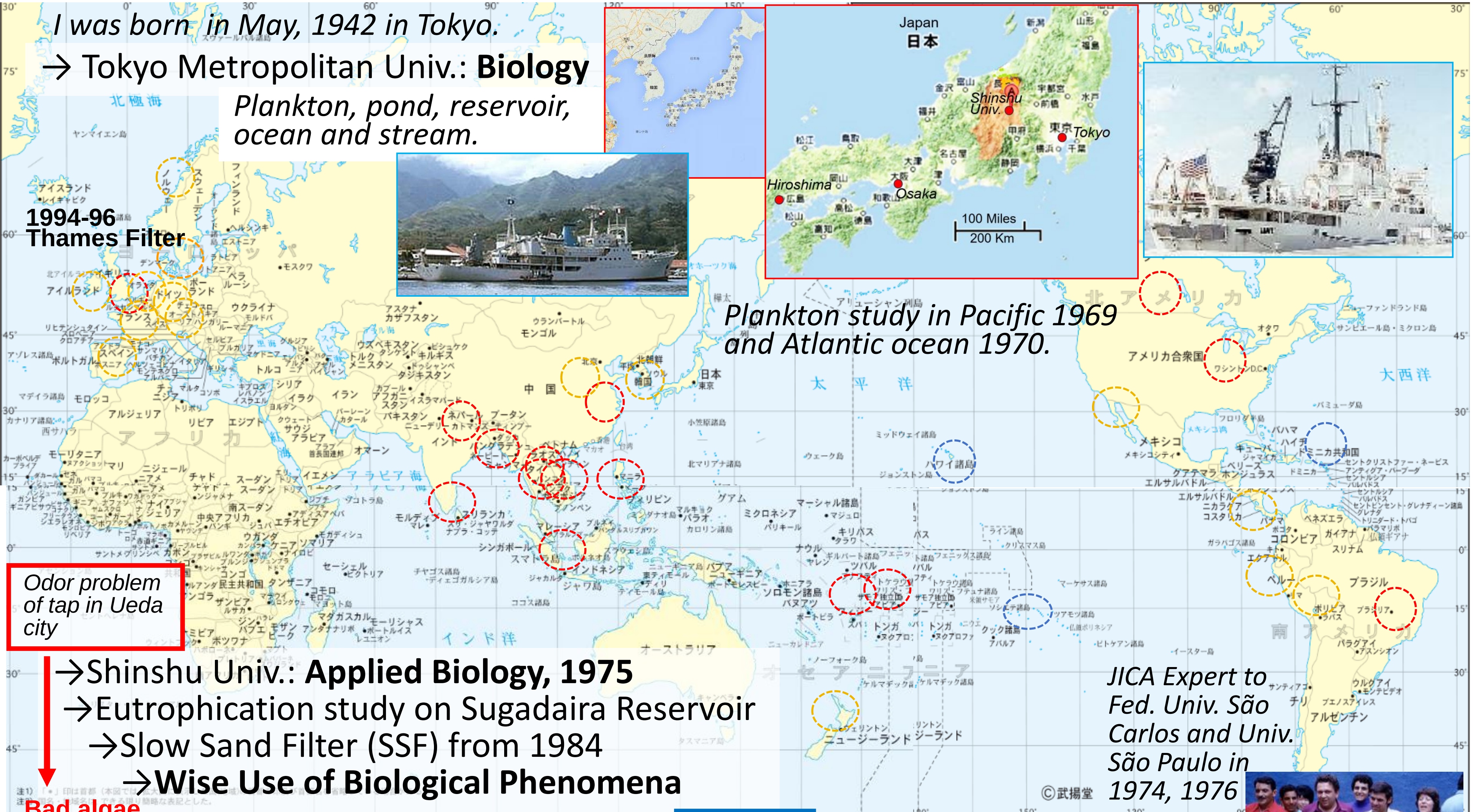
Plant manager said Good Algae in filter pond but Bad Algae in the reservoir.

→ I started to study Role of algae in a slow sand filter pond in 1984.

*I was born in May, 1942 in Tokyo.*

→ Tokyo Metropolitan Univ.: **Biology**

*Plankton, pond, reservoir, ocean and stream.*




*Plankton study in Pacific 1969 and Atlantic ocean 1970.*

*Odor problem of tap in Ueda city*

**Bad algae**

→Shinshu Univ.: **Applied Biology, 1975**

→Eutrophication study on Sugadaira Reservoir

→Slow Sand Filter (SSF) from 1984

→**Wise Use of Biological Phenomena**

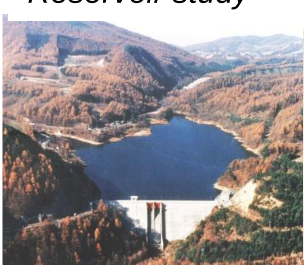
*JICA Expert to Fed. Univ. São Carlos and Univ. São Paulo in 1974, 1976*

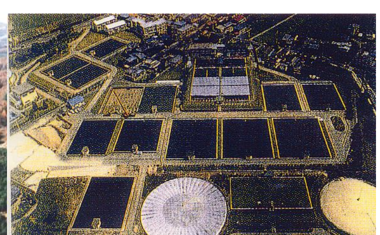
*1975: Shinshu univ. Reservoir study*

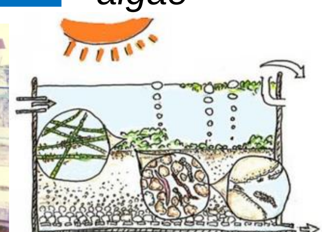
*1984, April: Slow sand filter* → *Stop algaecide* → *Turn to delicious tap water*

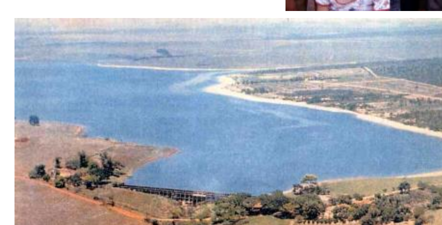
*Role of algae*

*Reservoir control of eutrophication*



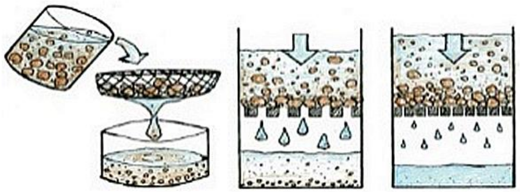






*Principle of Purification mechanism to make artificial safe drinking water had been misunderstood as mechanical filter by the name of Slow Sand Filter.*

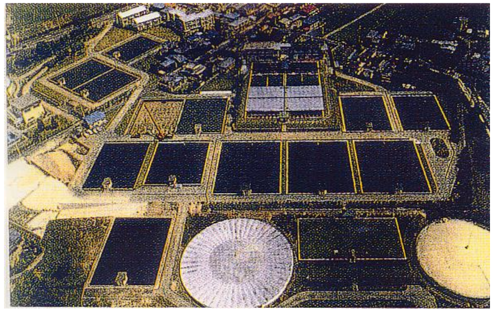
Image of Slow Sand Filter



Slow filtration by fine sand

*Mechanical Filtration*

*Slow sand filter was constructed in 1923 (100years ago) in Ueda city, Nagano Prefecture.*



*When Sugadaira Reservoir was constructed in 1968, odor problem was happened in tap water.*

*They believed that algal bloom produced odor substance in filtrate of slow sand filter.*

**Algae are Bad.**

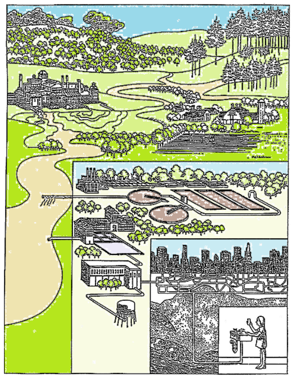
IS THE WATER SAFE TO DRINK?

*Harris Report 1974*

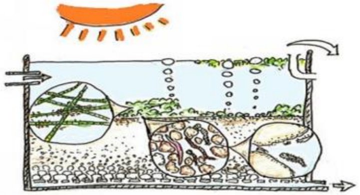
*Stop algicide*

*→Rename to*

*Ecological Purification System*

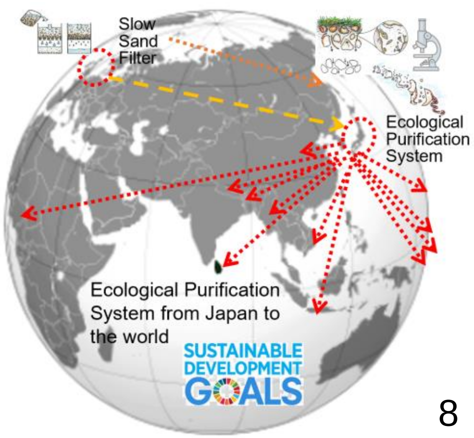


*Cancer risk by chlorine addition*

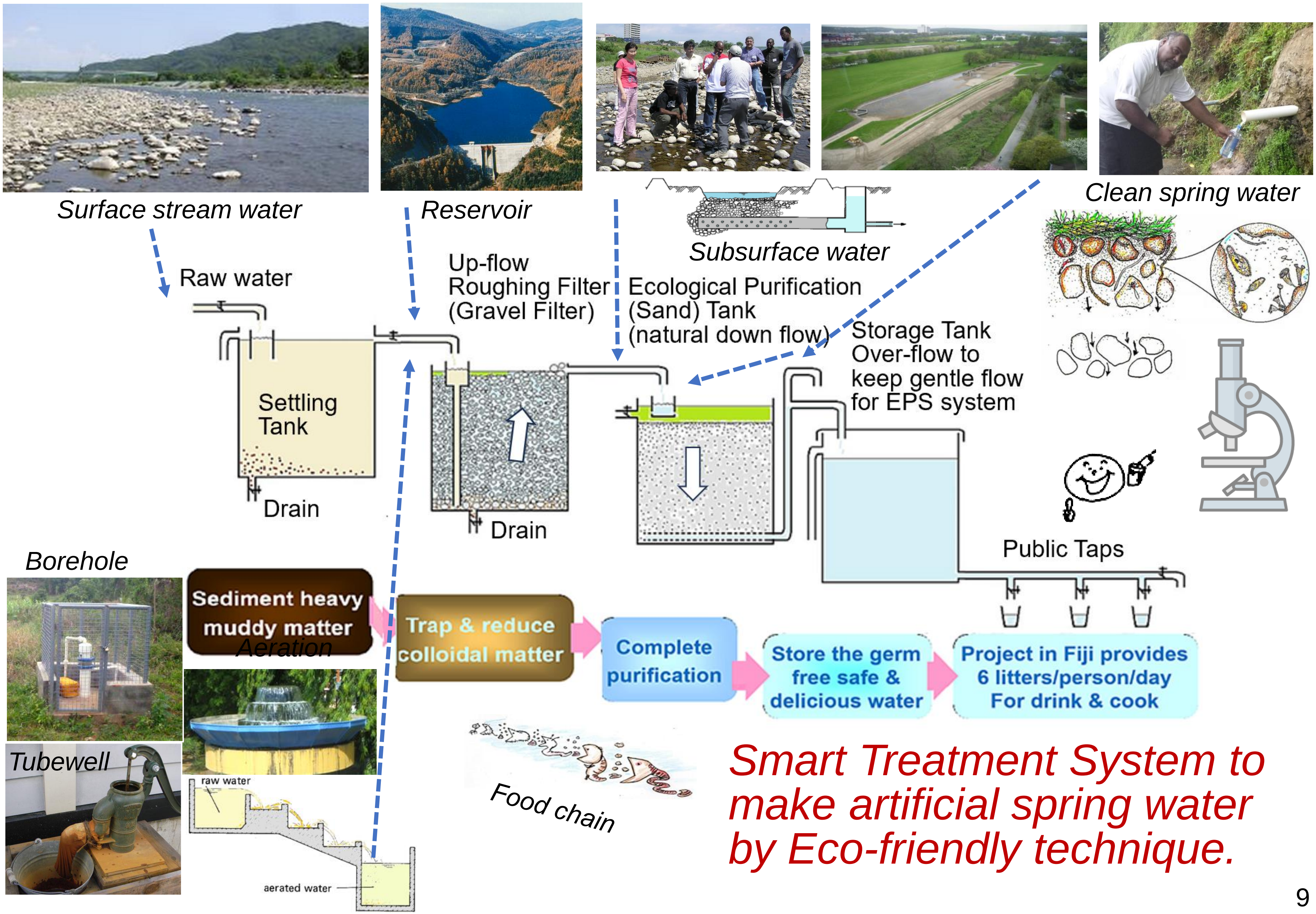


*Safe and delicious tap water by Ecological Purification System.*

https://www.youtube.com/watch?v=b7wPQIKVIMY



# EPS-Use of Natural Process-**Chemical Free** : **Gentle for small organisms**

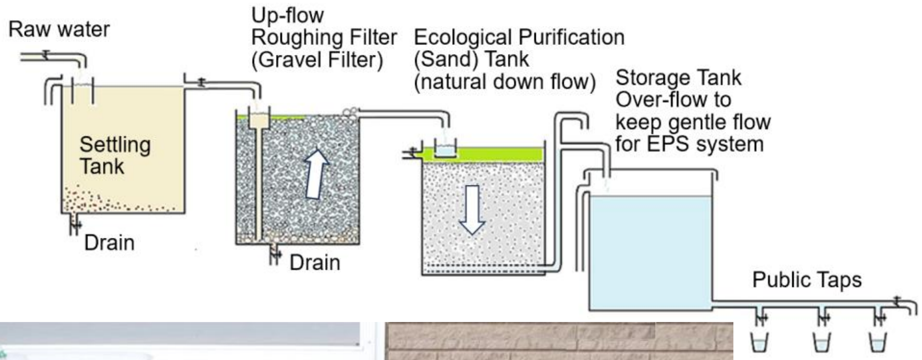



*Smart Treatment System to make artificial spring water by Eco-friendly technique.*

JICA-Hiroshima, July, 2018
Microscopic organisms



EPS model




EPS model


11th Pacific Water and Waste water conference, Noumea, New Caledonia, August, 2018

# 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

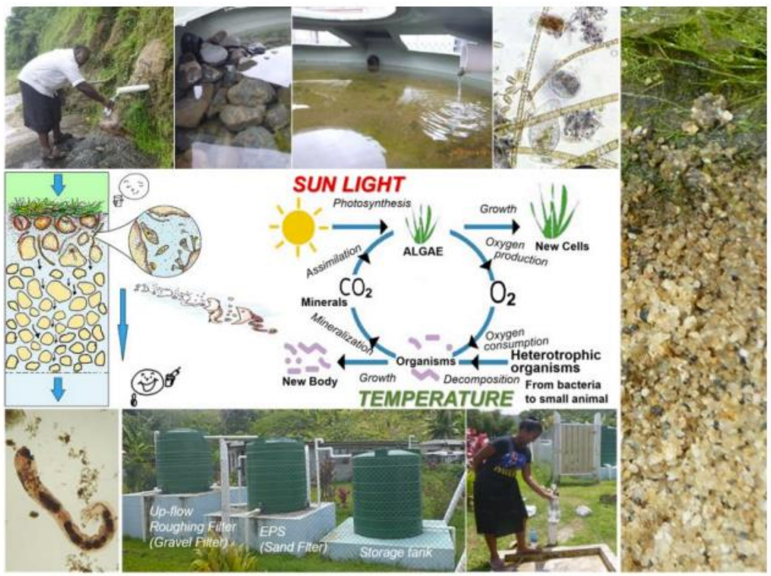




Fig.0. Fijian EPS using rain harvest tanks in a village.

August 2018

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

Ecological Purification System for Safe Drinking Water

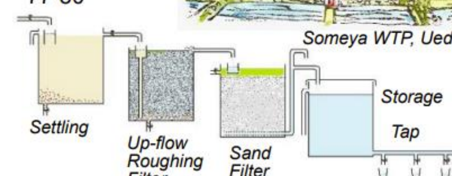
Contents



*Cast off skins of midge larvae*

*Someya WTP, Ueda*

*August 1992*




2

11[th] Pacific Water and Waste water conference, Noumea, New Caledonia, August, 2018


People loved the latest advanced technology. However, there is suitable technology for each country. That can be maintained and managed by local people. That is EPS.

Fijian Minister for Infrastructure opens the Ecological Purification System Project at USP (The University of South Pacific)

https://www.youtube.com/watch?v=iBcjbocOleQ&t=2s

11 min 21 sec

Fiji Government

The implementation of community based Ecological Purification System was made possible through the funding of government.
The Fijian Minister for Infrastructure, Transport, Disaster Management and Meteorological Services Hon. Jone Usamate, in saying this, officiated as Chief Guest at the opening of the Ecological Purification System (EPS) Workshop which was held at The University of the South Pacific.
**The EPS is a chemical-free and energy-free water purification technology** which was initiated by Dr. Nobutada Nakamoto, Professor Emeritus of Shinshu University in Japan.
Also present at the opening event was special guest was Deputy Vice Chancellor of USP Mr. Derrick Armstrong.
The workshop is a two-day event hosted by JICA from 12-13 march, 2019 at The University of the South Pacific ICT Centre in Suva, Fiji.



https://www.youtube.com/watch?v=fEl5ghBzfMw&t=62s

4min 32 sec

https://www.youtube.com/watch?v=vji0ay-7GA8&t=254s

7min 08 sec

EPS to make safe drinking water is real our technology.

## Remember Three Steps

1. Knowing is NOT enough, we must APPLY it to something useful.
2. Willingness is NOT enough, we must PUT it into the PLAN and ACTION.
3. Putting the PLAN into action is NOT enough, we must ACCOMPLISH the goals.

International Contribution Award of the 21st Japan Water Awards, 25. June, 2019

# Safe Drinking Water by Ecological Purification System

Chemical free purification system focused on food chain as a new treatment system from Japan.

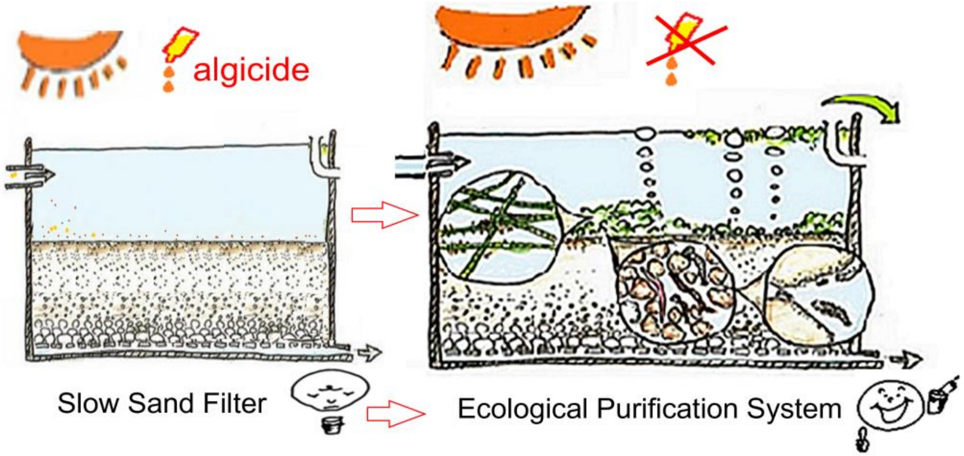



Fig. 1. Delicious water by stopping the algicide

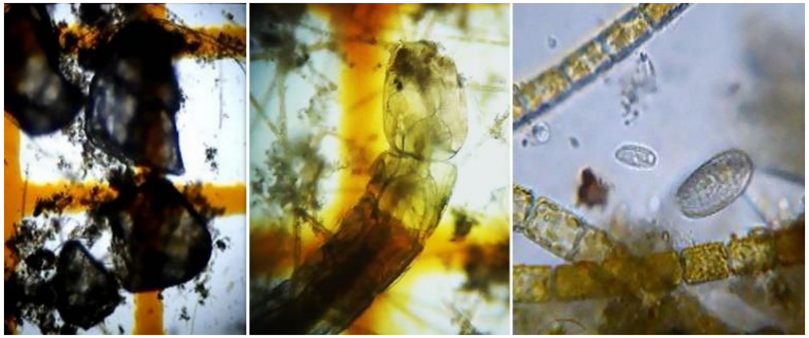


Fig. 2. Attention to the role of algae and micro-animals

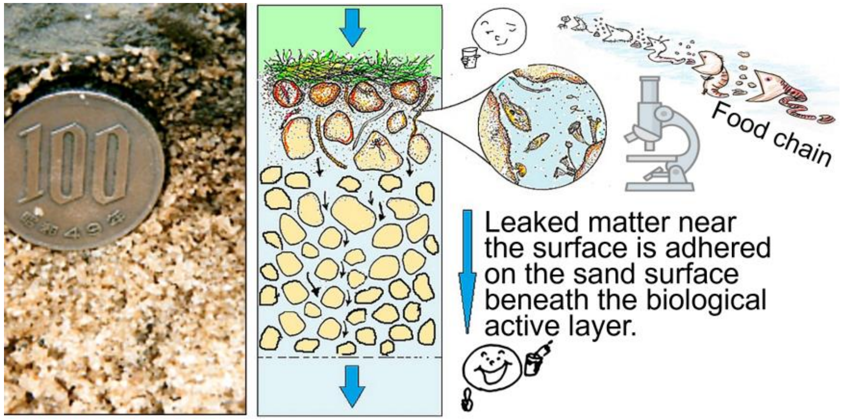



Fig. 3. Algae and small animals are active at the top

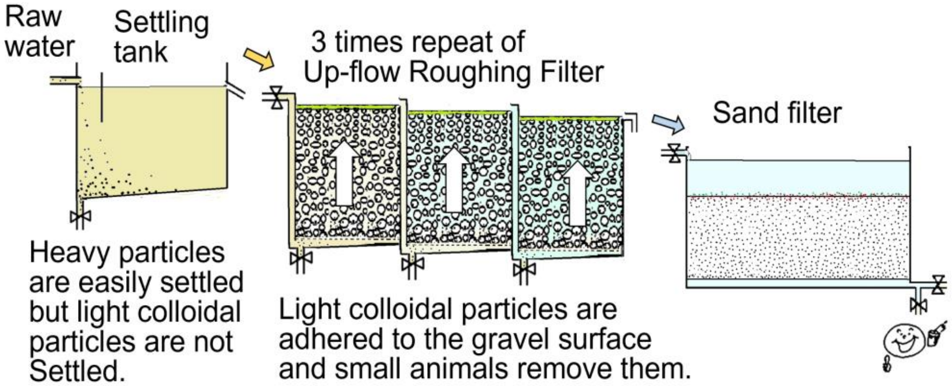



Fig. 4. Settling tank and URF for turbid reduction

http://www.cwsc.or.jp/files/pdf/Document_Int.Contribution_Award_21stJapan_Water_Awards(EN).pdf

Web Japan Ministry of Foreign Affairs of Japan


# Japan Video Topics

Feb. 2021.

Clean drinking water is essential for life, but expensive water filtration systems are out of reach for many communities around the world. Japanese scientist NAKAMOTO Nobutada is unlocking the water-cleaning power of algae and microorganisms to bring down costs!

日本語 世界の水をきれいに

英語 Clean Water for All

ポルトガル語 Água Limpa para Todos

中国語 创造洁净水源—日本的净水技术

フランス語 De l'eau propre pour tout le monde

スペイン語 Agua limpia para todos

アラビア語 المياه النظيفة للجميع

https://www.youtube.com/watch?v=ki8Qyb2lZ10

https://www.japan.go.jp/kizuna/2023/07/utilizing_microorganisms_to_purify_water.html

Health & Welfare

# Utilizing Microorganisms to Purify Water and Enhance Public Health

07/07/2023

A Japanese researcher has been promoting a method called the ecological purification system to purify water utilizing the activities of small organisms. **What is this low-tech but smart solution that produces safe and affordable drinking water to help protect people's health?**

"In places without safe access to this vital resource, slight improvements to water for drinking and cooking can reduce instances of diarrhea or dermatological diseases. You'll then see a change in people's health awareness. **The key is promoting sustainable, do-it-yourself technologies and fostering awareness.**"

# Ecological Purification System (EPS)

*Chemical Free*
*Eco-friendly*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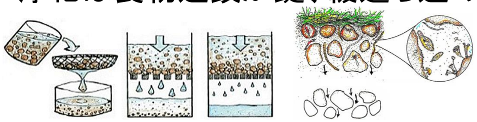


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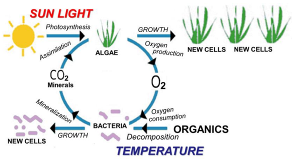
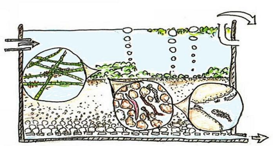
緩速ろ過池の藻類と動物



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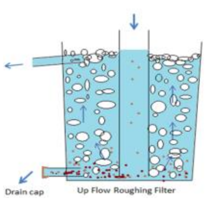

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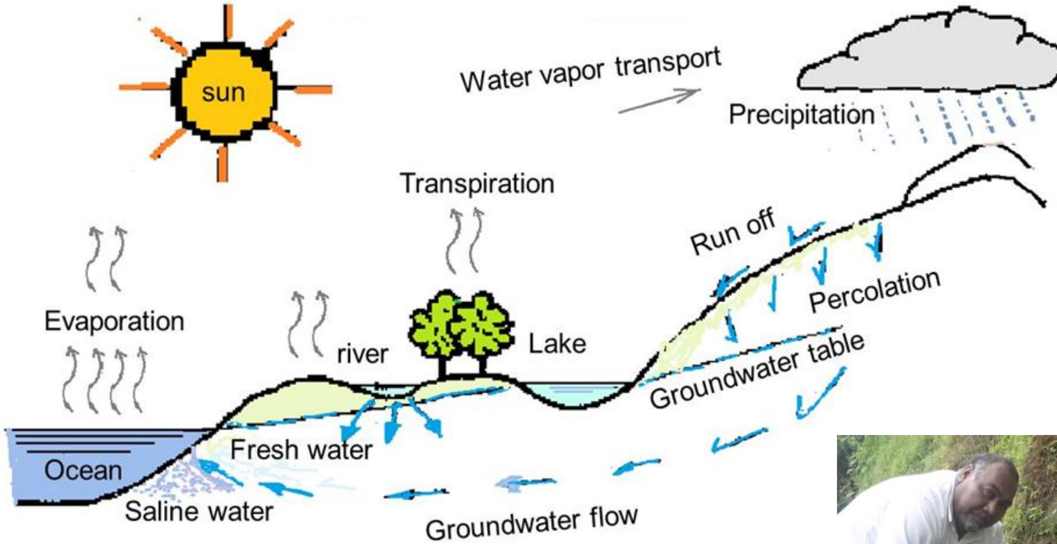
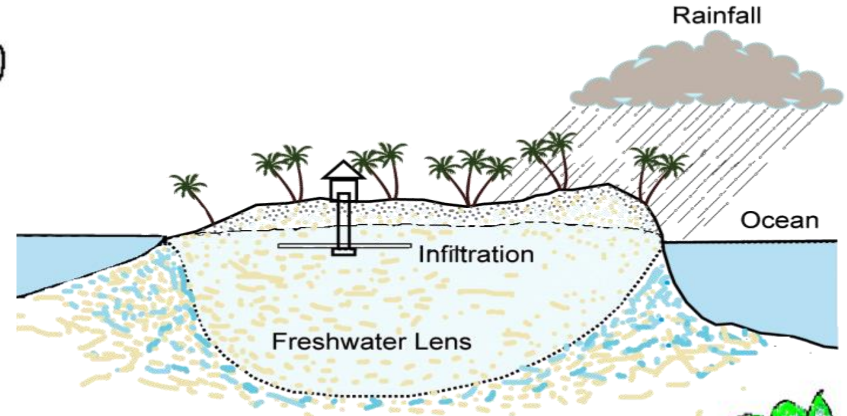
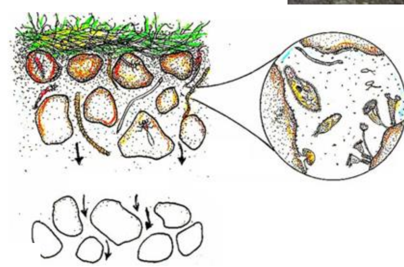
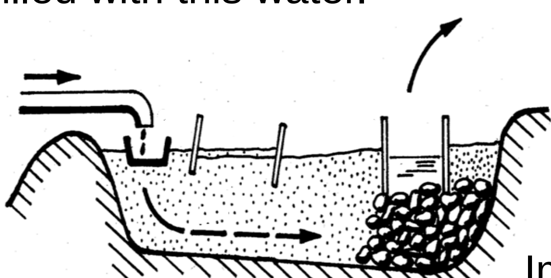




We have been use natural safe water which is natural spring water. This water is purified in nature without any chemical. We prefer this water than chlorinated tap water. Commercial bottle water is just filled with this water.





Artificial clean subsurface water in a flood plain.

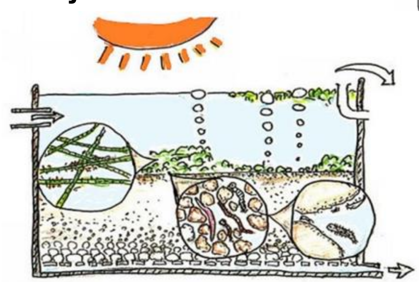
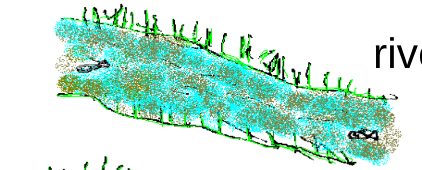


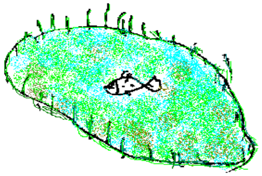
Image of Slow Sand Filter as Ecological Purification System (EPS).

EPS is a new purification system to make artificial safe water. This is wise use of natural phenomena. This is not same as slow sand filter.

Familiar surface waters are not always safe. How to get safe water.

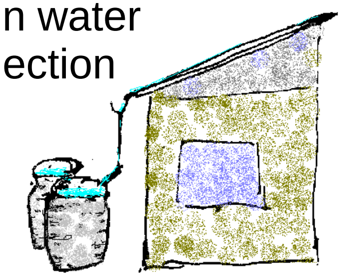


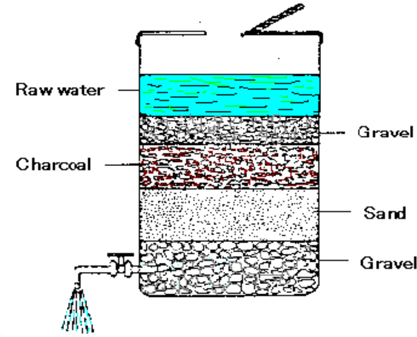
river



pond

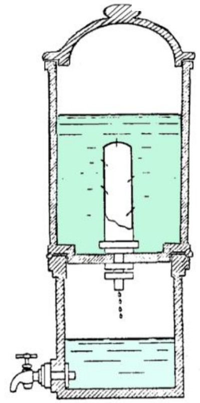
Rain water collection



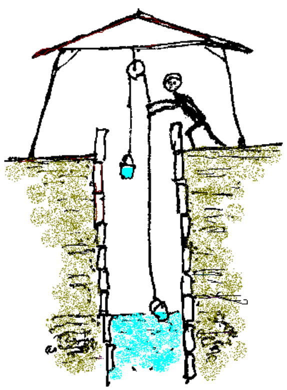


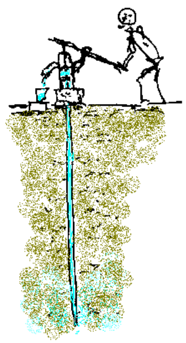

Surface water is easily contaminated by pathogens and other dangerous worms. It is not always safe to drink directly.

Fish is one of the indicator.



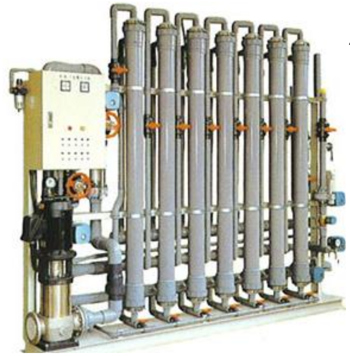
Multiple layer filter, Bio-Sand Filter and Ceramic candle filter do not perform completely at removing pathogens. These can be reduced the risk.





*Heavy metals are easily dissolved in underground water. This water does not contain* ***enough amount of dissolved oxygen****.*

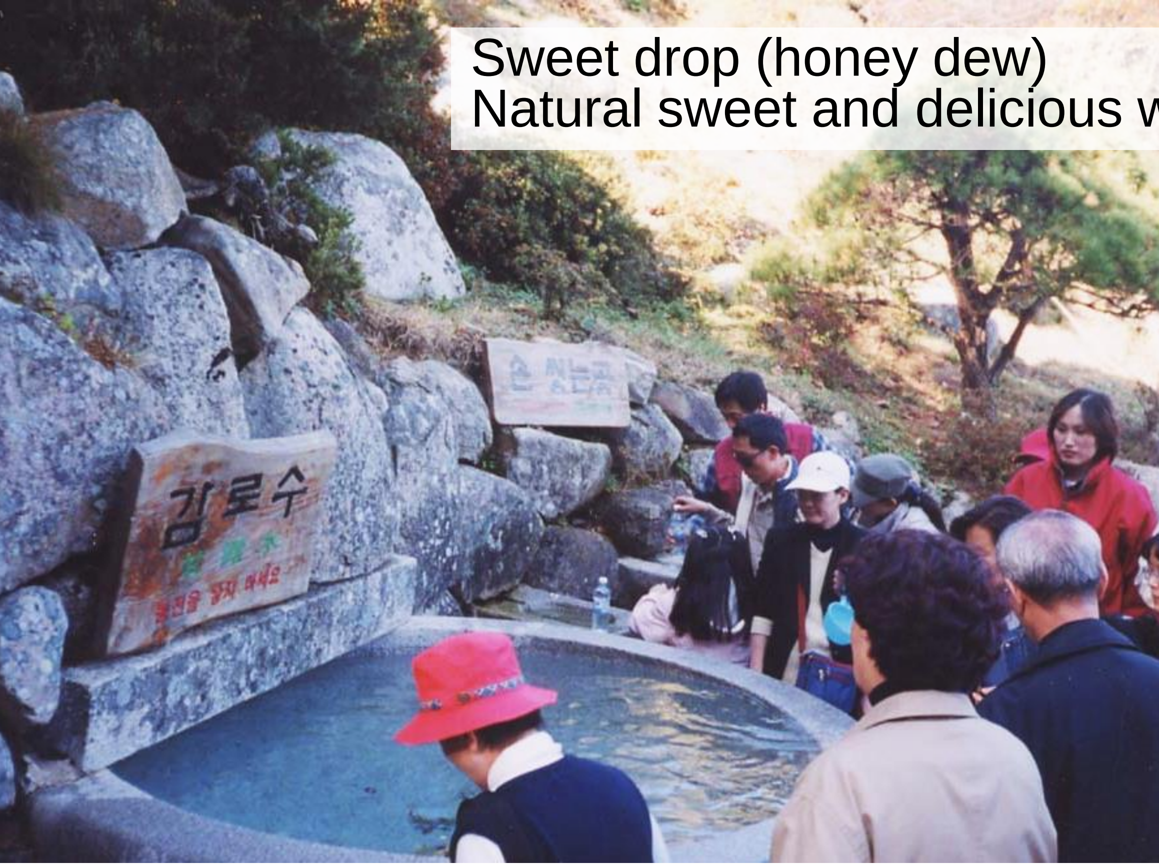
Boiling is the best way against pathogens.



Almost all pathogens may be removed by ceramic filter. The pore size is smaller than 1.5 micron.

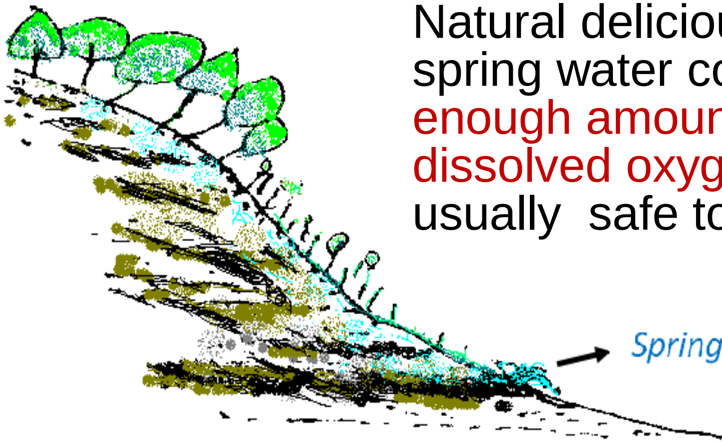
All the contaminated particulate matter can be removed by a membrane filter. But it's running cost is so big.

Sweet drop (honey dew)
Natural sweet and delicious water



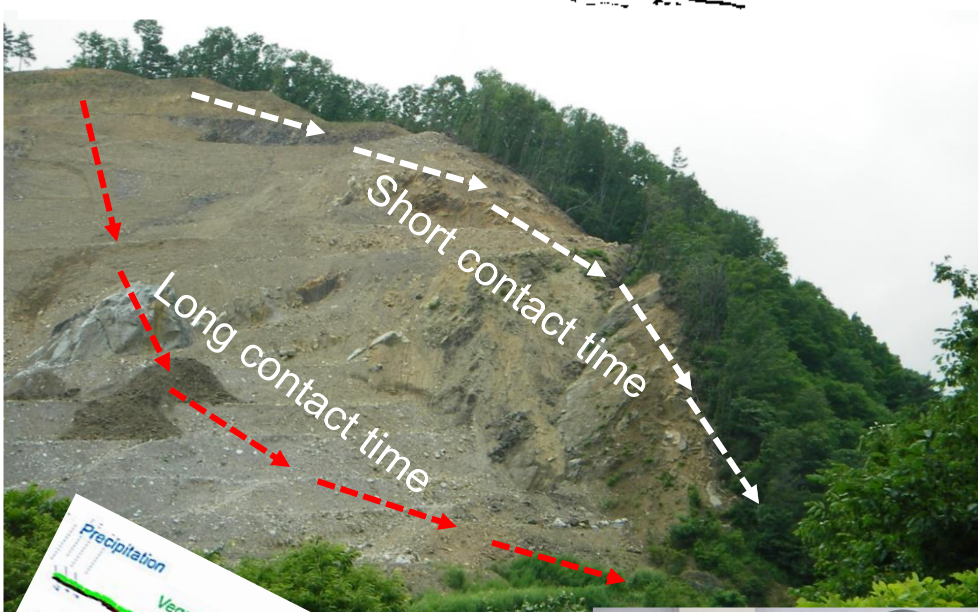

Rain harvesting

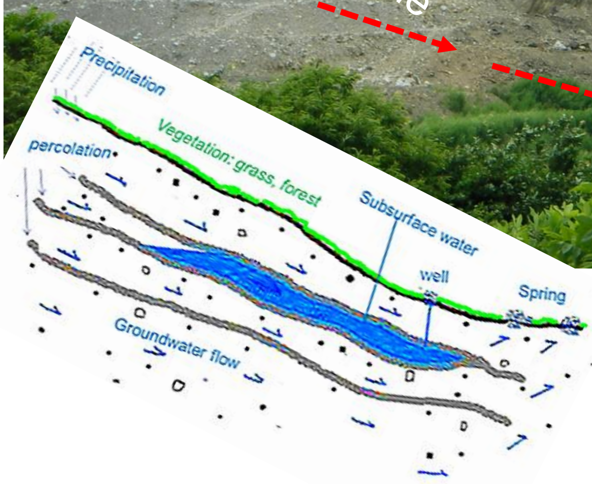
Natural spring water and rain water are usually sweet and delicious.




Natural delicious spring water contains enough amount of dissolved oxygen. It is usually safe to drink.

## Dissolved oxygen is key.

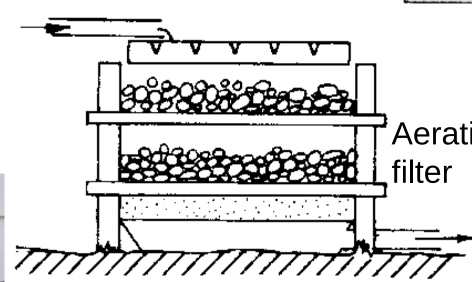


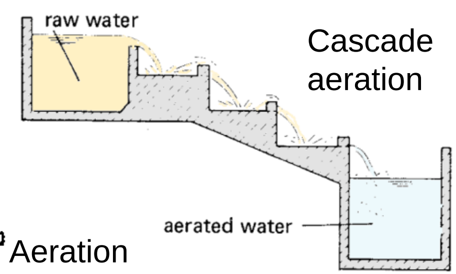

## Addition of oxygen:

Aeration is frequently used for treatment of groundwater (reduction of unpleasant tastes and odors, discoloration, precipitation of iron and manganese).

Heber 1985

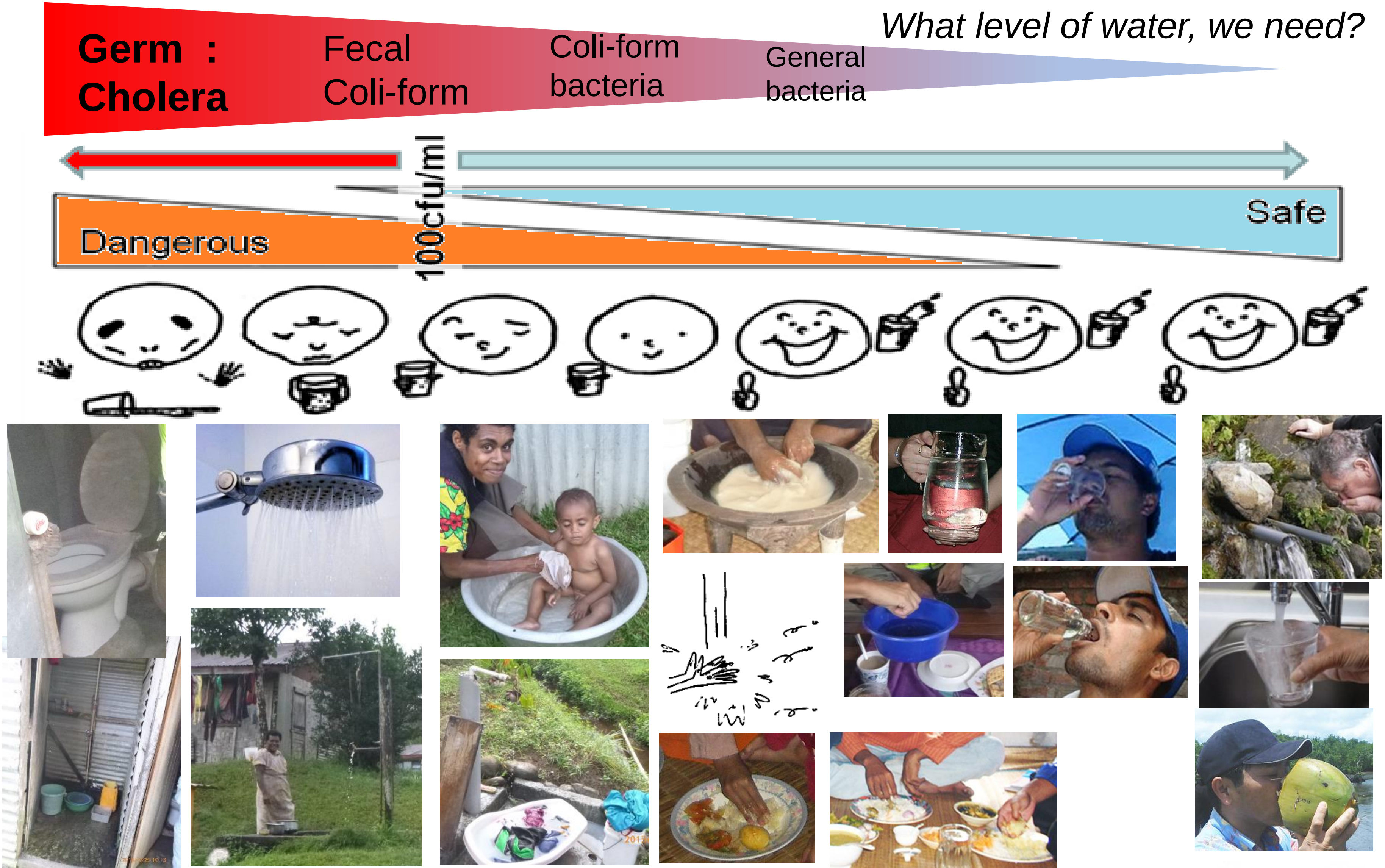


Aeration filter




Cascade aeration

Iron and manganese are oxidized and form nearly insoluble hydroxide sludge. They can be removed in a settling tank (a coarse filter).

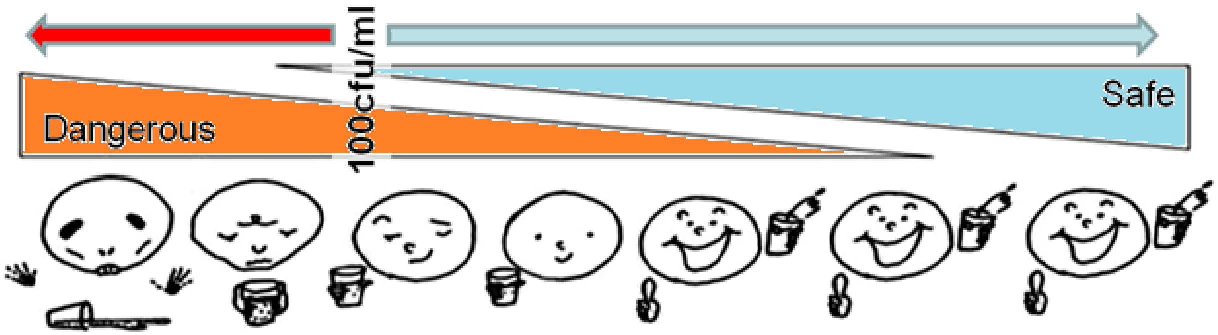



We have to think about acceptable risk and treatment.

Which level of treatment, we need?

Is this, safe or not?

# We have to think about acceptable risk.



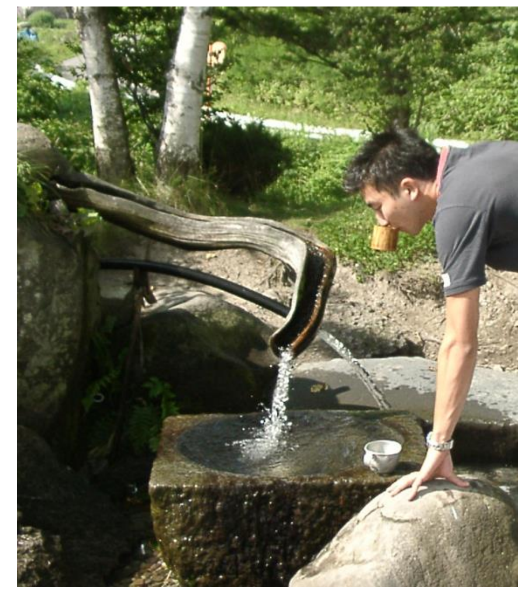

General bacteria: many in the natural environment

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

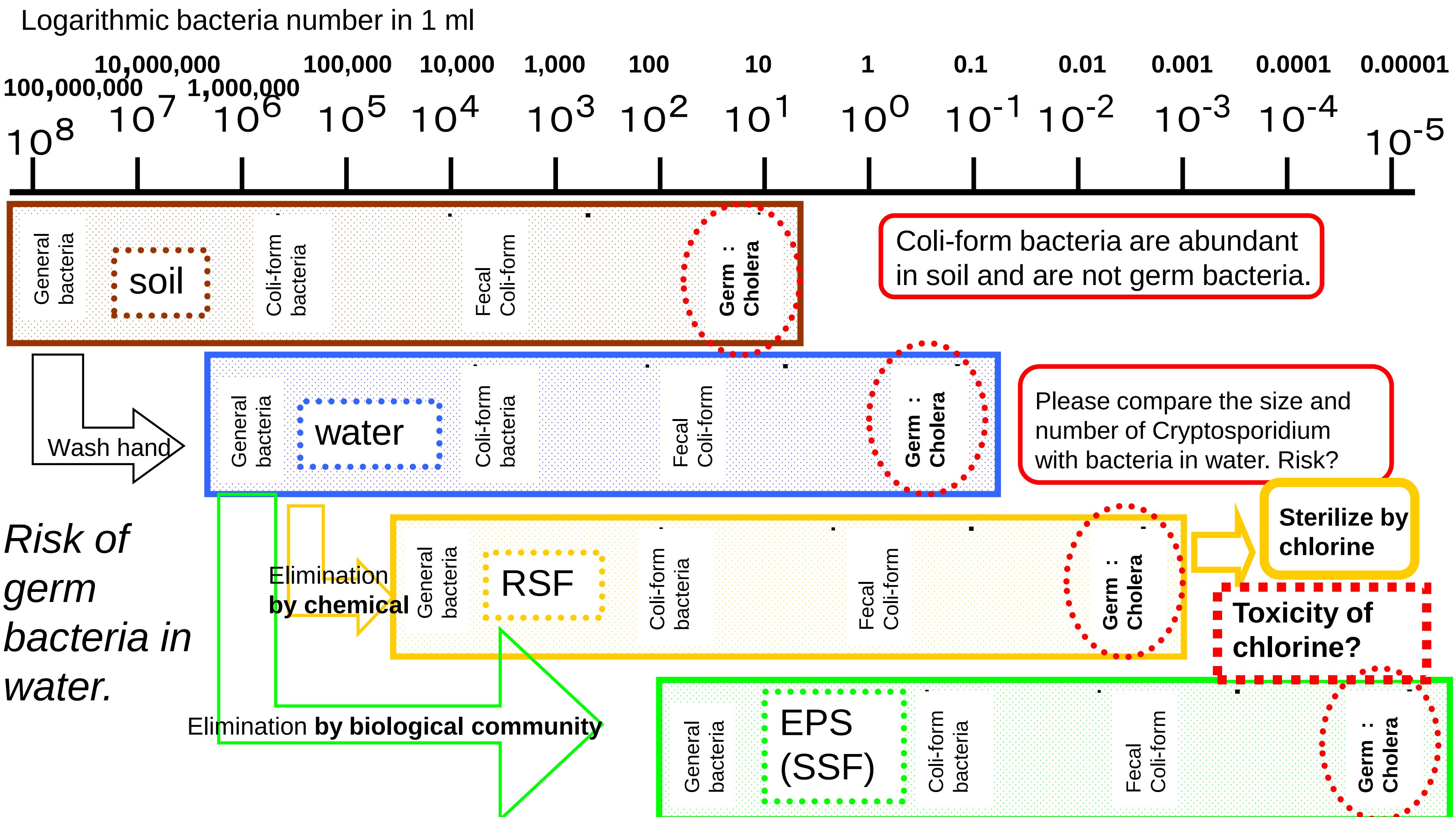
*Escherichia coli* : indication of intestinal bacteria.

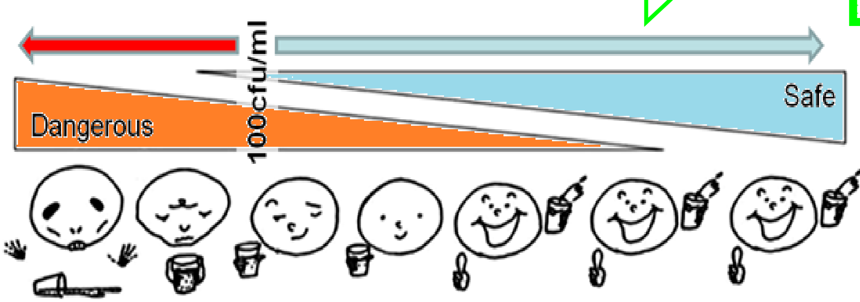
Fecal *Escherichia coli* : an indicator of fecal contamination of mammals.

**Pathogenic bacteria**



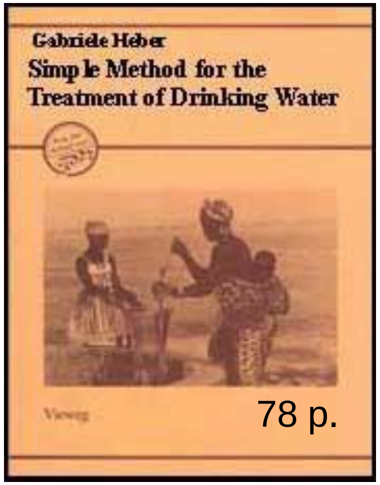
*There are so many bacteria.→Medical doctor touches with patients. Doctor is safe.*




*We have to think about acceptable risk.*

# Gabriele Heber 1985: Simple Methods for the Treatment of Drinking Water




https://www.nzdl.org/cgi-bin/library.cgi?e=d-00000-00---off-0hdl--00-0----0-10-0---0---0direct-10---4-------0-0l--11-en-50---20-about---00-0-1-00-0-0-11-1-0utfZz-8-10&cl=CL3.21&d=HASH175e57dd8f453120fc2d5d&gt=2

| Turbidity, Average Values (NTU) | E. Coli (MPN/100 ml) | Processes and Combinations |
|---|---|---|
| Up to 10 | 10 | No treatment necessary |
| 10 | 100 | Only disinfection |
| 100 | 1,000 | Slow sand filtration |
| 250 | 1,000 | Pretreatment + Slow sand filtration |
| 250 | 10,000 | Pretreatment + Slow sand filtration + Disinfection |
| 1,000 | 100,000 | Two pretreatment methods: e.g. sedimentation + coarse filtration or coagulation/fluctuation + sedimentation Subsequently: slow sand filtration + disinfection |
| 100 | 2,000 | Rapid filtration + disinfection |
| 1,000 | 3,000 | Pretreatment + rapid filtration + disinfection |

Table 4: Treatment processes and combinations as a function of turbidity and E. Coli count in the raw water. Additional aeration generally helps to increase the water's oxygen content. The turbidity values refer to the contents of settleable and non-settleable substances. The choice of pretreatment method thus depends on the type and composition of turbidity.


It is popular in the world to eat with our bare hands. We have to remove the contaminated small stones in food. This is a reasonable way.

# *Chemical Free*
# *Eco-friendly*

# *Ecological Purification System (EPS)*


0. Introduction: Phytoplankton, Reservoir study, Meet Slow Sand Filter, Importance of Ecological point.    JICA training
植物プランクトン、貯水池研究、緩速ろ過、生態学の視点、JICA研修へ

*1-17* *17*

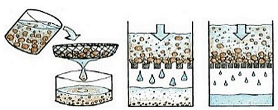
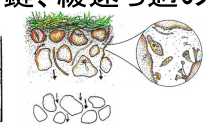
1. Water cycle, Safe water, Acceptable risk.
水循環、安全な水、許容できるリスク

*18-26* *9*



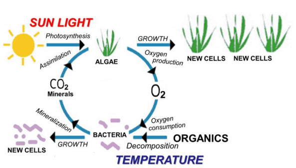
2. Key of purification in nature is food chain.
Refocus to Slow Sand Filter.
浄化は食物連鎖が鍵、緩速ろ過の再認識

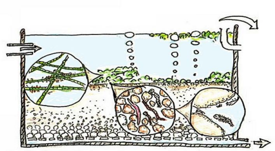
*27-51* *25*


3. Algae and animals in Slow Sand Filter.
緩速ろ過池の藻類と動物

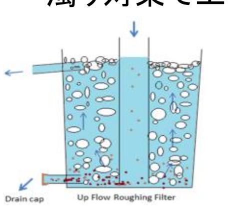
*52-73* *22*



4. Up-flow Roughing Filter to reduce SS
濁り対策で上向き粗ろ過、モデルで解説

*74-100* *27*



5. From JICA training in Miyako-jima, Okinawa to Samoa
宮古島JICA研修からサモアへ

*101-116* *16*



6. Safe water for rural people by EPS in Fiji
フィジーの展開：生物浄化法で地方給水へ

*117-138* *22*



7. Aerobic condition is essential for EPS.
生物浄化法は酸素が必須

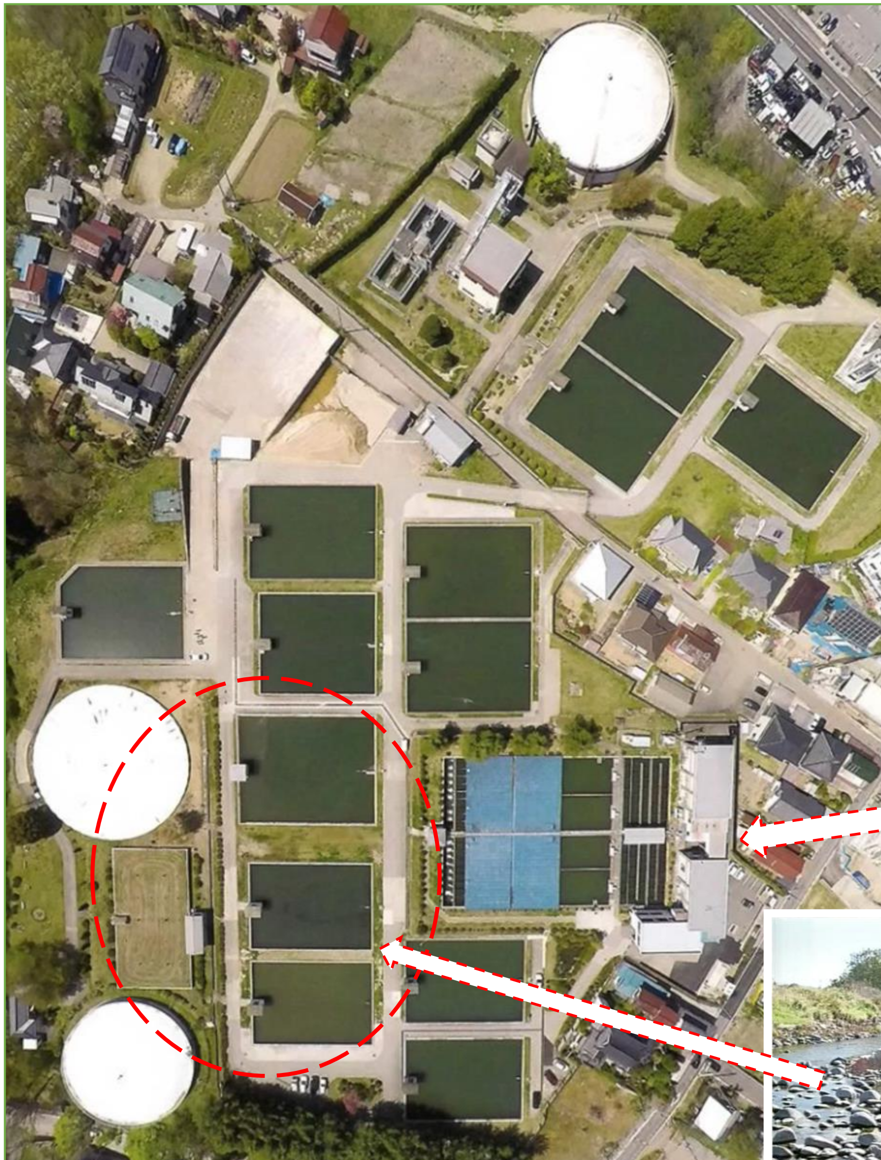
*139-148* *10*



8. Confirm by yourself. Don’t believe commercial.
Trust your true sense.   自分で確かめよう。

*149-163* *15*

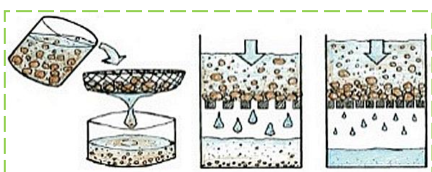




*Bad Algae in the reservoir.*

Odor problem of tap water appeared, after the construction of the Sugadaira Reservoir in **1968**.

The original water source was a **subsurface water** in a flood plain of the River Chikuma from **1923**.

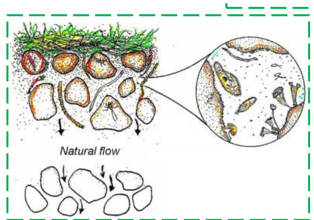


*Slow Sand Filtration*

*Large area →but only filter*

*Slow rate→bad efficiency*

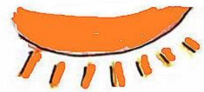
*Fine sand→easy to clog*
*→scrape by man power*




*Ecological Purification System*

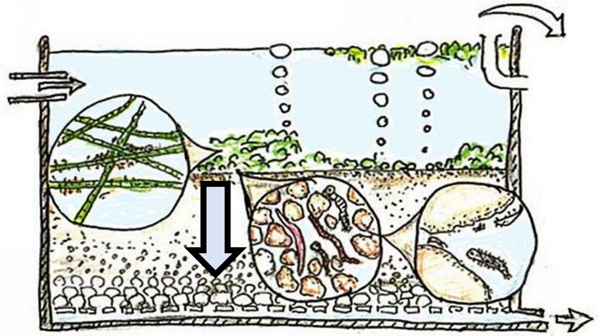
*Slow rate→passing time is very short.*

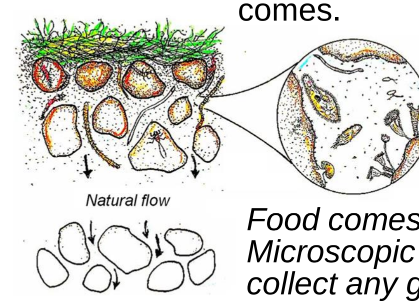
*Natural spring→no maintenance*



There is vertical downward current in a filter pond. This is gentle environment for small organisms where sand does not move.

Filamentous algae grow well on the sand surface. Microscopic and small animals live on and among the sand layer where food comes.



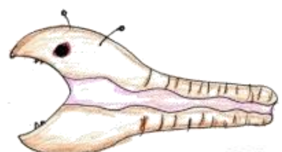



*Food comes from the top. Microscopic organisms collect any germ cells.*

Germ free safe water to drink

*There is no food in deep place.*

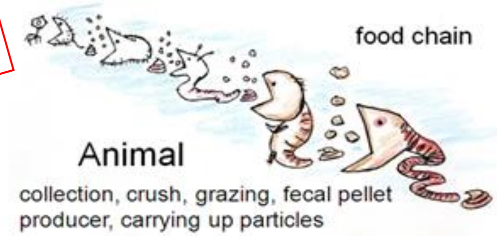
*Small animals collect any turbid matters near the surface where food comes.*



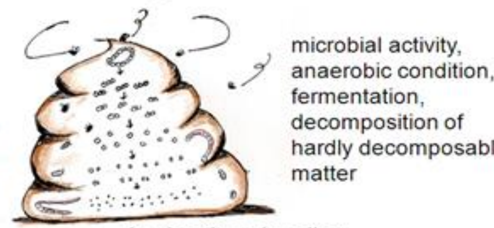
*Trap and collection time of particle by small organisms is very short. Passing time of food in body is also very short.*

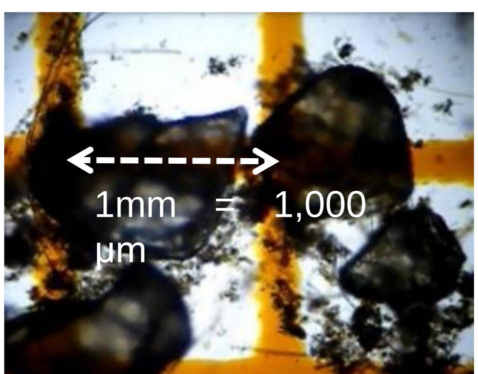
*Oxygen is necessary for small animals.*

## Short time work




## Long term action

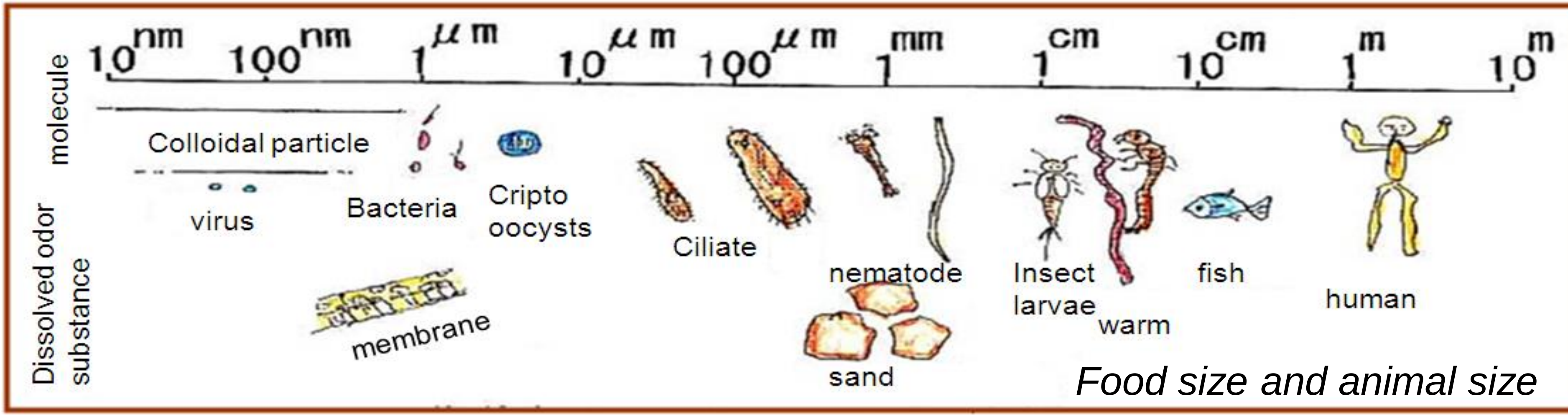



*Food chain by small animals is the key for purification system.*

Healthy and hungry condition of animals are important to collect any particles under gentle condition.

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

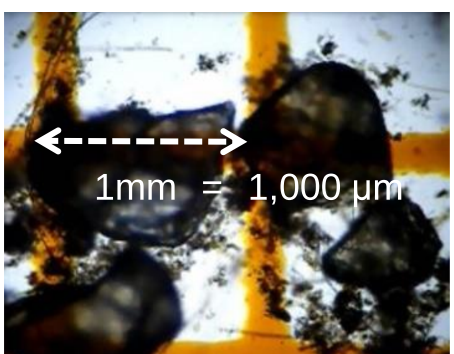




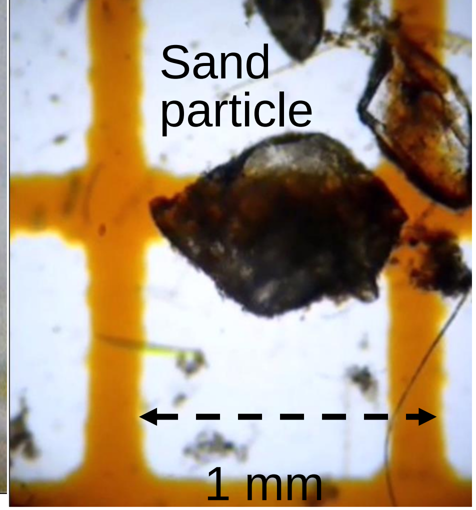
Long term action

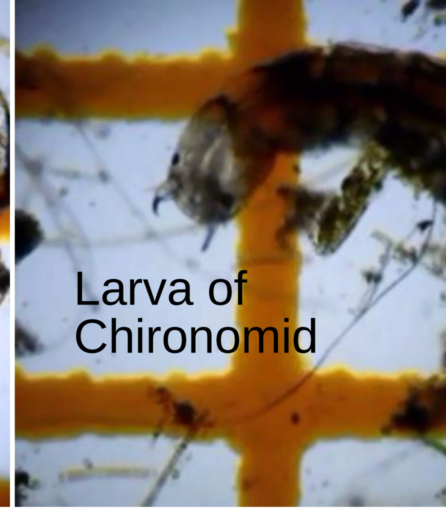
Complete decomposition (mineralization) in the faecal pellet.

*Anaerobic condition inside of fecal pellet.*



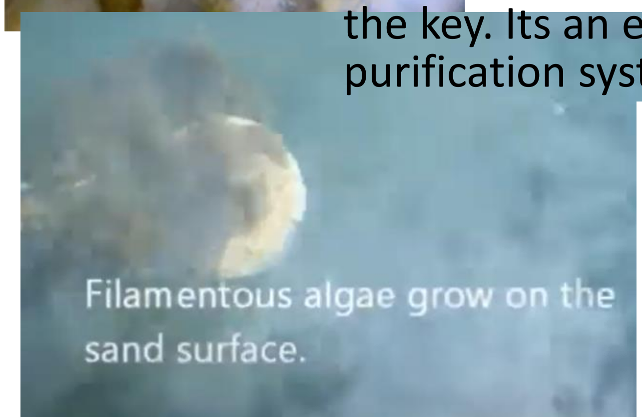

Hungry animals are important to trap any particles under gentle condition.


Fecal pellet of Chironomid larva


Slow sand filter is real ecological purification system. Food chain is the key. Its an ecological purification system. / 5:22




https://www.youtube.com/watch?v=pBmHoxOqi1U&t=3s

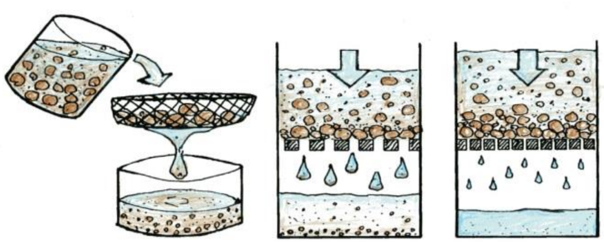
Detail of Ecological Purification System for safe drinking water / 6:23


https://www.youtube.com/watch?v=Pk_JNC6RTyo

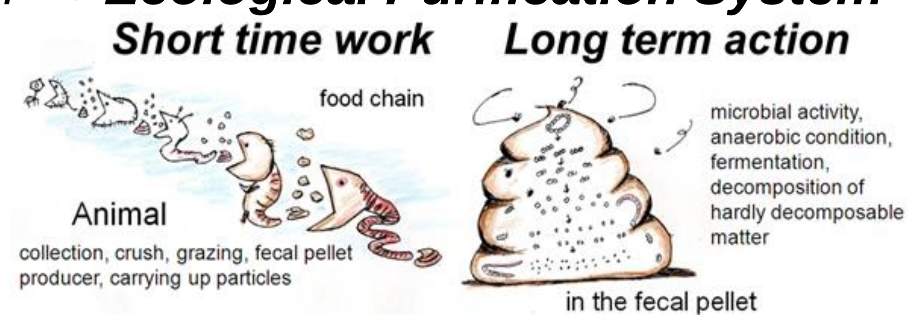
# THIS is FOOD CHAIN

The first use of slow sand filter for the public supply of drinking water began in 1804 in Paisley, Scotland. The present vertical type of slow sand filter was devised by James Simpson in 1829 after his 2,000 miles inspection trip all over the Britain. This filter provided safe drinking water, free of pathogens to residents in London. This **vertical** type of filter spread round the world and was known as the “English Filter”.  Slow sand filter has been believed that it was a **mechanical filter with fine sand under slow current**. However, the major contribution of the purification of the impurities is the **food chain** in this system. The word of “**slow**” was “**gentle for organisms**”. Recently, the English filter of “**Slow Sand Filter**” has been recognized as “**Ecological Purification System**” in Japan.

*Slow Sand Filter → Biological Filter → **Ecological Purification System***



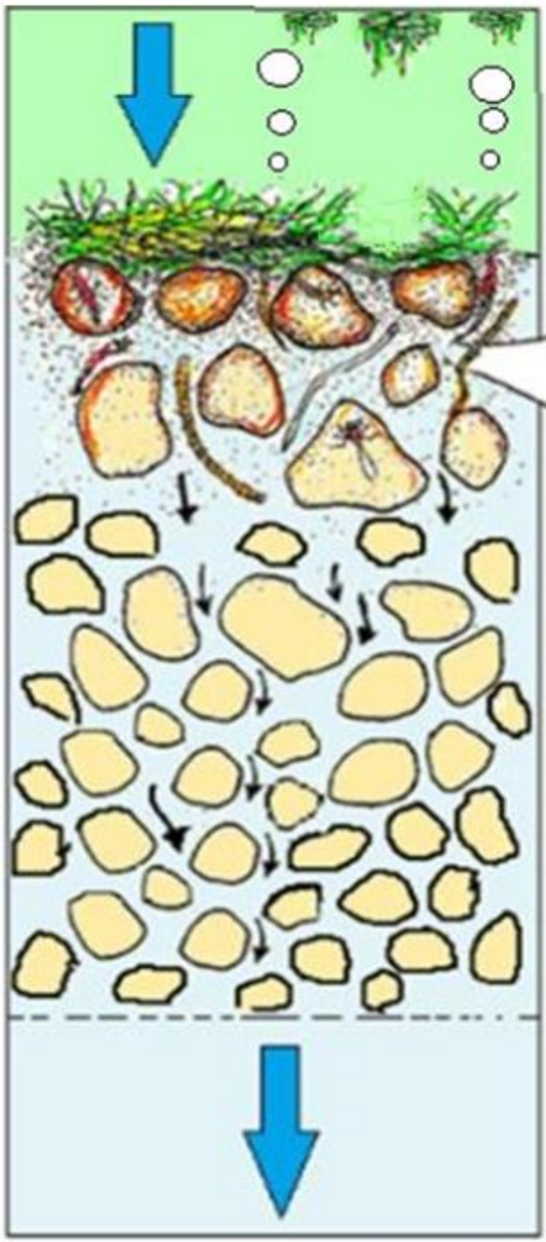
*English Filter : Mechanical filter*

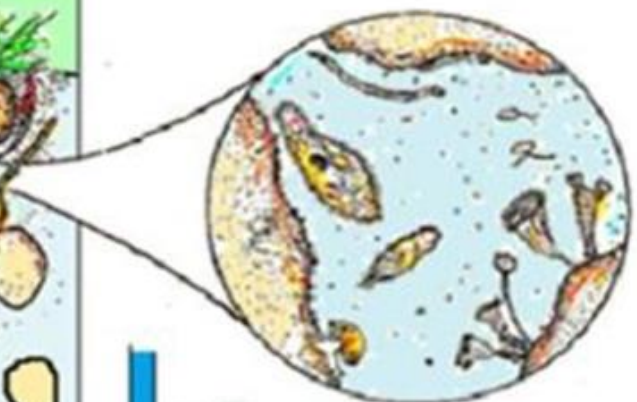



*New Concept and New Name*

# Passing time during biological active layer is very short.

English standard filter rate
4.8m/d (20 cm/h)





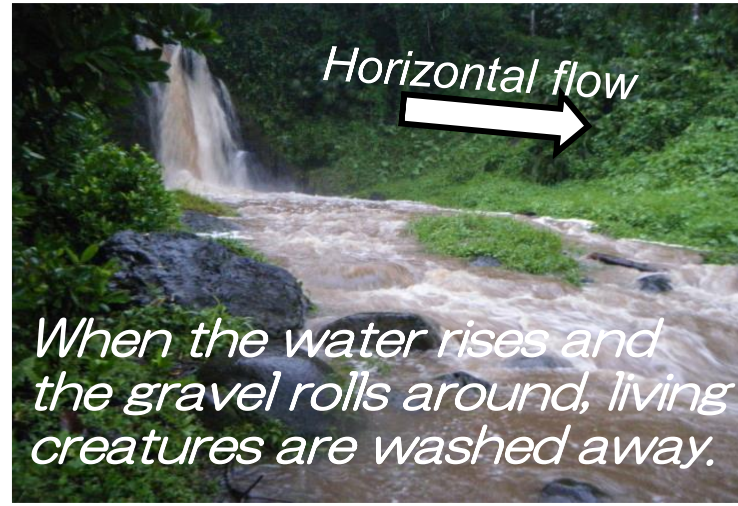
Purification is done during the passing time of 1 to 2 minutes through biological active layer.

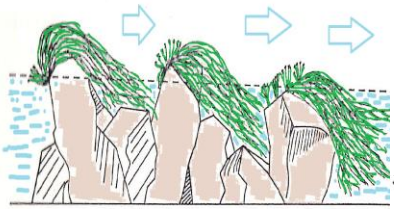
**Purification time is very short near the surface.**

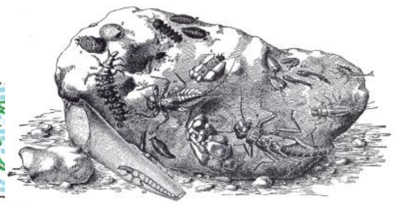
**Guarantee and insurance layer for emergency**

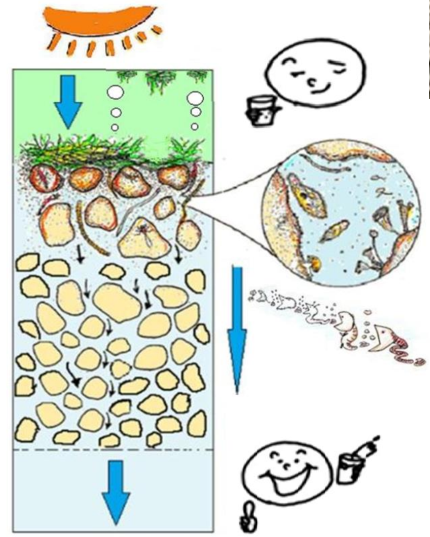
When the porosity is 50% in sand layer, filter rate becomes double.  9.6m/d (40 cm/h)

English standard filter rate
4.8m/d (20 cm/h)





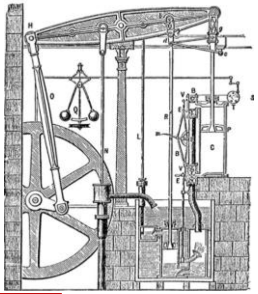


Spring water is always clear.

Sand and stone are not moved under vertical current.

# Origin of Public water supply.

Trade flourished during the Age of Discovery.

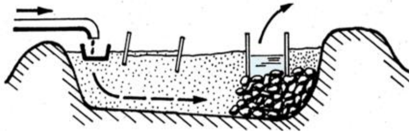


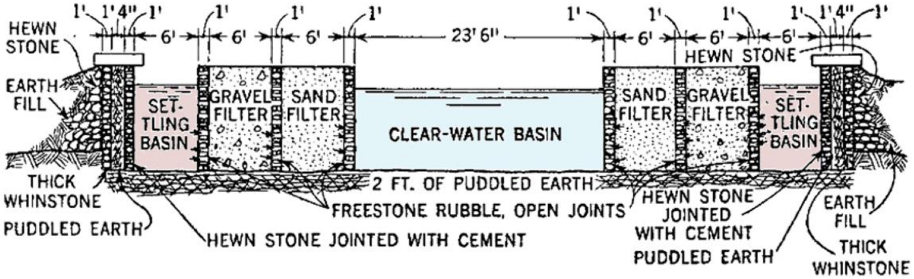
Steam Engine was developed by James Watt from 1763 to 1775 in Glasgow, Scotland.

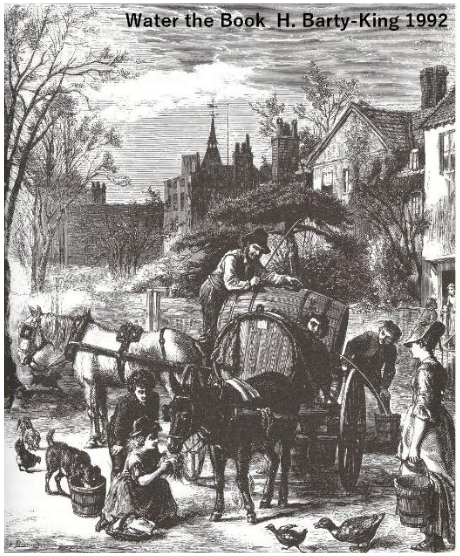
Industrial Revolution

Textile Industry developed.


A large amount of clean water was required to wash the dye out of the dyed fabric.





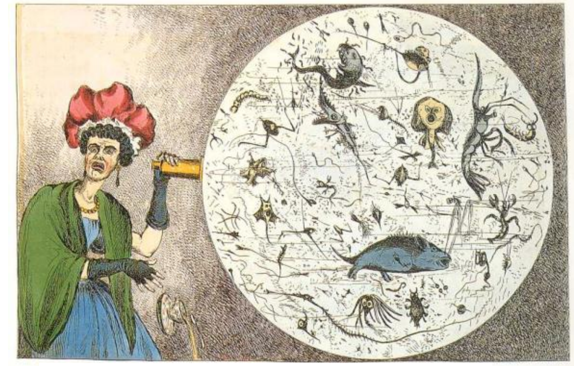



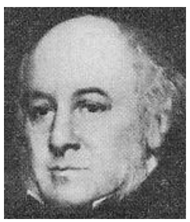

John Gibb took a hint from the clear water that springs up from the riverbed. He poured muddy river water horizontally into gravel and sand tanks to obtain a large amount of clean water in Paisley near Glasgow in 1804.

He got a surplus of clean water, so he sold it all over the city. This is origin of Public water supply.

During the Industrial Revolution, the population gathered in cities. The rivers in cities were polluted.







James Simpson examined vertical type of slow sand filter from 1827-1828 and made a practical plant in 1829.

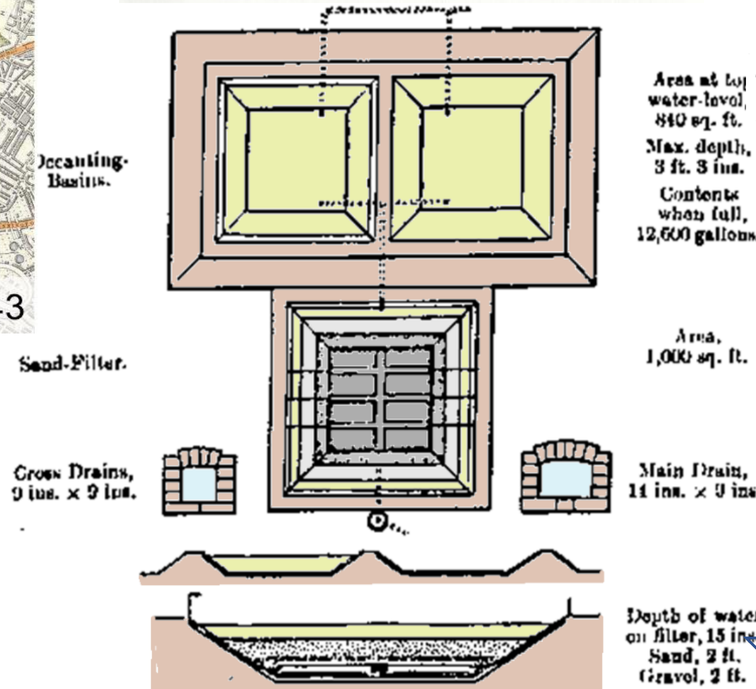
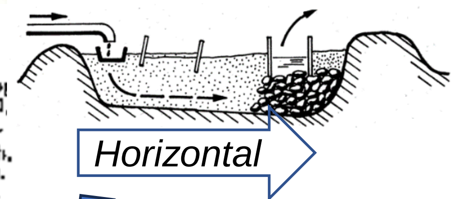
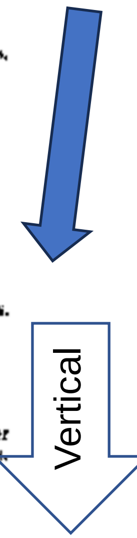



FIG. 28. JAMES SIMPSON'S EXPERIMENTAL FILTER OF 1827–1828




**Completion of present Slow Sand Filter: 200 years ago.**

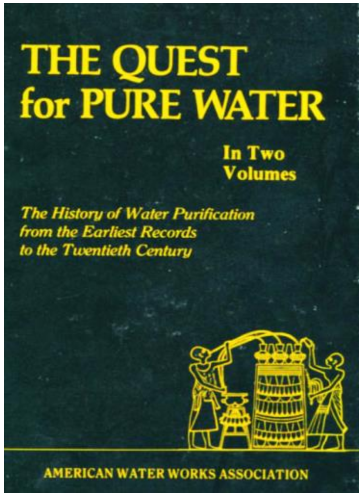
*The filter rate was 2-3 m/d (10cm/h).*

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

They believed that **Slow Sand Filter** purified by **slow** filtration with **fine sand**.

They believed this was **mechanical reduction** with **fine sand**.

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



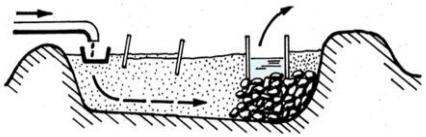

### *James Simpson and the Chelsea Water Works Company*

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.

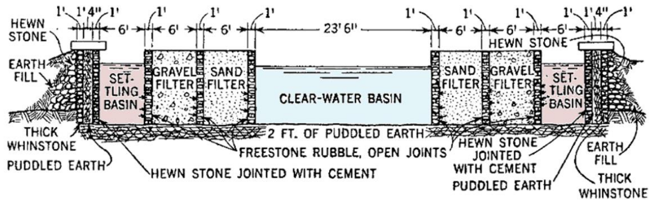
Of the eight water companies supplying Metropolitan London in the 1820's, five, including the Chelsea until early in 1829, served raw water from the always polluted and sometimes turbid Thames, taken within the tidal reach of the stream into which numerous sewers discharged. The Chelsea Water Works Co.,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

Unfortunately, this drawing does not remain.

# Completion of Vertical English Filter

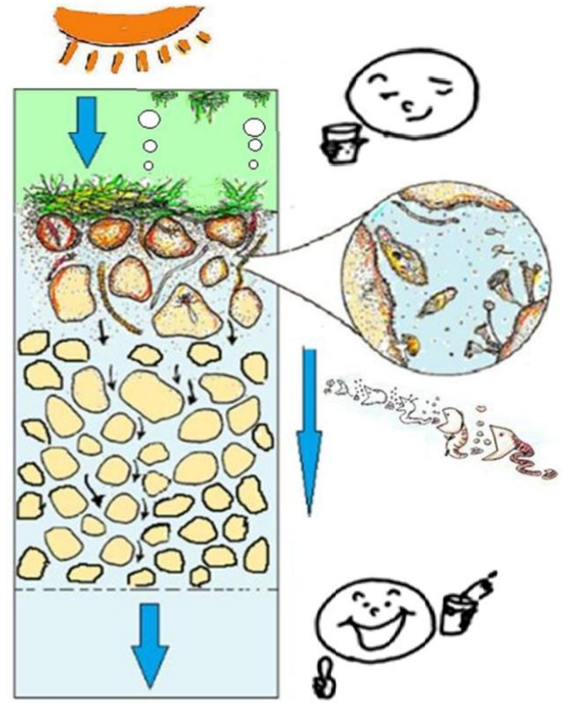


***Horizontal***




*Vertical*

J. Simpson examined vertical type of slow sand filter from 1827-1829 and made one acre filter for practical use in 1829.

*Polluted Thames water*

*Settling basin*

*Vertical Slow Sand Filter*

*Germ free filtrate*

The shallow depth and the vertical flow allowed creatures to be active and safe near the surface of sand layer.

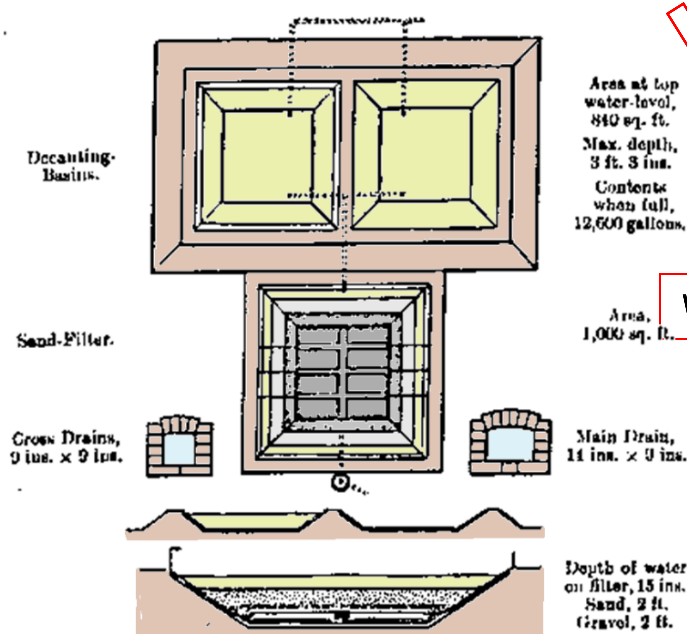


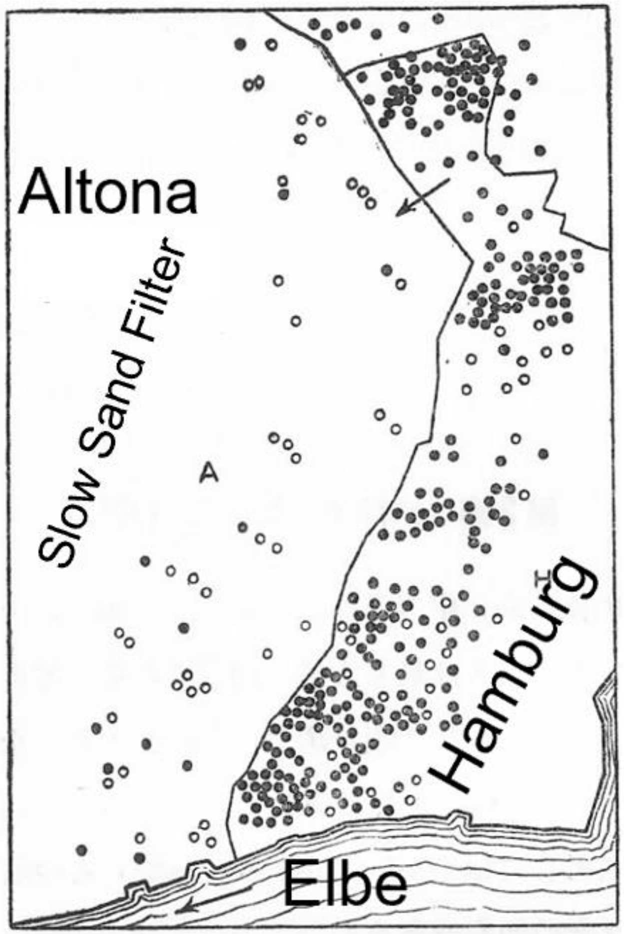

Fig. 28. James Simpson's Experimental Filter of 1827–1828

*Vertical*

*Shallow depth*

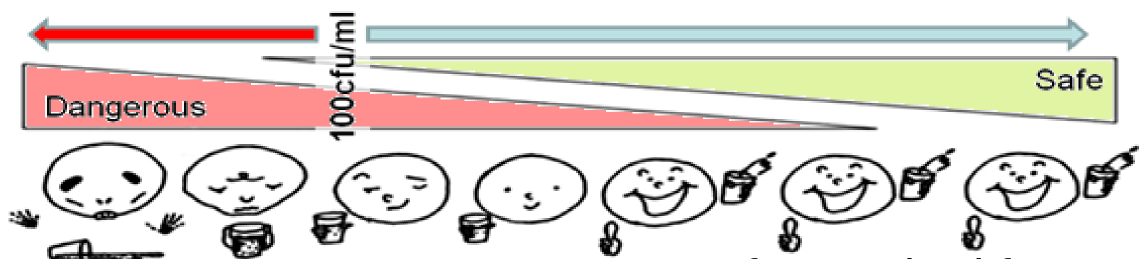
| | |
|---|---|
| 38 cm | Water depth |
| 61 cm | sand layer |
| 61 cm | gravel layer |

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




The clear proof of the filtration was provided in **1892**. This was **130 years ago**. **Hamburg** suffered from a cholera epidemic that infected and caused more than 7,500 deaths, while **Altona** was few.


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.



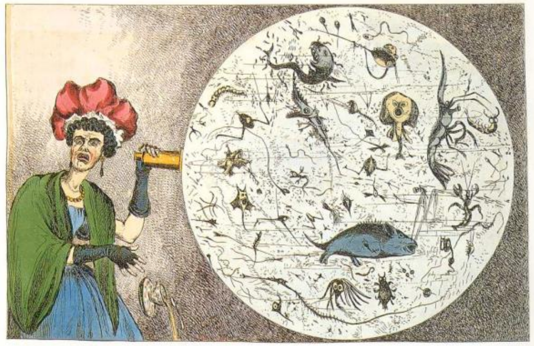

Present WHO safe standard for bacteria is referred to this 100 cfu/mL by Dr. R. Koch.

*They believed SSF was **mechanical reduction** of impurity by **slow** filtration with **fine sand**.*

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

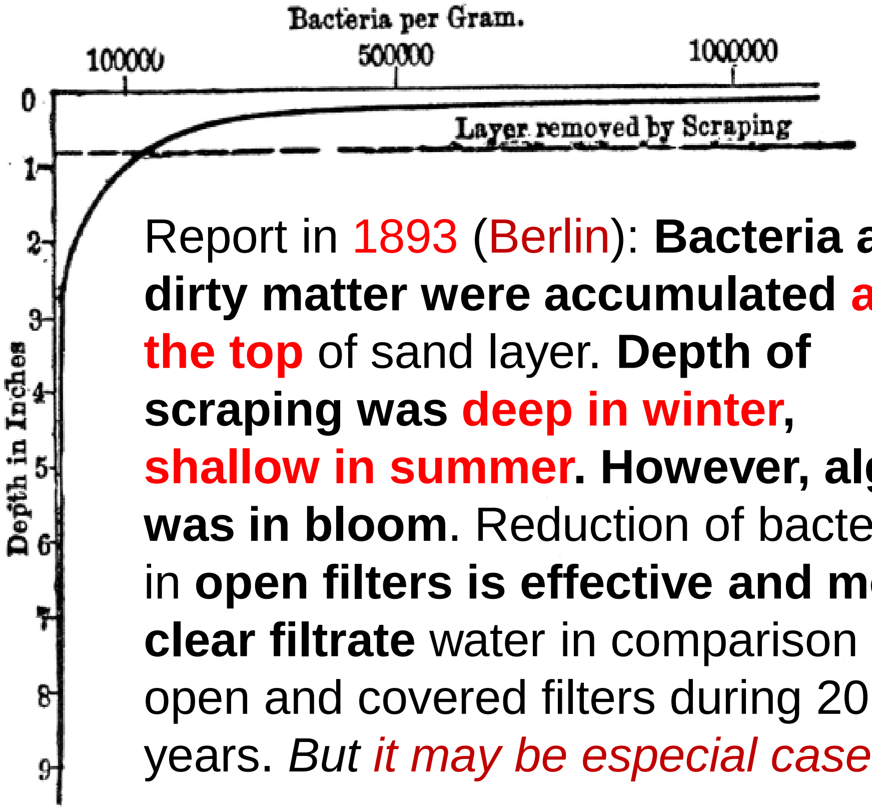
Wash our hands!
Reduce the risk.

**It was found that SSF could eliminate pathogens and spread all over the world as English Filter.**

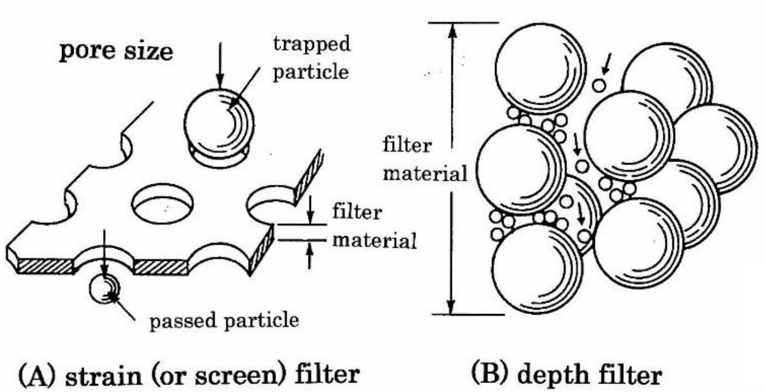


Monster Soup commonly called Thames Water on the Metropolitan Water supply in 1828.


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



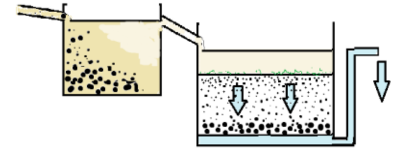

Report in 1893 (Berlin): **Bacteria and dirty matter were accumulated at the top** of sand layer. **Depth of scraping was deep in winter, shallow in summer. However, algae was in bloom**. Reduction of bacteria in **open filters is effective and more clear filtrate** water in comparison with open and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

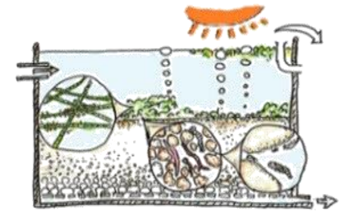



Removal of pathogens is not explained by these phenomena in comparison with size of microbial pathogens and opening space of sand grains. We can operate the filter without any clog during long filter run. **We can not explain the reduction mechanism of pathogens by physical phenomena.**

It was notified to biological phenomenon. However, he said that physical process was main.

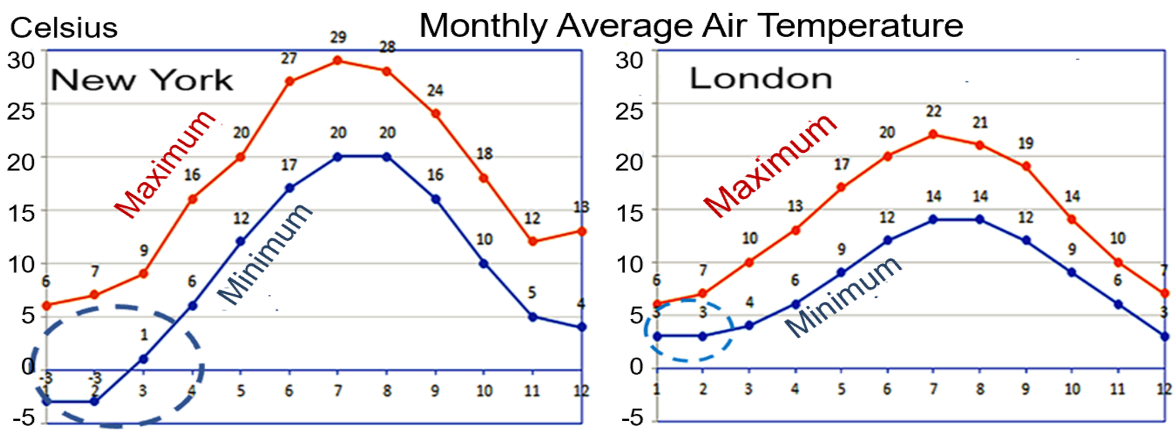
*M.N.Baker 1949. The Quest for Pure Water*

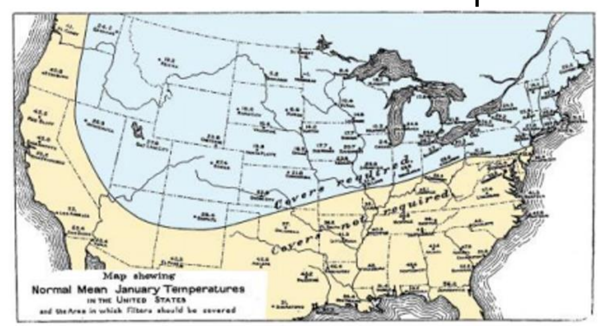





Safe drinking water was made by the biological activity.

The average temperature in January is below 0℃. Covered filter was required.

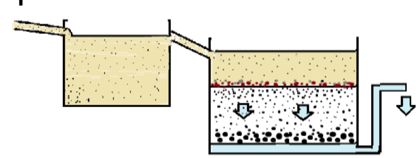


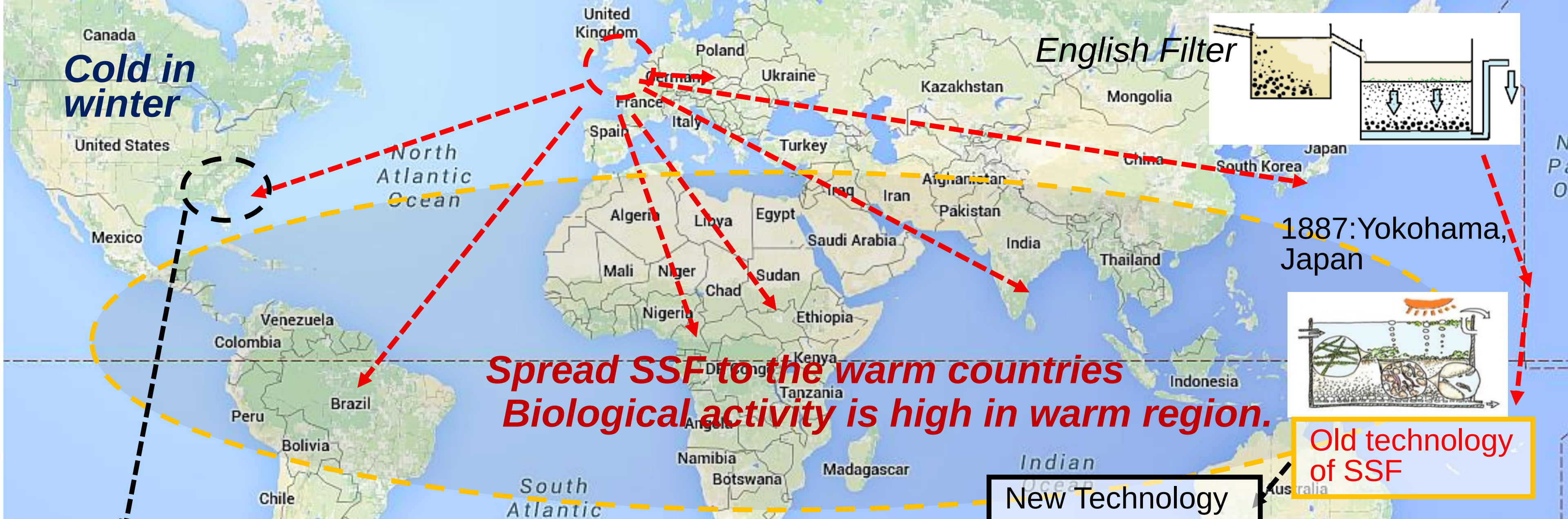
New York has cold winters and hot summers.

London is not cold even in winter due to the warm current.

The turbidity of rivers in the continental plain is fine and difficult to sink.



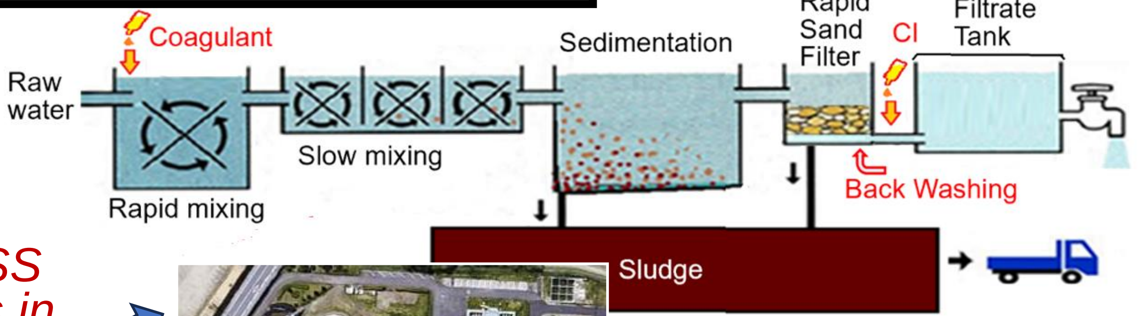
Winter temperatures in North America are cold and biological activity is weak.
And the viscosity of water is high in winter.



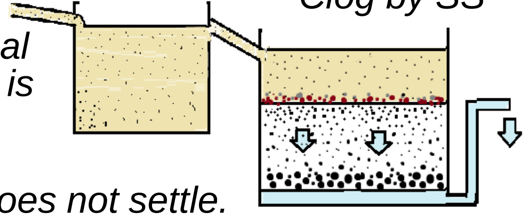

**Non-polluted river in new continent: poor food for small organisms**
1882: NJ, USA, Coagulation treatment : Origin of Rapid sand filter
1910: NJ, USA, Chlorine treatment Completion of **American Filter**

## Rapid Sand Filter is chemical treatment.

*Fine much suspended solid*




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




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

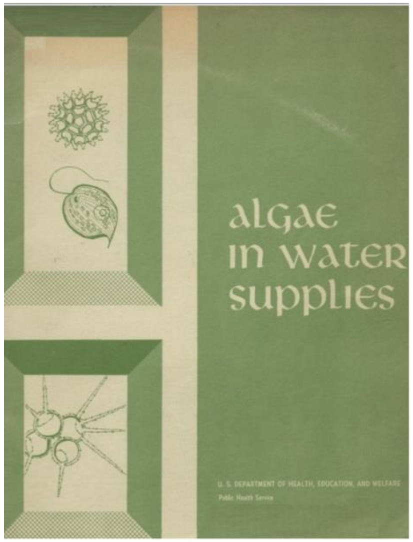
*Does not settle.*

*Filter easy to brock by suspended solid.*

*People loves new technology.*

RSF spread to the world.

*This is American Commercial Filter.*

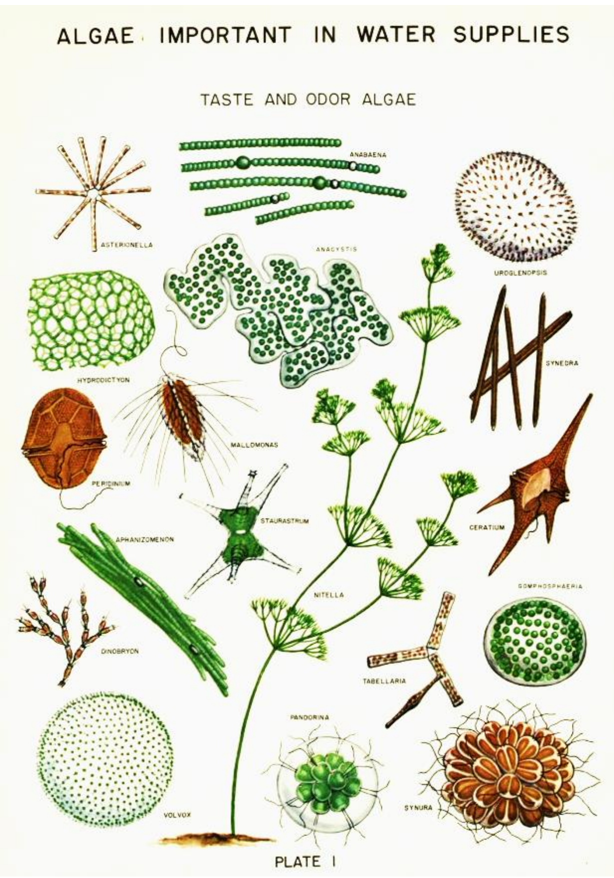


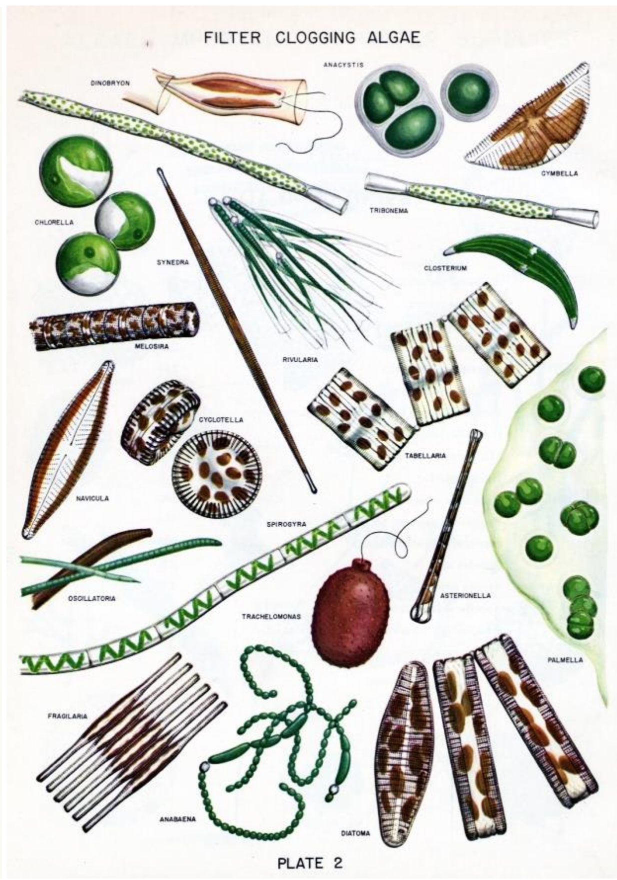

# Algae in water supplies: an illustrated manual on the identification, significance, and control of algae in water supplies. C. M. Palmer 1962

http://digital.library.unt.edu/ark:/67531/metadc9129/m1/

*Algae had been trouble for the conventional filter (rapid sand filter) in US. Taste and odor algae, filter clogging algae are important in water supplies (Rapid Sand Filter).*

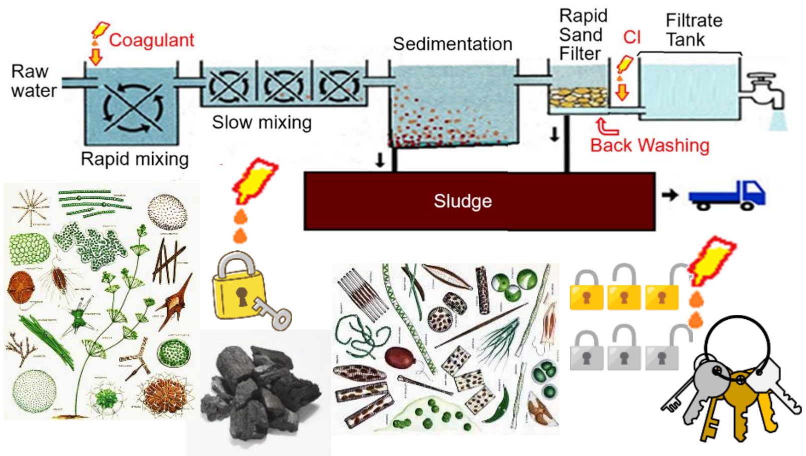
*In slow sand filter, the algae and other aquatic microorganisms may play a* ***useful part in the treatment process.*** *They form a loose, slimy layer over the surface of the sand and act as a filter. The algae in this layer release oxygen during photosynthesis, and the oxygen in turn is utilized by aerobic saprophytic bacteria, fungi, and protozoa which establish themselves in and on the filter. This permits the decomposition or stabilization of the organic material that was present in the raw water. In p.22.*




*Main focus* of this book is ***how to kill algae*** for ***Rapid Sand Filter***.

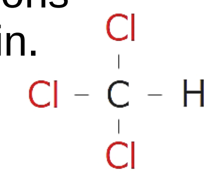
# *Refocus to Slow Sand Filtration as chemical free treatment instead of chemical treatment of Rapid Sand Filter.*

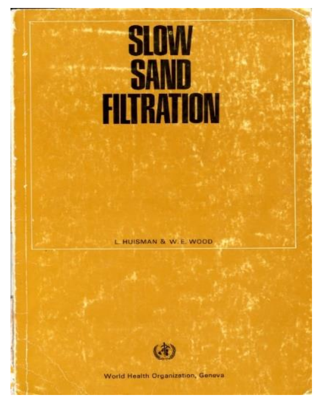



Filter problem : Odor, taste and filter clog problem caused by algae. New chemicals were developed one after another.

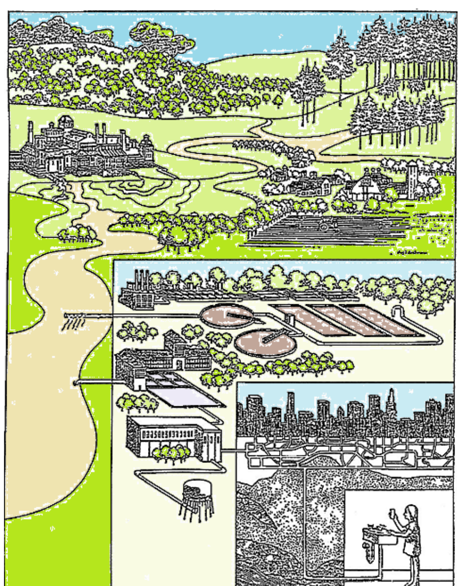

Rachel Carson 1962 Silent Spring.
Pesticides and herbicides have been pointed out the risk of chemical hazards through biological concentrations through the food chain.

That was Chlorine compound.




WHO published a manual of Slow Sand Filtration which is chemical free treatment for safe drinking water in 1974.

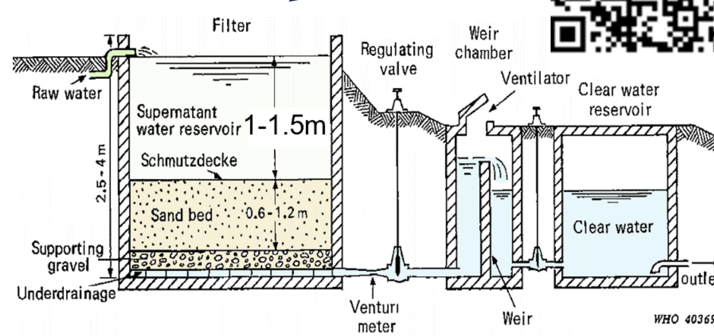


IS THE WATER SAFE TO DRINK?

By Robert H. Harris and Edward M. Brecher and the Editors of Consumer Reports

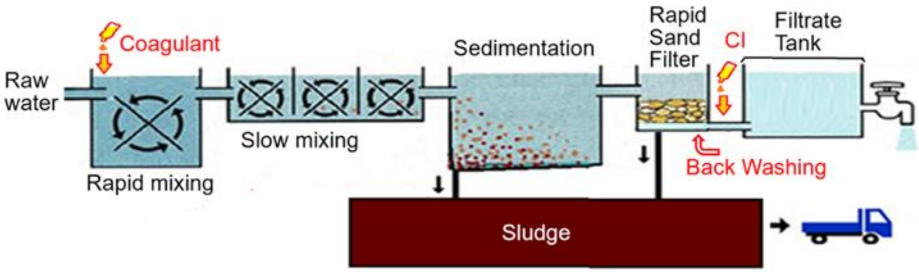
PART 1: THE PROBLEM

Robert H. Harris et. al. 1974 Consumer Report.
Chlorine sterilization is essential for rapid filtration of chemical treatment. There is a warning that trihalomethanes, which are carcinogenic substances, are generated by adding chlorine.




*Water depth is **1-1.5 m**.*
*Simpson filter in 1827 is **38 cm**.*

# *The diarrhea-causing crypt parasites passed through the backwashing process of the rapid sand filtration.*

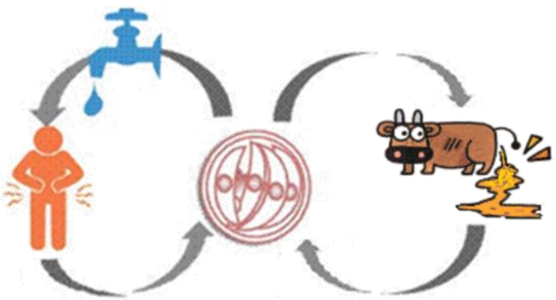


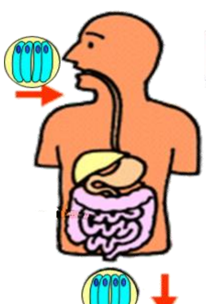

In April 1993, an outbreak of massive diarrhea in 400,000 people due to Crypto-protozoa occurred in Milwaukee, USA. The dormant protozoa had thick shells and passed through the rapid filter ponds and were not killed by the final chlorine.



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

*They said Refocus, Re-discovery, Timeless Technology for Modern Application.*



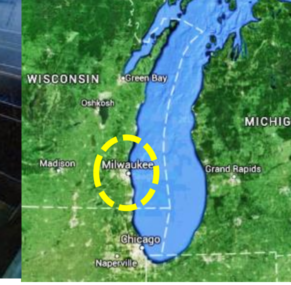


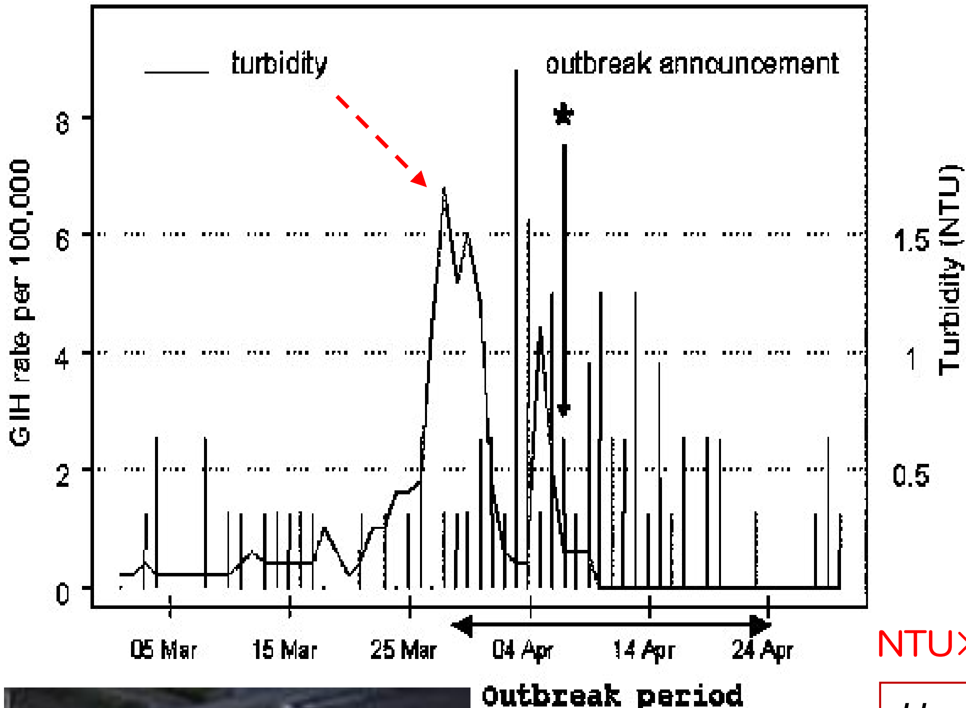
Only mammals with long intestinal tracts had watery diarrhea.

It became clear that RSF was a deadly process.

→ *However, people loves New Technology.*


*Give up American Filter!!*




Japanese Turbidity Unit (Kaolin)

1.05

0.70

0.35

0.00

NTU×0.7≒Kaolin Unit

*A large outbreak of diarrhea was occurred in Milwaukee, USA, in 1993. Over 400,000 people were sickened by cryptosporidium.*

Slow sand filtration system was refocused and a workshop on it was held at Salem city, Oregon state by American Water Works Association in Sept.1994.

*However, people loves New Technology.*

Japan's tap water turbidity standard of 2 degrees (kaolin) was suddenly recommended to 0.1 degrees or less after this outbreak.

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

*Membrane filtration is recommended in Japan.*

**Journal AWWA**
Volume 88, Issue 12 December 1996
Pages 8-8

**Acceptable Microbial Risk**

Charles N. Haas

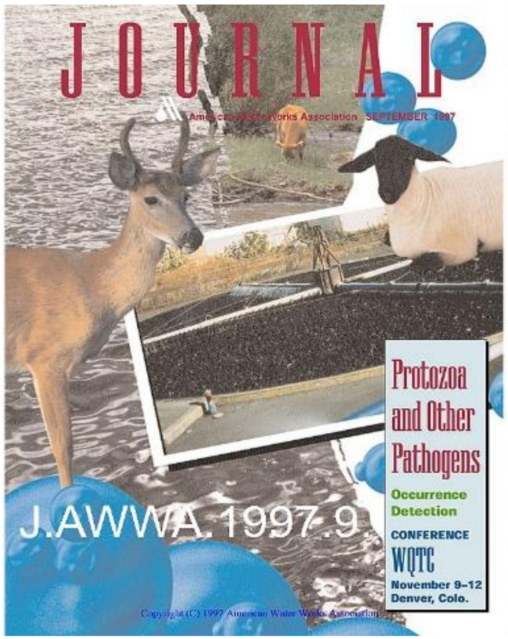

**Journal AWWA**
Volume 89, Issue 12 December 1997
Pages 14-15

**Slow Sand Filtration: Still a Timeless Technology Under the New Regs?**

Stephen A. Tanner

With slow sand filtration, they can trust that it will be absolutely safe even if it is contaminated with crypto-protozoa. SSF plant was constructed in 1997 at Central Bridge, NY, USA.

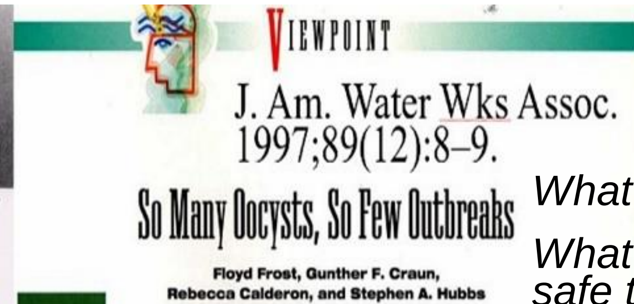
Crypto-protozoa are detected in more than 85% of surface water, but no crypto-protozoa are detected in treated water.





Am. Water Wks Assoc. 23,10,1997

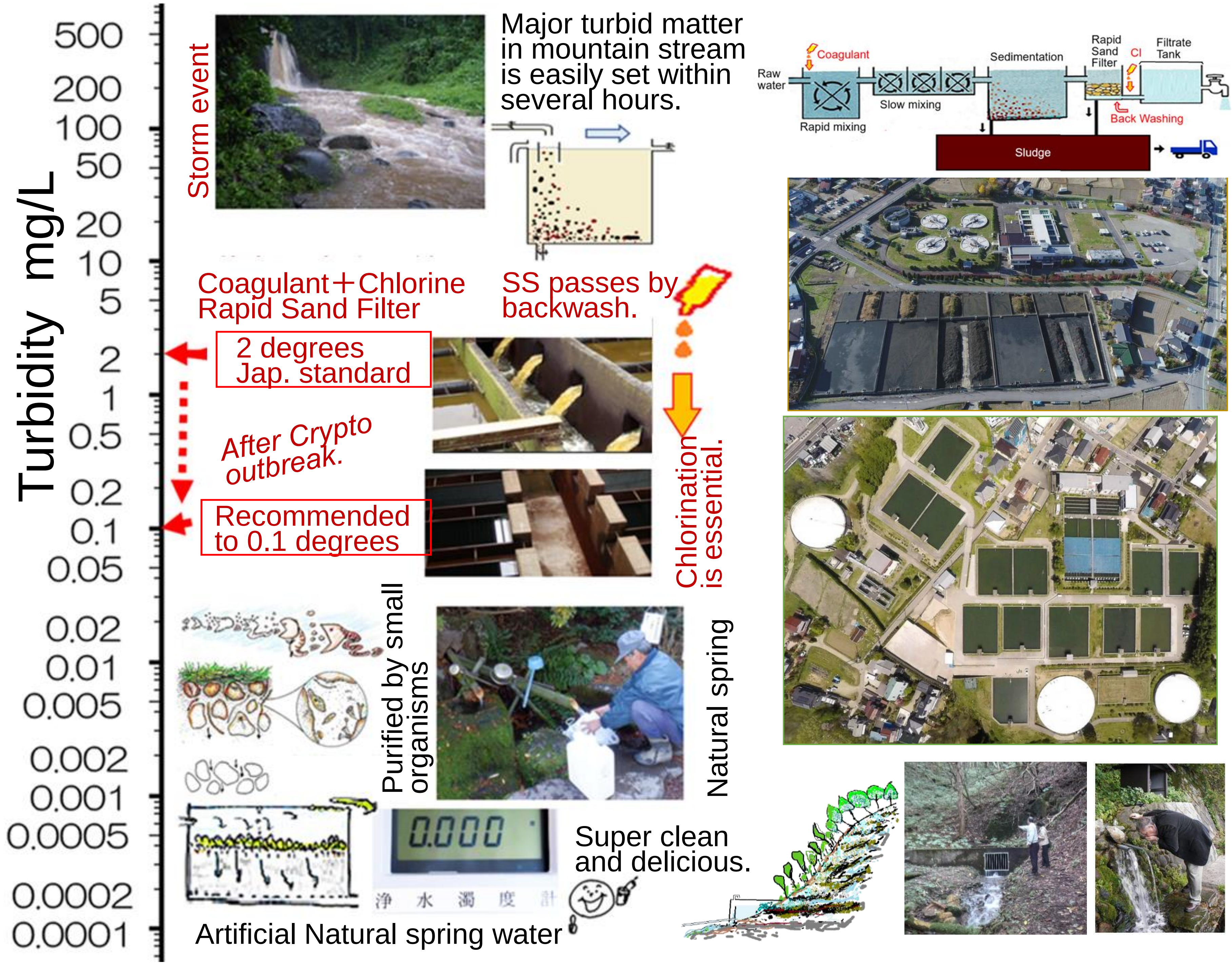
*Cryptosporidium* has never been detected in the finished water of NSWC; however, studies have found *Cryptosporidium* in greater than 85 percent of all surface water supplies. These same studies identified *Cryptosporidium* in more than 25 percent of the treated (filtered) water supplies with effluent turbidities of less than 0.1 ntu.



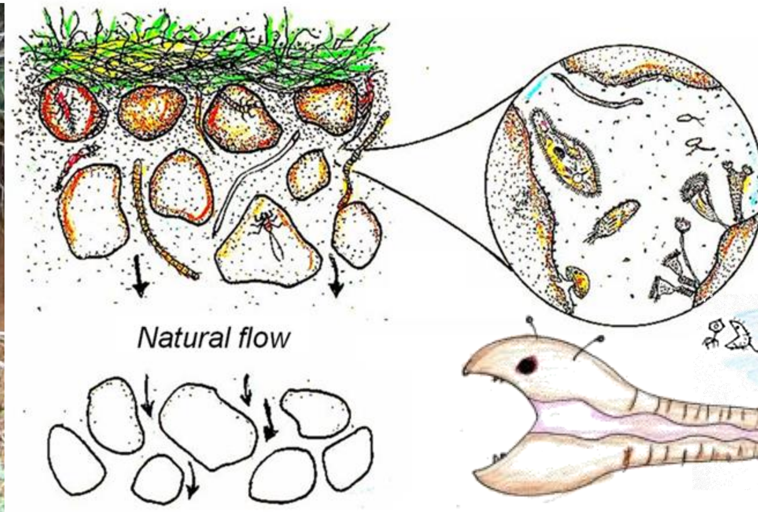

*What is real risk?*

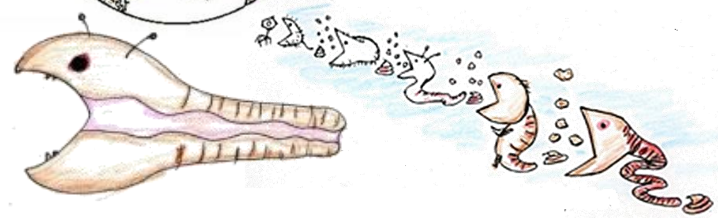
*What is more safe treatment?*

Many oocysts are detected everywhere, but there are almost no diarrheal infections.


Turbidity mg/L
500
200
100
50
20
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
0.0005
0.0002
0.0001
Storm event
Major turbid matter in mountain stream is easily set within several hours.
Raw water
Coagulant
Rapid mixing
Slow mixing
Sedimentation
Rapid Sand Filter
Cl
Filtrate Tank
Back Washing
Sludge
Coagulant＋Chlorine Rapid Sand Filter
SS passes by backwash.
2 degrees Jap. standard
After Crypto outbreak.
Recommended to 0.1 degrees
Chlorination is essential.
Purified by small organisms
Natural spring
0.000
浄 水 濁 度 計
Super clean and delicious.
Artificial Natural spring water

# Purification by small organisms is done near the surface.

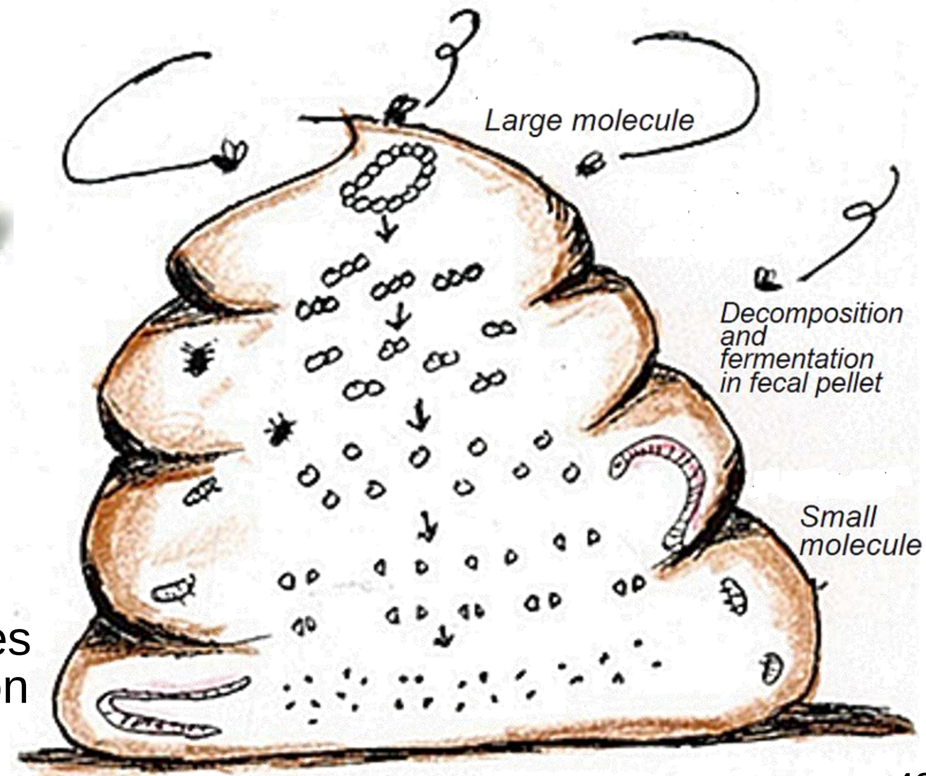


Living organisms has an ability to escape from risks.

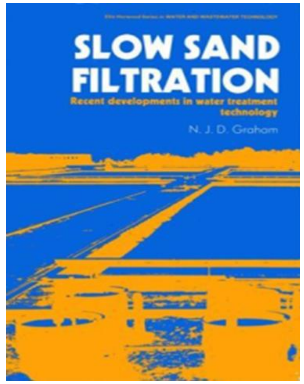
Hard surface to protect for risks.
Dry period, escape from grazer, escape to cold season.

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

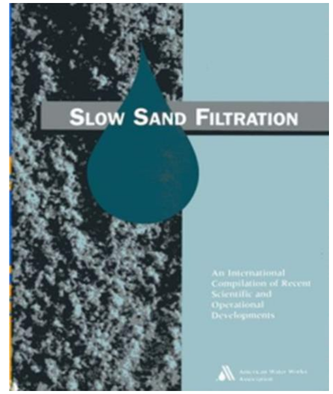


# Focus to Slow Sand Filter in the world.

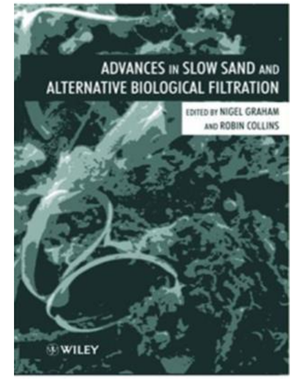

My first visit to Thames Filter was Aug. 1991.



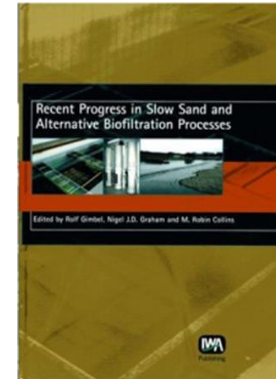

1988, Nov. 1st. SSF Conf. in London, UK




1991,Oct. 2nd. SSF Conf. in New Hampshire, USA



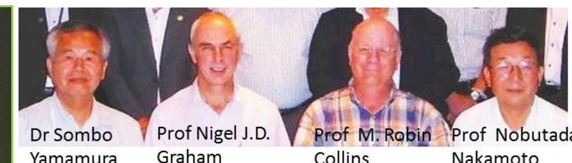

1996 April, 3rd SSF Conf. in London, UK




2006 May, 4th SSF Conf. in Mulheim, Germany

I could study on Thames Filters during 1994 to 1996.


*Eco-Tech Award. World Expo. 2005. Aichi, Japan.*



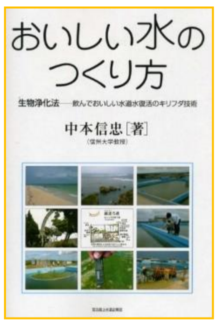


***Natural** filter of slow sand filter*

May, 2002.

Aug. 2005.

For Miyako wks.



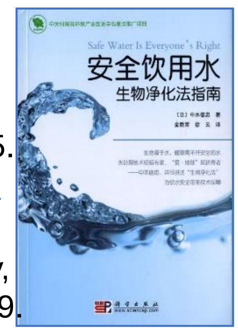


How to make drinking water by **Ecological purification system**

Aug. 2005.

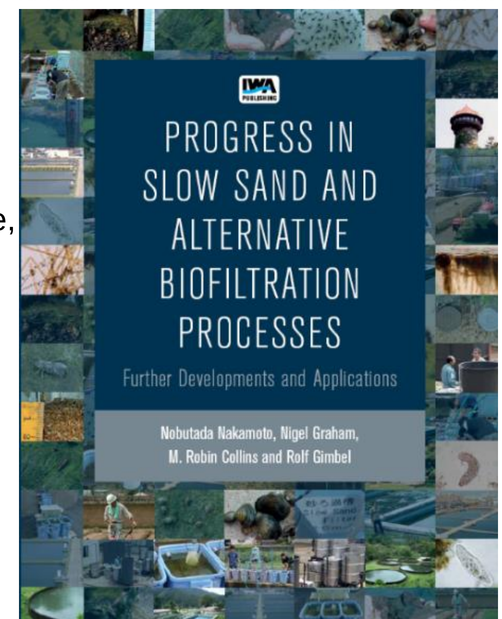
Aug. 2005.

May, 2009.




Chinese, China

2014 June, 5th SSF Conf. in Nagoya, Japan

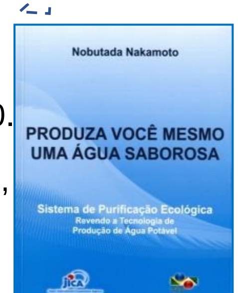



March, 2009.

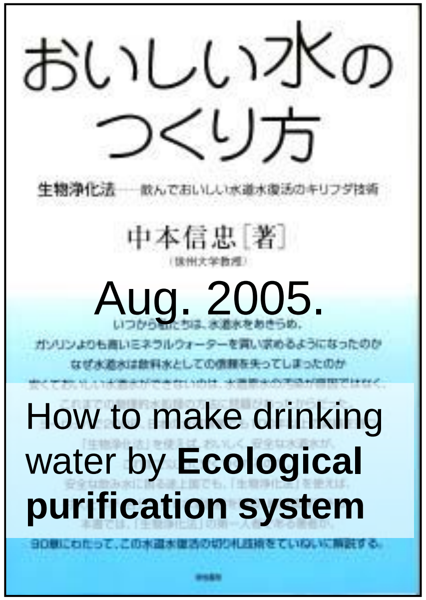

*Internet text by JICA*

July, 2010.

Portuguese, Brazil

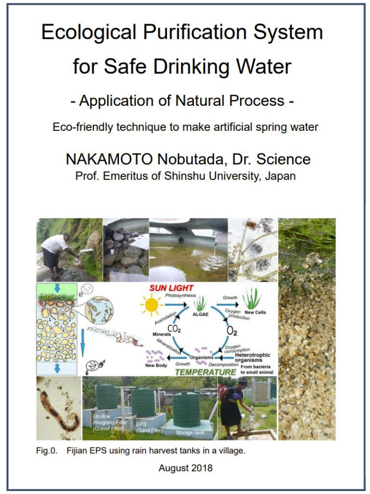



Ecological Purification System was focused and recognized.




Aug. 2005.

How to make drinking water by **Ecological purification system**

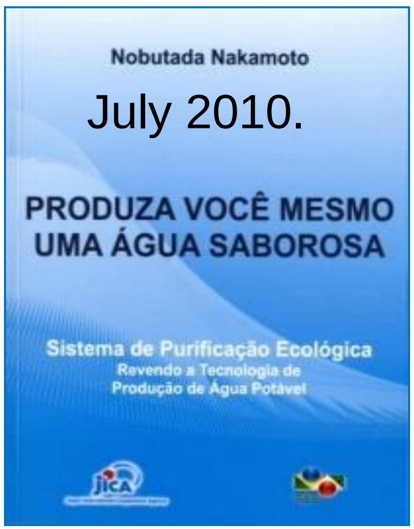



August, 2018

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


How to make drinking water by **Ecological purification system**

Feb. 2021.




July 2010.

http://www.cwsc.or.jp/files/pdf/english/TratamentoEcologicoTextoFinalAbril080428.pdf


March, 2009.

*Internet text by JICA*

Slow sand filtration: creating clean, safe water


2020/04/24

(26 min Full)

https://www.youtube.com/watch?v=V6_uDZE_l8E&t=423s


2021/12/23

(3 min Digest)

https://www.youtube.com/watch?v=QAH1SoAgfL0&t=27s


*Chemical Free*
*Eco-friendly*

# *Ecological Purification System (EPS)*

0. Introduction: Phytoplankton, Reservoir study, Meet Slow Sand Filter, Importance of Ecological point.  JICA training
植物プランクトン、貯水池研究、緩速ろ過、生態学の視点、JICA研修へ

*1-17* 　*17*

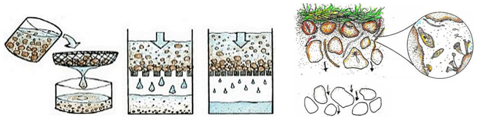
1. Water cycle, Safe water, Acceptable risk.
水循環、安全な水、許容できるリスク

*18-26* 　*9*



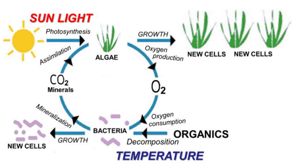
2. Key of purification in nature is food chain.
Refocus to Slow Sand Filter.
浄化は食物連鎖が鍵、緩速ろ過の再認識

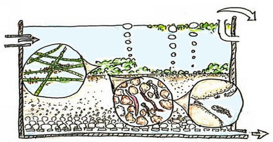
*27-51* 　*25*




3. Algae and animals in Slow Sand Filter.
緩速ろ過池の藻類と動物

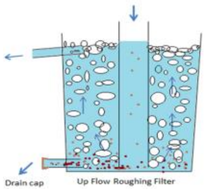
*52-73* 　*22*



4. Up-flow Roughing Filter to reduce SS
濁り対策で上向き粗ろ過、モデルで解説

*74-100* 　*27*



5. From JICA training in Miyako-jima, Okinawa to Samoa
宮古島JICA研修からサモアへ

*101-116* 　*16*



6. Safe water for rural people by EPS in Fiji
フィジーの展開：生物浄化法で地方給水へ

*117-138* 　*22*



7. Aerobic condition is essential for EPS.
生物浄化法は酸素が必須

*139-148* 　*10*



8. Confirm by yourself. Don't believe commercial.
Trust your true sense.　自分で確かめよう。

*149-163* 　*15*



Just after storm event, stone and sand became clear.

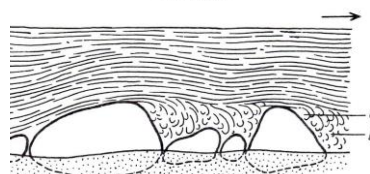
Small organisms on and among rocks were flushed out.

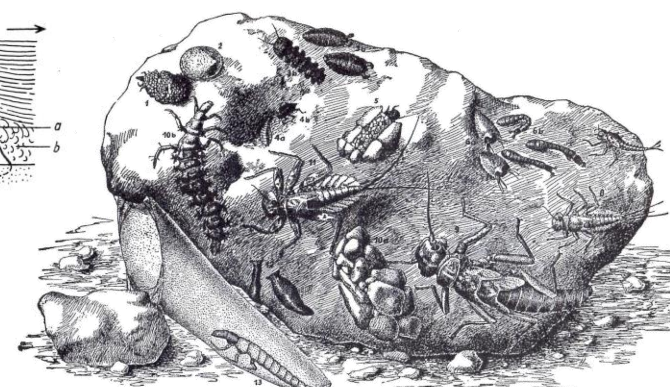
Muddy water due to a heavy rain. Soil is easily flushed out and flow into a river.

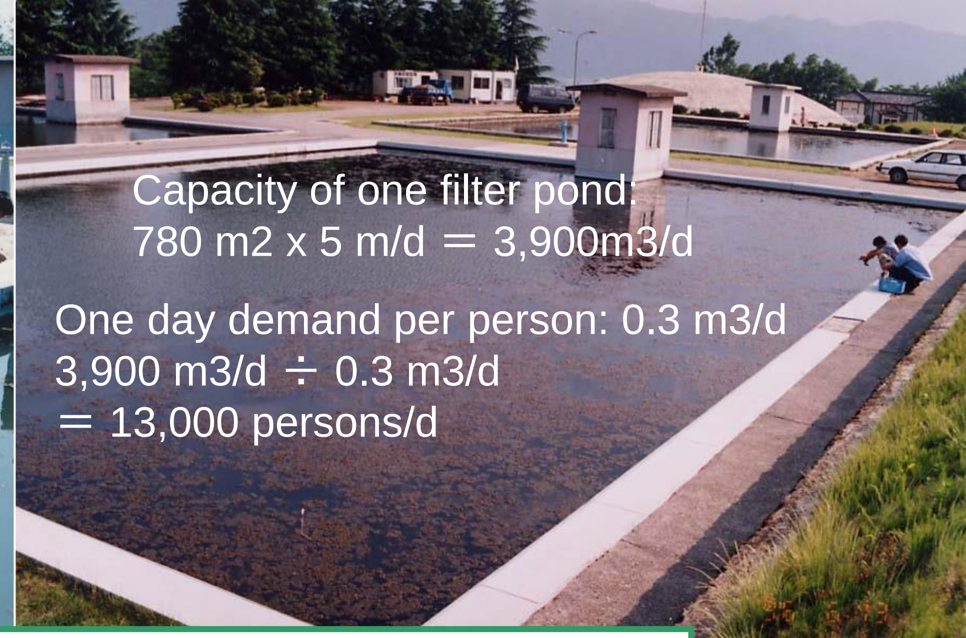
*Sand, stone and rocks **don't role and move** in a small creak among dense forest.*

*Small animals on the surface of rocks collect turbid matters.*

*When plants and animals do not flush out, water is always clear.*








Continuous Culture system of filamentous diatom

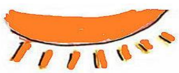
Algal mat lifts by oxygen bubbles produced by photosynthesis.

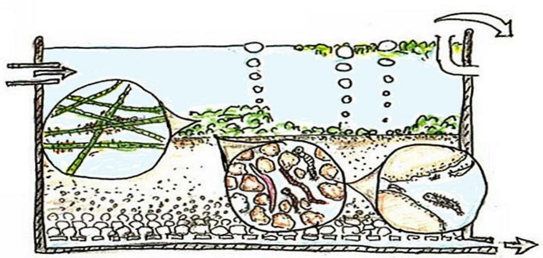
Particles were trapped to the filamentous algae.

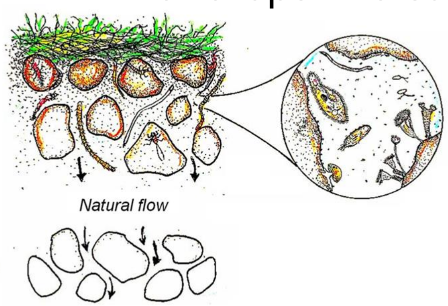
In the text, on the surface of the sand there is a thin slimy (gelatinous) mat known as the *Schmutzdecke*, or filter skin. This explanation is not correct.

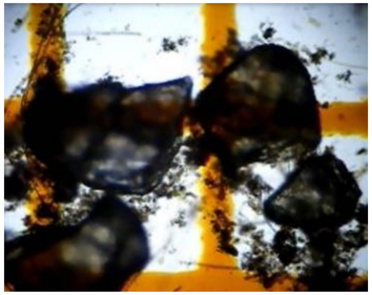
On the surface of sand layer, there is a soft mat like light feather mat. Filamentous algal mat is just lay down.

Sand is clear at the site in water. When we pull up this mat from the bottom to surface and in air, sand turns dirty color. A large amount of trapped SS among filamentous algal mat drops into sand layer.



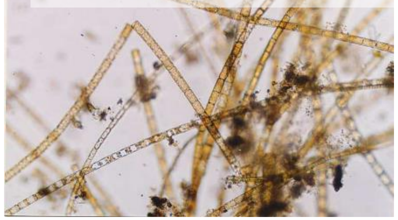


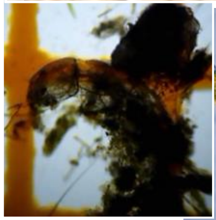


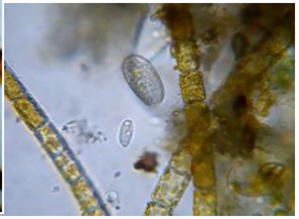



On the shallow bottom, filamentous algae grow well.

Algae are the best food for animal.







Filamentous diatom is a pioneer plant in cold water.

Opflow: American Water Works Association 1993.7.

I made algal mat sampler without any damage of sand filter during the filter run.

Opflow
ISSN 0149-8029 Vol. 19 No. 7 July 1993
A monthly publication of the American Water Works Association

# Schmutzdecke Sampler Reduces Filter Bed Damage

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A schmutzdecke is a sticky algal mat cultivated on the fine sand surface of a slow sand filter. The schmutzdecke is valuable because it acts to remove turbidity without chemical coagulation. The algae prevents the filter from becoming clogged by trapping suspended matter and producing oxygen to promote decomposition activity on the surface sand. When a schmutzdecke is properly maintained, it acts as an "automatic purifier." For a schmutzdecke to form, flow rates must be kept very low.

Operators frequently have difficulty checking the condition of the schmutzdecke while the slow sand filter is being operated. The device described in this article allows samples to be drawn so that the schmutzdecke can be easily analyzed without any damage to the sand surface during operation of the filter.

## Sampler Components

The schmutzdecke sampler shown in Figure 1 was assembled from the parts listed in the box below. Figure 2 (page 4) shows a schematic view of the sampler.

The total costs of all components was estimated to be about $100, primarily for the hand pump and acrylic tube. Several hours were required to construct the sampler.

## Building the Sampler

The schmutzdecke sampler can be constructed by following the steps listed below.

1. To construct the ring weight, drill an inner hole 1.4 in. (35.7 mm) in diameter in the 2.75-in. × 2-in. (70-mm × 50-mm) brass rod. Drill two holes through the ring weight for screws to secure the acrylic tube. Form the 0.3-in. (8-mm) edge on the bottom of the ring weight.

Figure 1 The schmutzdecke sampler

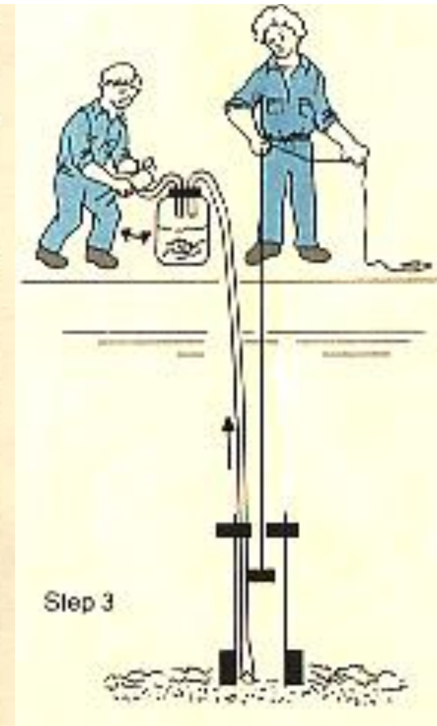
2. Drill a hole in the inner hammer rod for the hanger string.

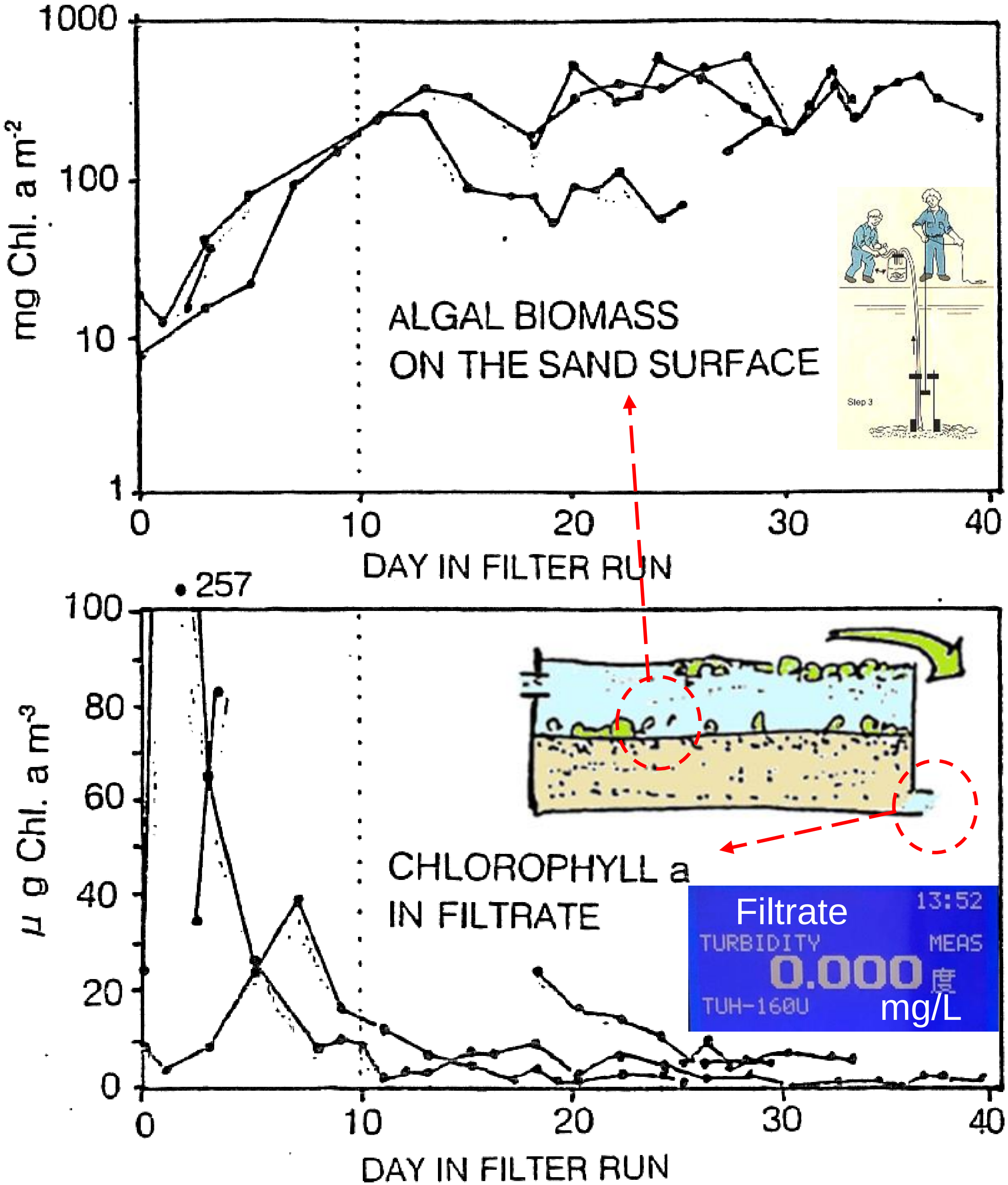
3. In the stopper rod, drill 0.18-in. (4.5-mm) diameter holes in the center for

(continued on page 4)

### Materials and Costs of the Schmutzdecke Sampler

| Item | Purpose | Cost |
|---|---|---|
| one brass rod, 2.75 in. × 2 in. (70 mm × 50 mm) | ring weight | $ 1.50 |




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

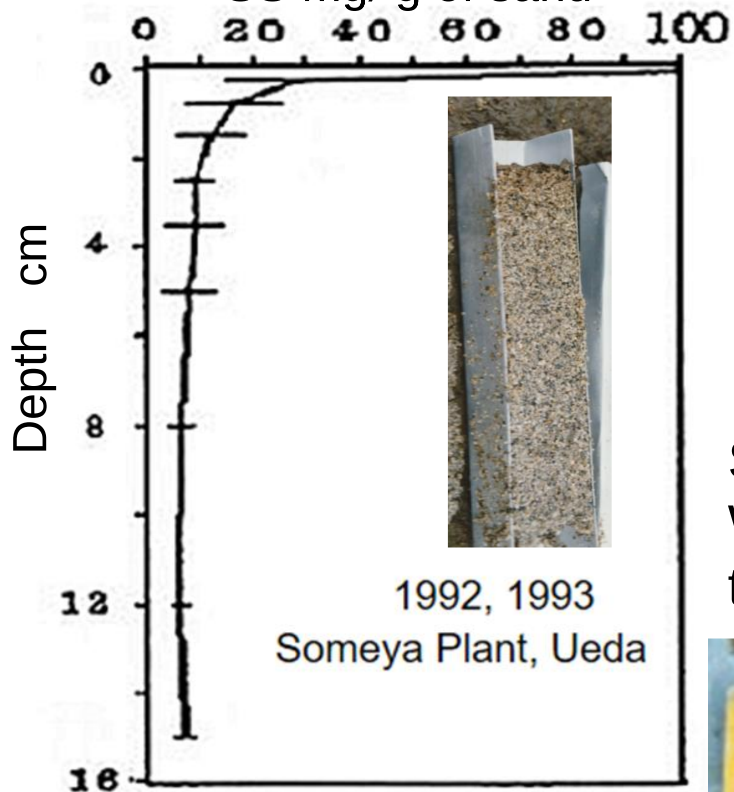
Filtrate water became clear water in 10 days. Grazing animal community grew well within 10 days.

In summer, scrapping of surface mud is not necessary.

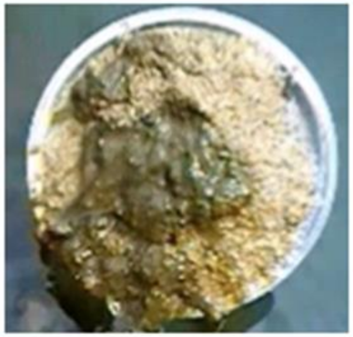
*Japanese standard filtrate is 2 degrees (mg/L).*

*Super clean filtrate.*

Suspended Solid in washed sand.
SS mg/ g of sand



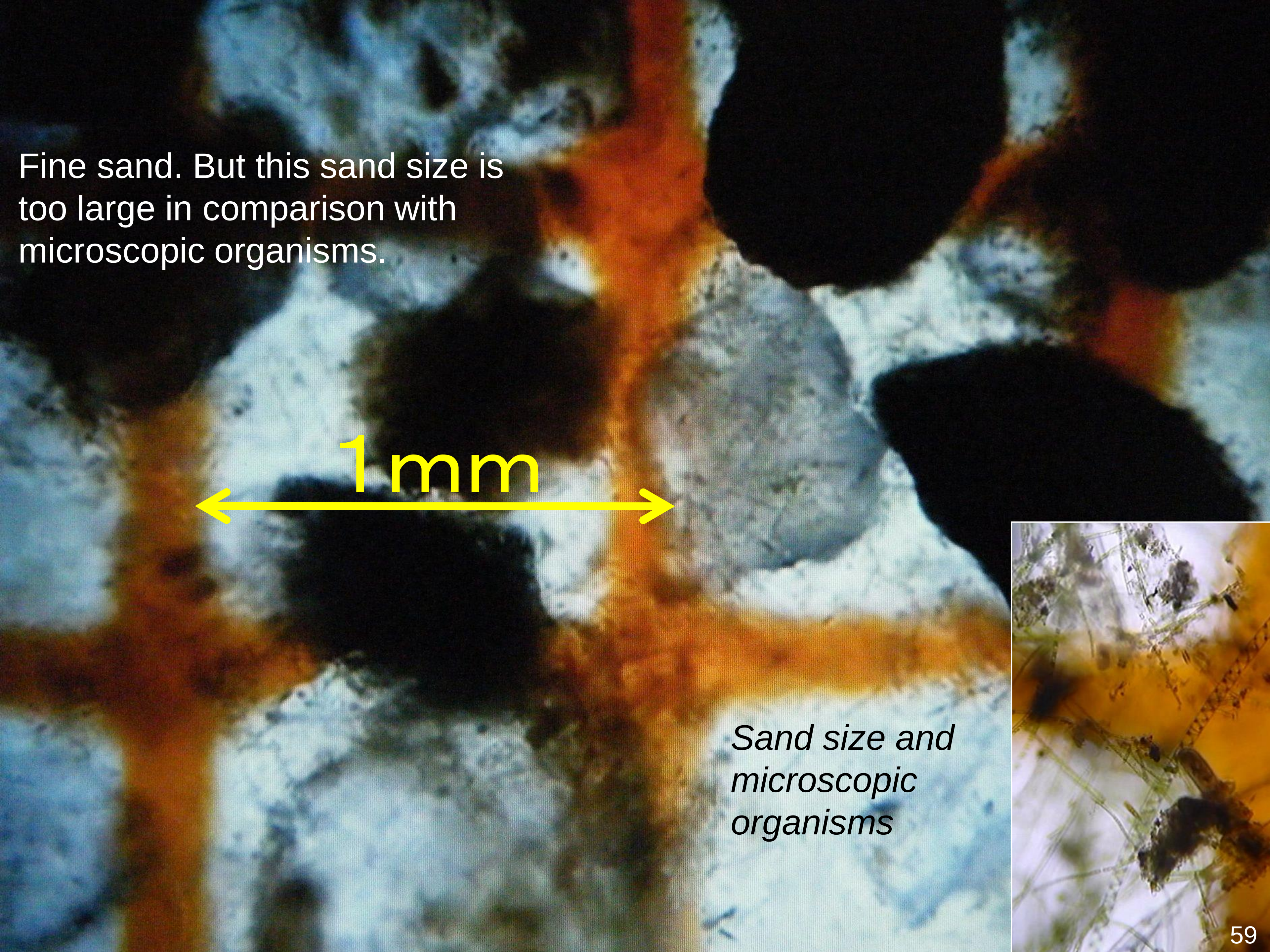

Algal mat on the sand surface in water.



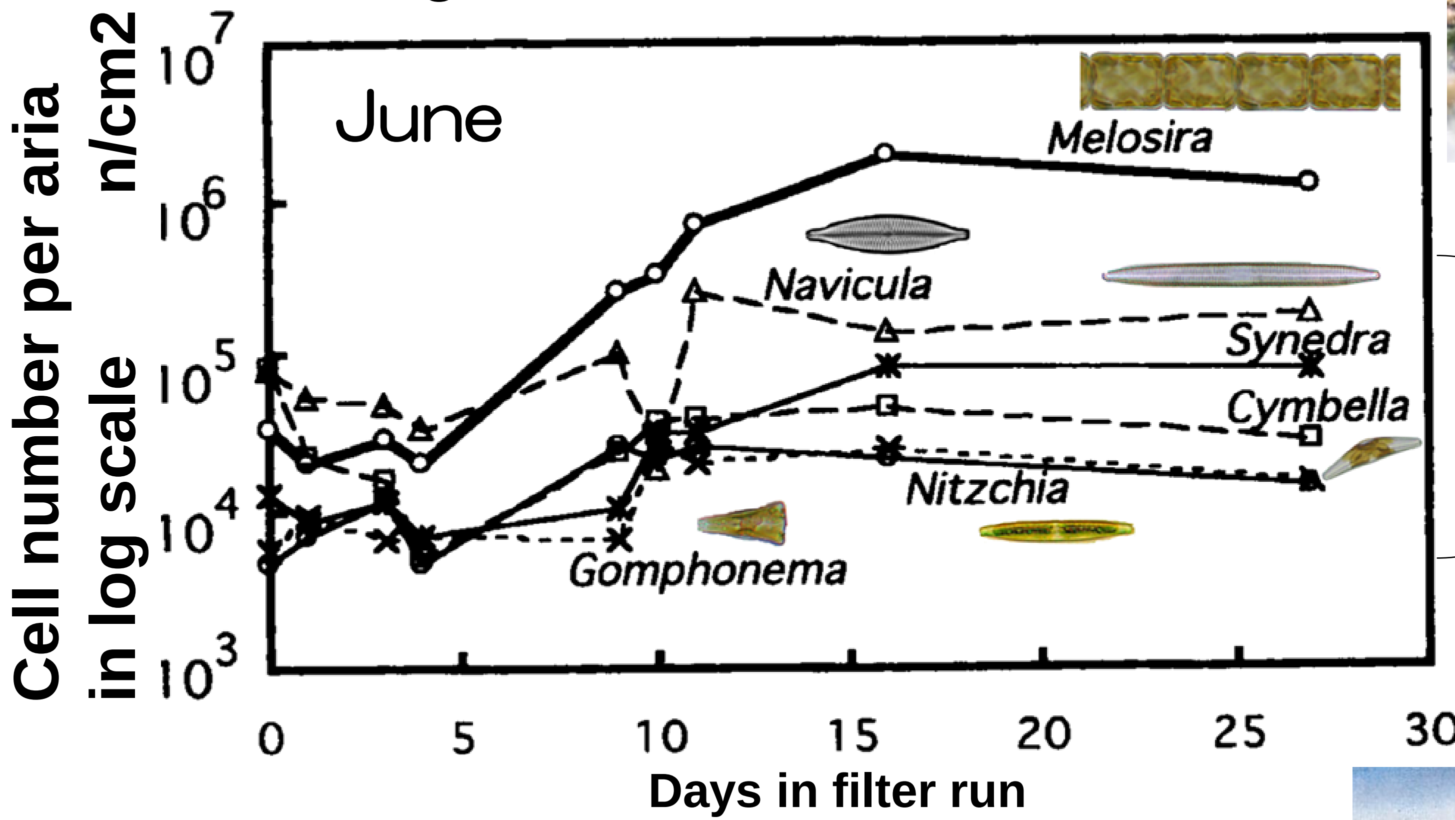
Lift up in air.

Sand beneath the surface in water is clean. When the supernatant water drain off, the trapped SS releases and drops into sand layer.

Scraping time, I took sand sample.


Fine sand. But this sand size is too large in comparison with microscopic organisms.
1mm
Sand size and microscopic organisms

# Development of algae on the sand bed during filter run in June.




Grew in the filter

From a river

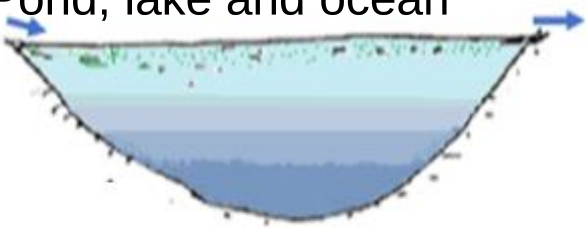
In June, algae first appear on the sand are the same as attached algae (periphyton) on the rock of riverbeds.

As the filtration continued, filamentous diatom of *Melosira* became dominant.

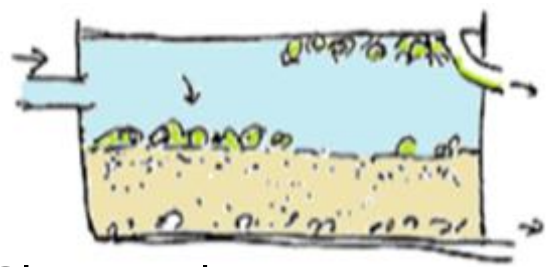
Different type of algae grow in different environment.

In Slow Sand Filter pond, there is down ward current from surface.
Filamentous form of algae can grow on the sand bed.

Pond, lake and ocean

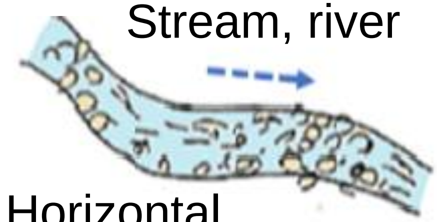


Stagnant water



Slow gentle current

Stream, river



Horizontal running water

Occasional storms and rapid currents.

Float and drift algae

Phytoplankton

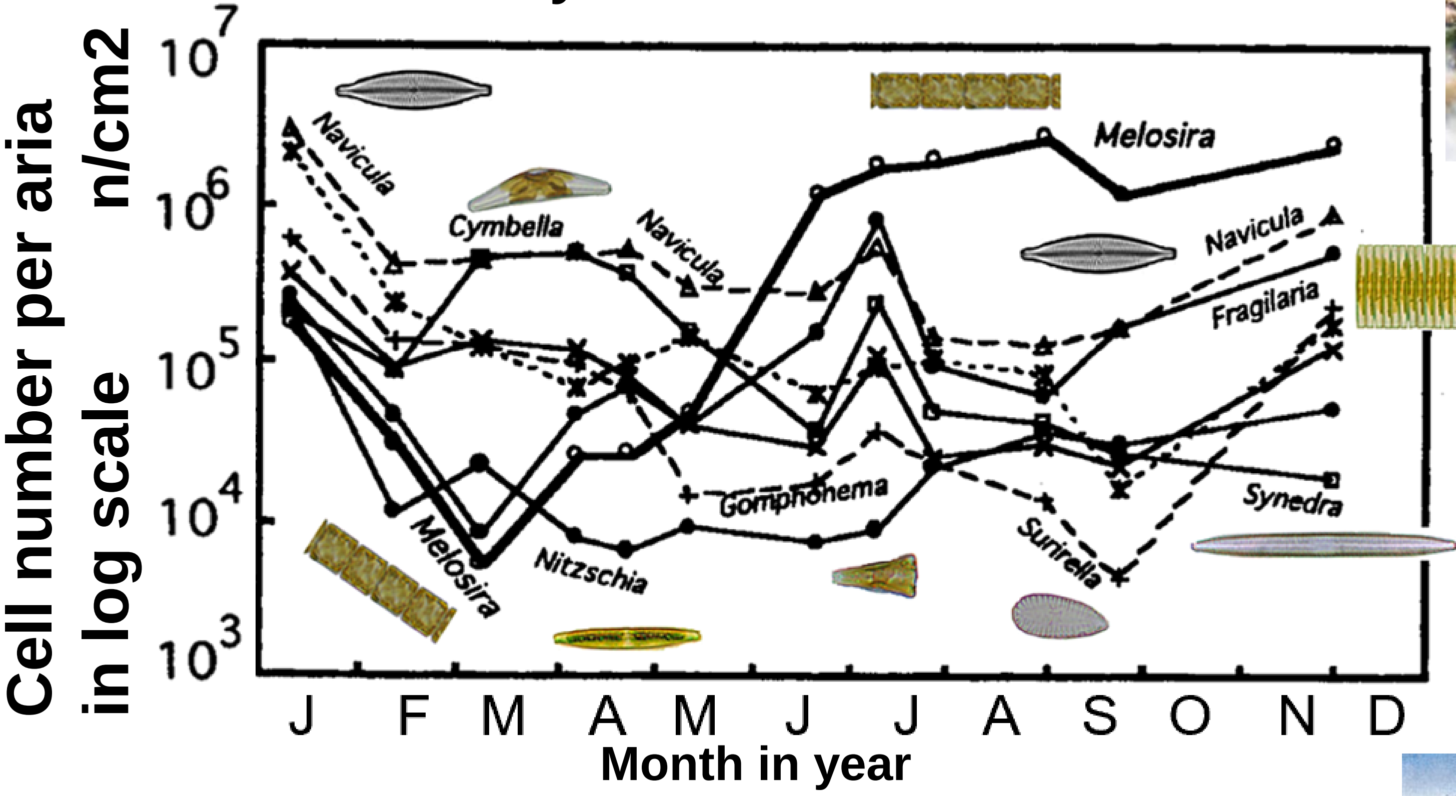
Flagellated algae

Filamentous algae


Periphyton

Attached algae

# Seasonal changes of the algal mat after 10 days of filtration run.




Grew in the filter

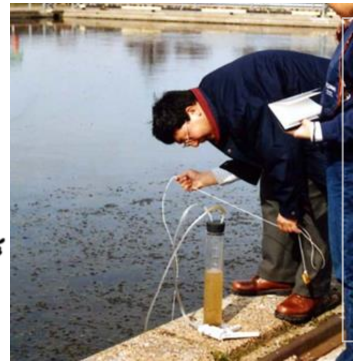
From a river

In winter, it was the same as the attached algae on the riverbed.

When the amount of solar radiation increased and the water temperature increased, the filamentous diatom of *Melosira* became dominant until December.

# *Quest for algal growth in winter.*

Algal growth made delicious tap water.



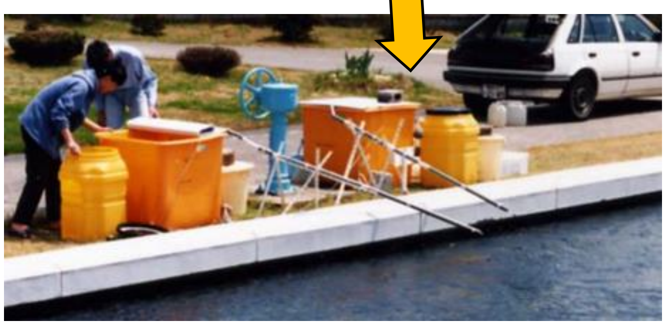
Even in winter, the diatom *Melosira grew* well in London, UK.


I thought that the nutrient concentration in rivers in Ueda city was poor than in London.

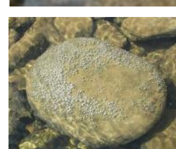
When I put nutrient to the floating bottle in winter, algae grew even in cold condition in Ueda.

I put nutrient to the filter pond in cold winter.

But no growth of algae in the filter pond.



In March when snow melt period, algae did not grow in the filter pond.

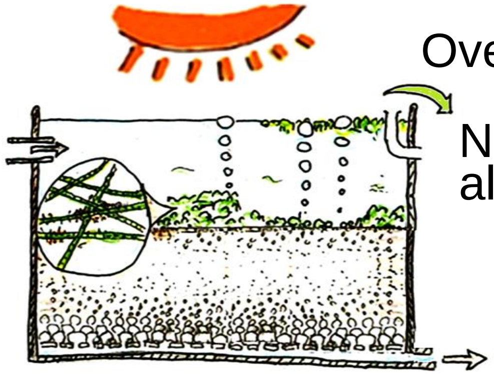


Algae grew well in shallow water in the flood plain.

Algae grew well in a shallow model.

I found depth was the key of growth of algae than nutrient.

# Continuous algal culture system means nutrient reduction system.

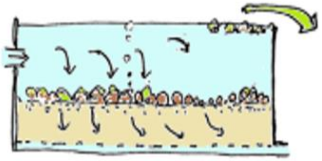



Harvest experiment was done.

Average daily harvest during 11 days in July

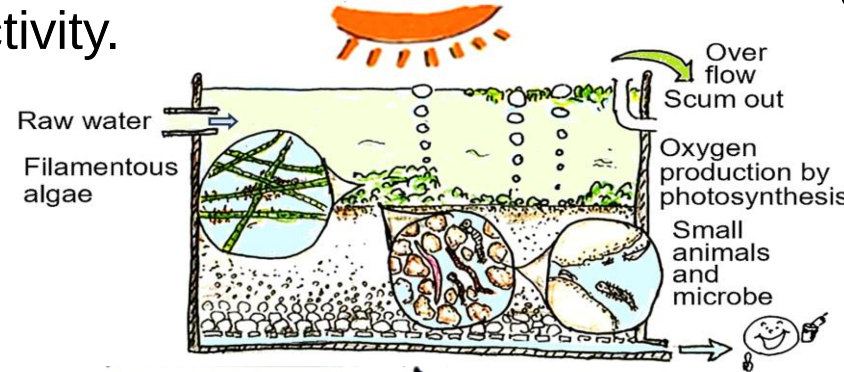
| | |
|---|---|
| Wet matter | 173 g/m2 |
| Dry matter | 25.9 g/m2 |
| Organic matter | 7.81 g/m2 |
| Nitrogen | 373 mg/m2 |
| Phosphorous | 32 mg/m2 |

Nutrient reduction r from inflow water to filtrate by algal growth.



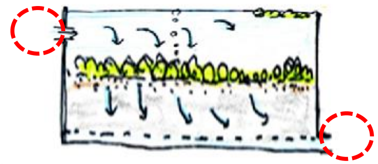
Nutrient removal as
Nitrogen 4.6 %
Phosphorous 27%

Aerobic condition is essential for biological activity.

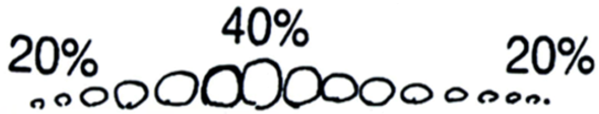



$$CO_2 + H_2O \rightleftarrows CH_2O + O_2$$

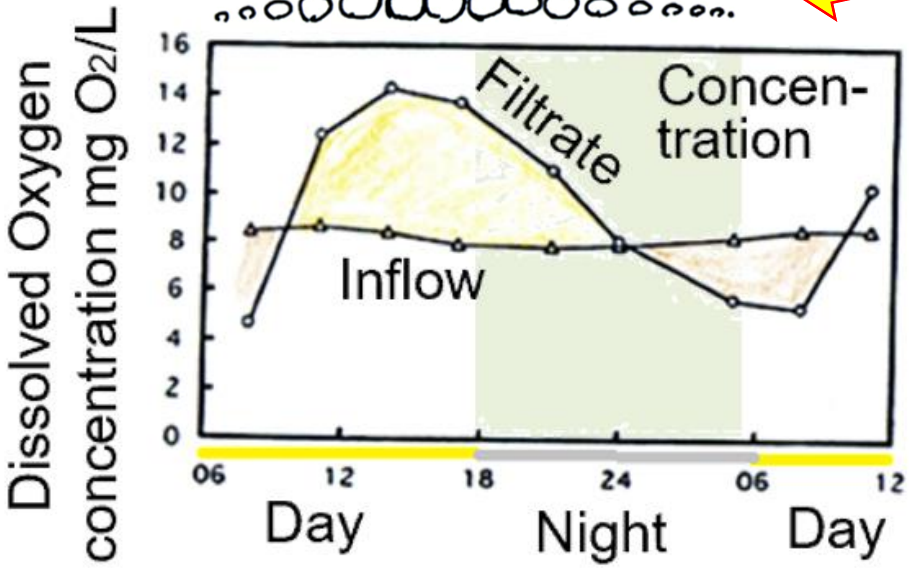
There is down ward current.

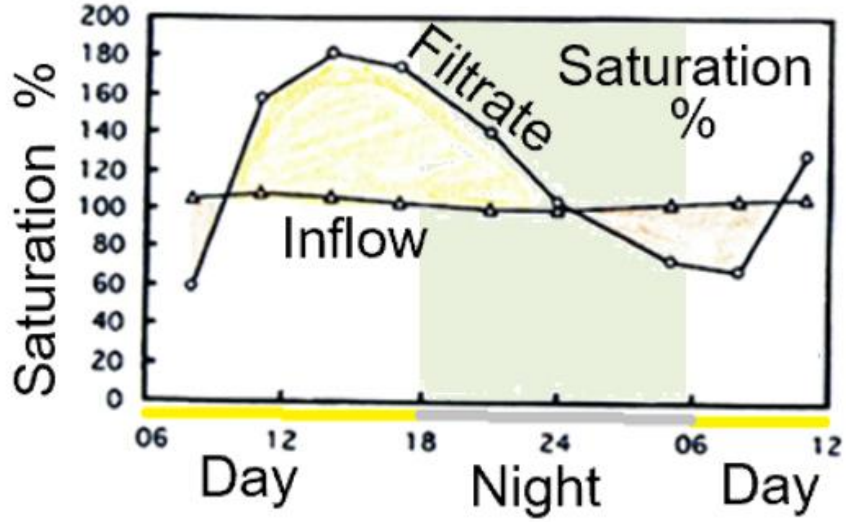



Diurnal change of dissolved oxygen (DO) was measured.




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.

Algal photosynthesis accelerates purification process.

*I investigated the seasonal change of algae in Thames filters in London from 1994 to 1996, more than 30 years ago.*

Ashford Common WTP, Thames Water

Nutrient rich water

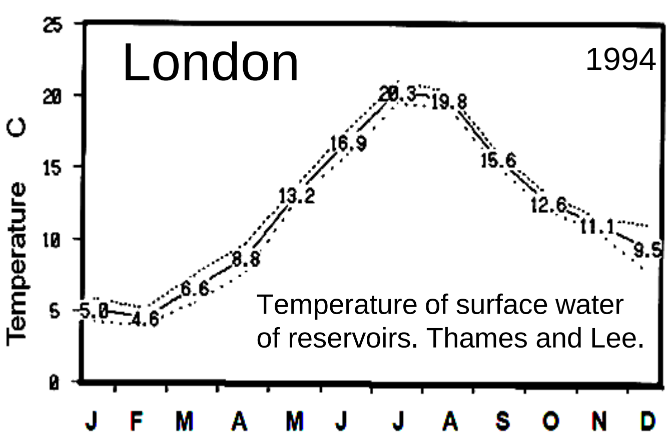


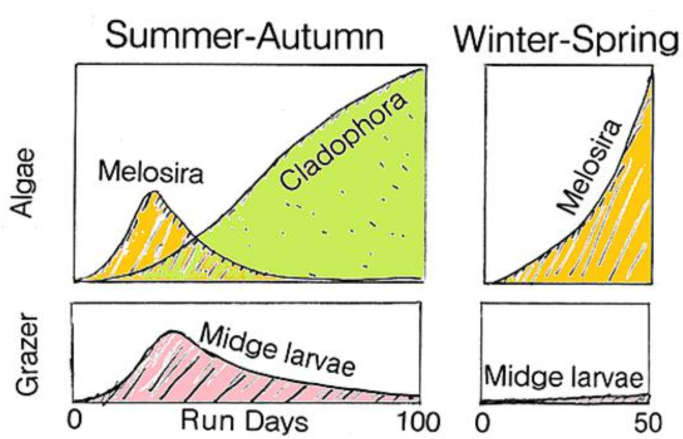
Biological roughing filter without chemical.

100mx35m
32 Filters

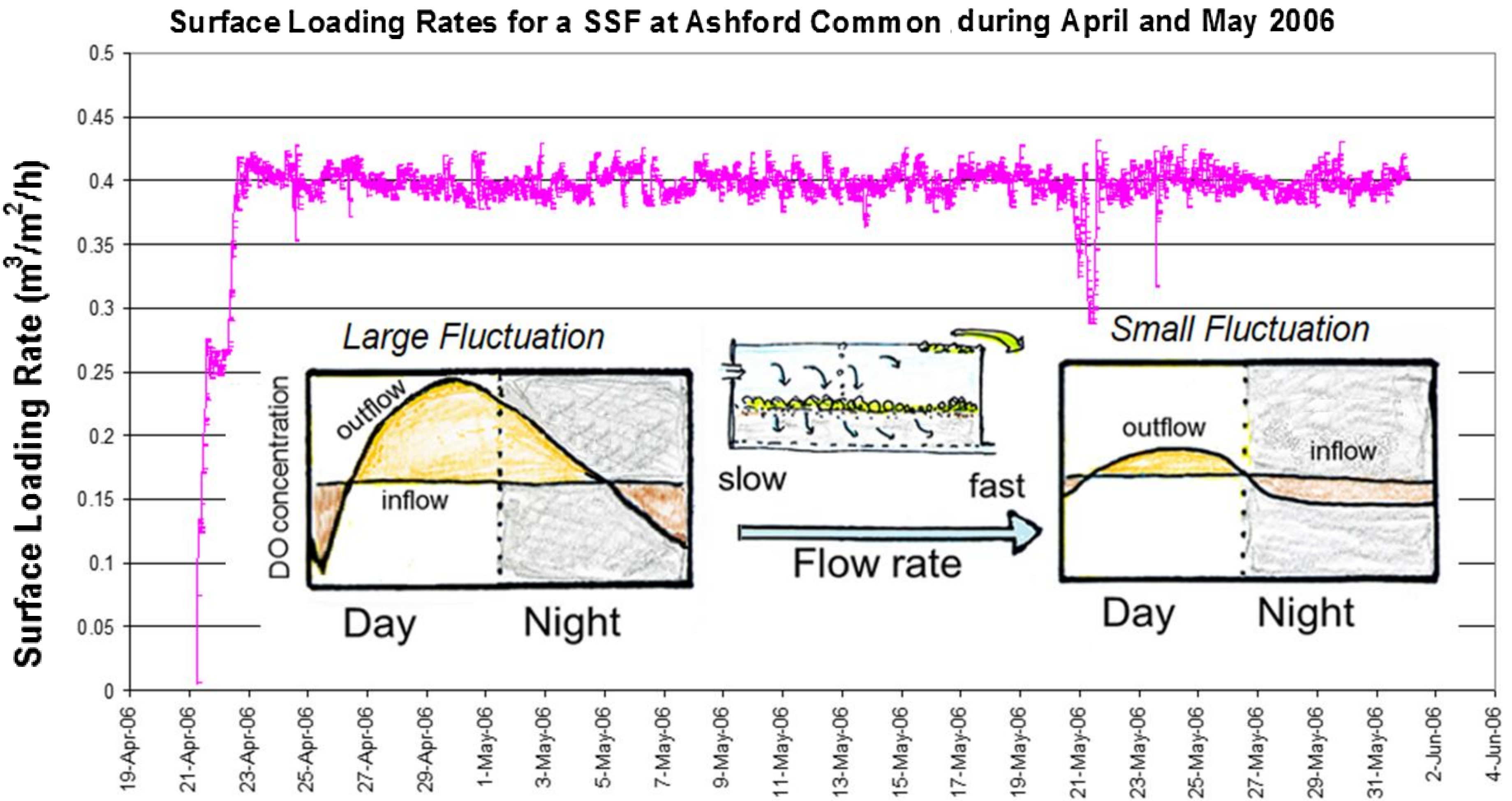

Filamentous green algae bloom in summer


Filamentous diatom in winter

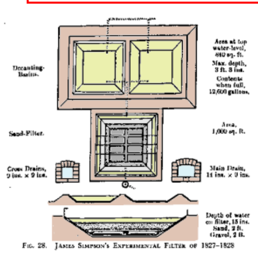



Diatom to Green algae in summer is due to grazing activity.




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



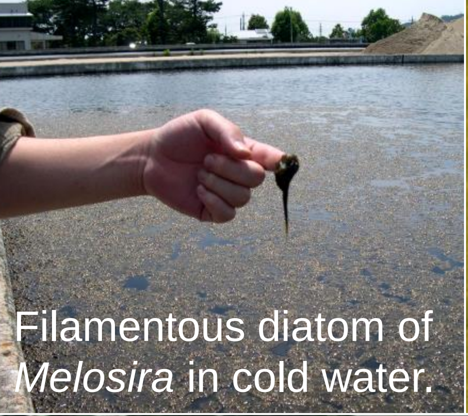
*The filter rate was*
*2-3 m/d (10cm/h).* → *4.8 m/d (20 cm/h)* → The filter rate of 0.4 m/h (9.6 m/d) is adopted in Thames filter plants in London to escape oxygen drop in filtrate during the night time.

*38cm water depth*

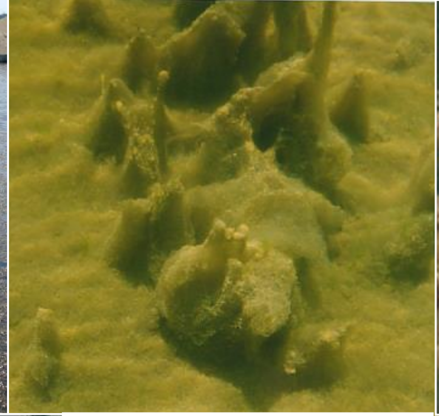
*200yrs ago*

*World wide English Standard Filter rate*

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

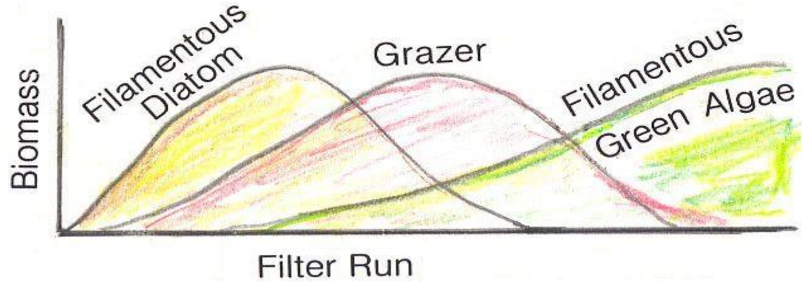


Filamentous diatom of *Melosira* in cold water.

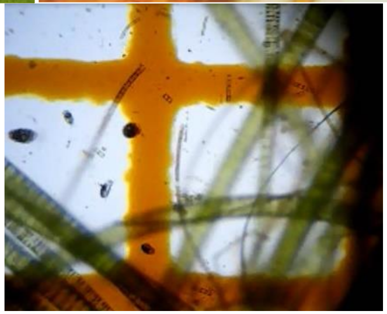


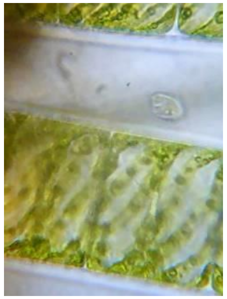
Casting skin of midge(*Chironomid*) and adult midge are remarkable in warm water.

Filamentous diatom was grazed up and filamentous green algae are remarkable in warm water or in case of long filter run.

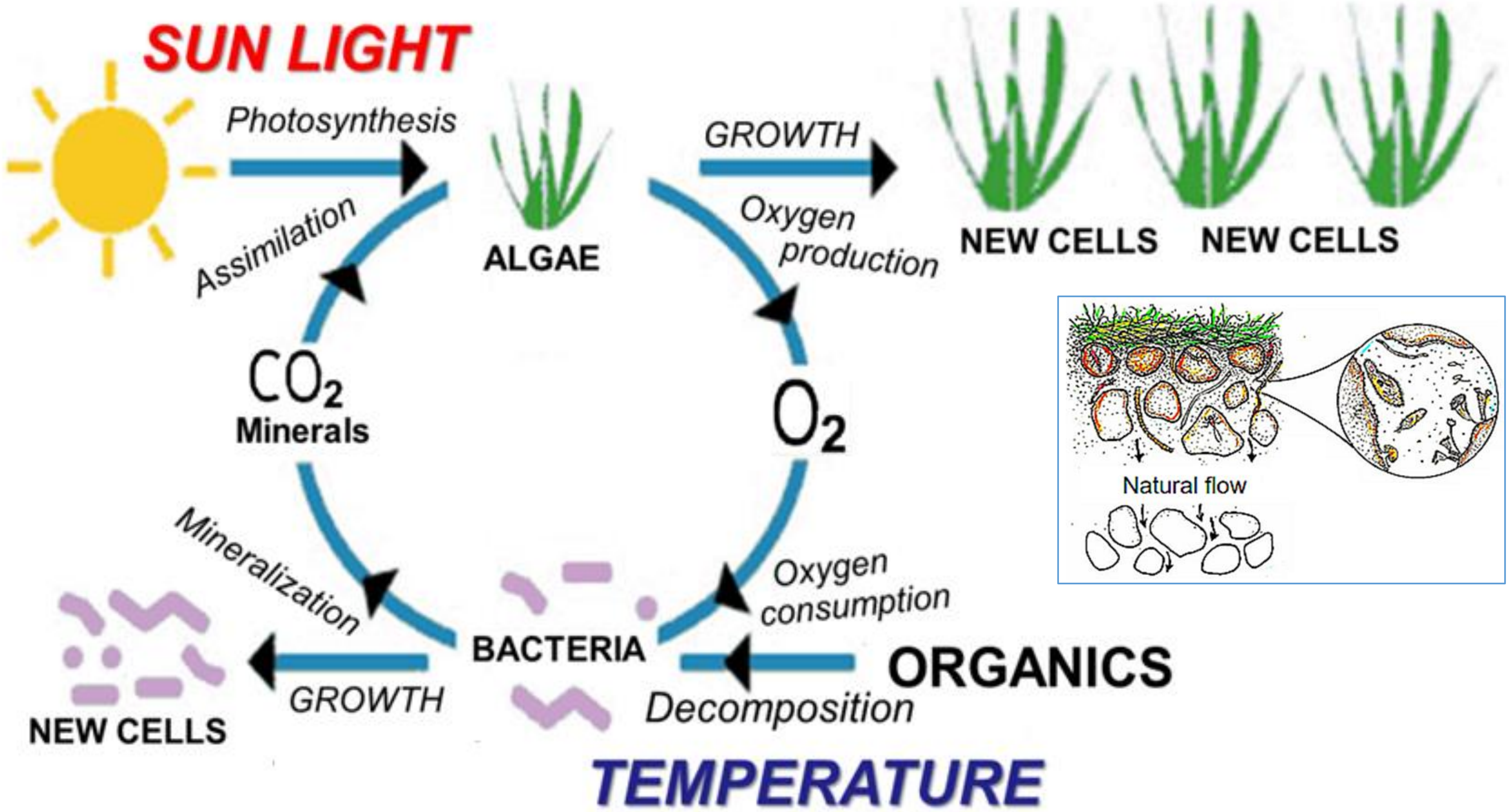



At the beginning, filamentous diatom dominates. However, filamentous green algae becomes dominant during the long filter run.



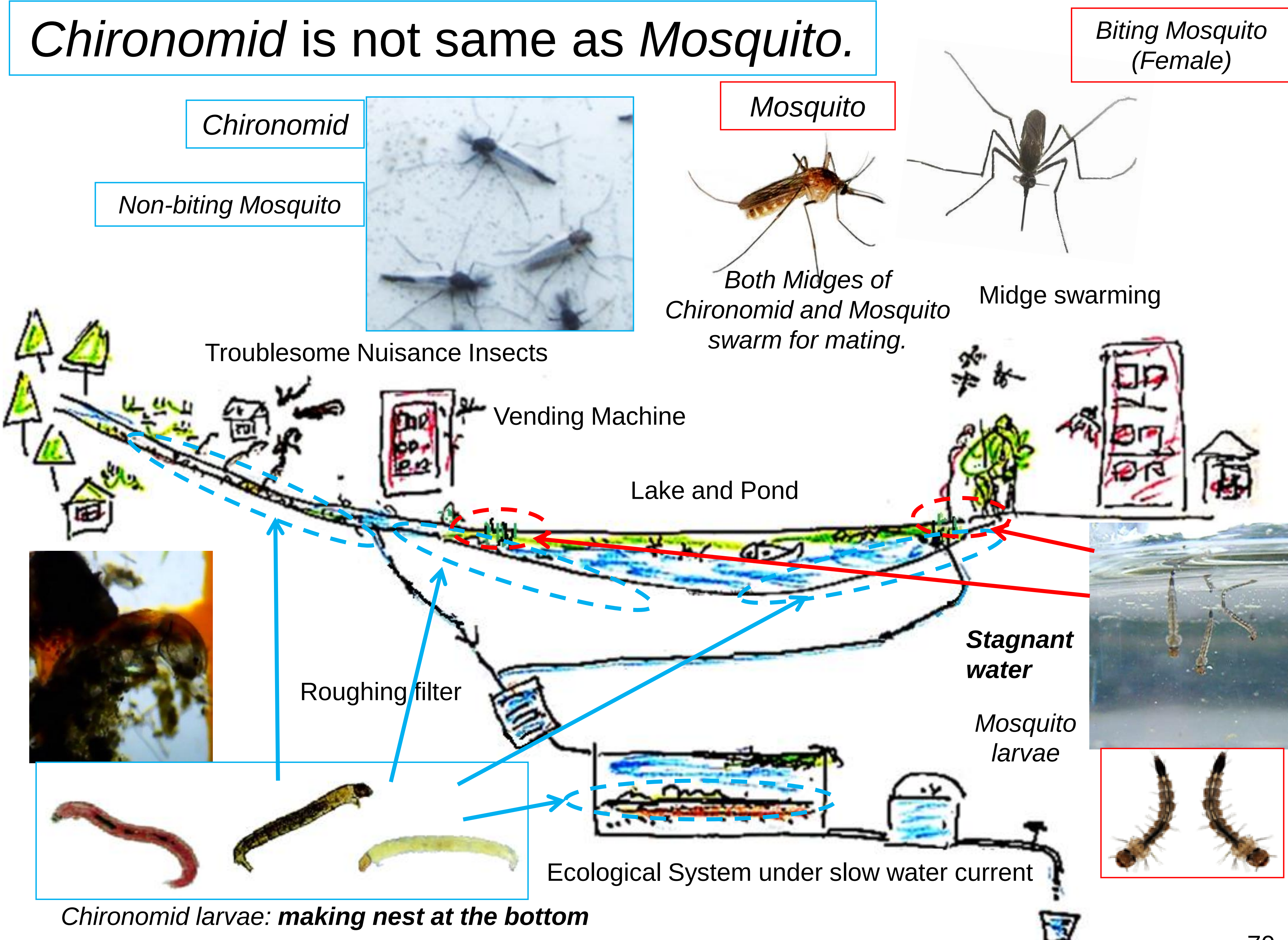


After diatom is grazed by small animals, filamentous green algae (*Cladophora, Spirogyra, Hydrodictyon, etc.*) are remarkable algae. These green algae have hard cell wall and larger size. After that , Mollusk appears.

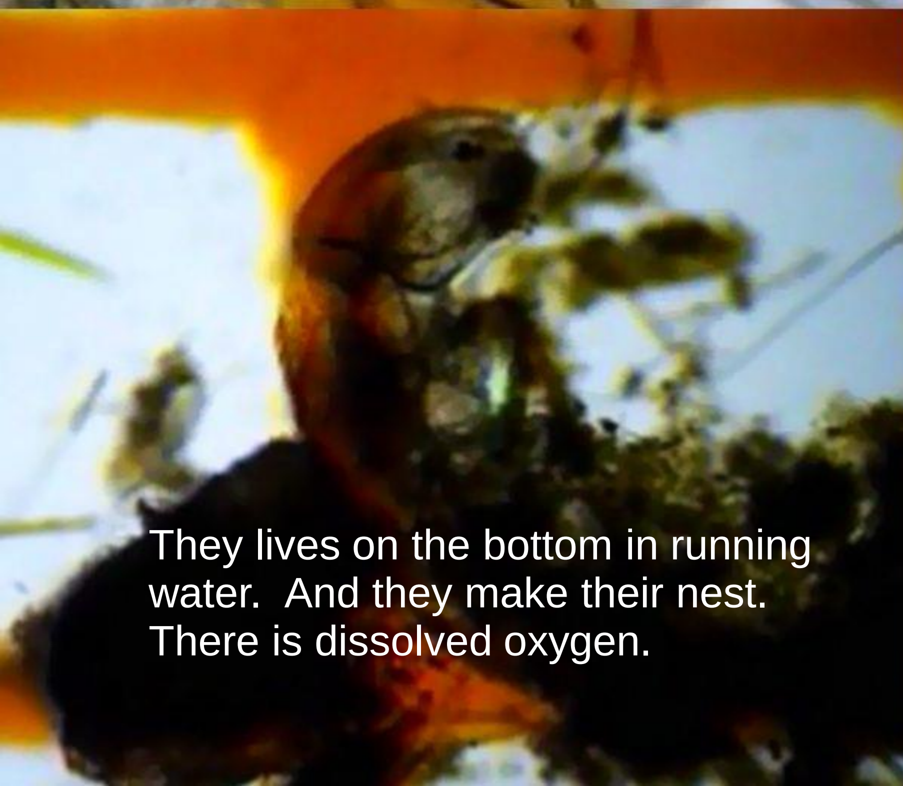



Algal photosynthesis relates to solar radiation and the activities of bacteria and animal relate to temperature.

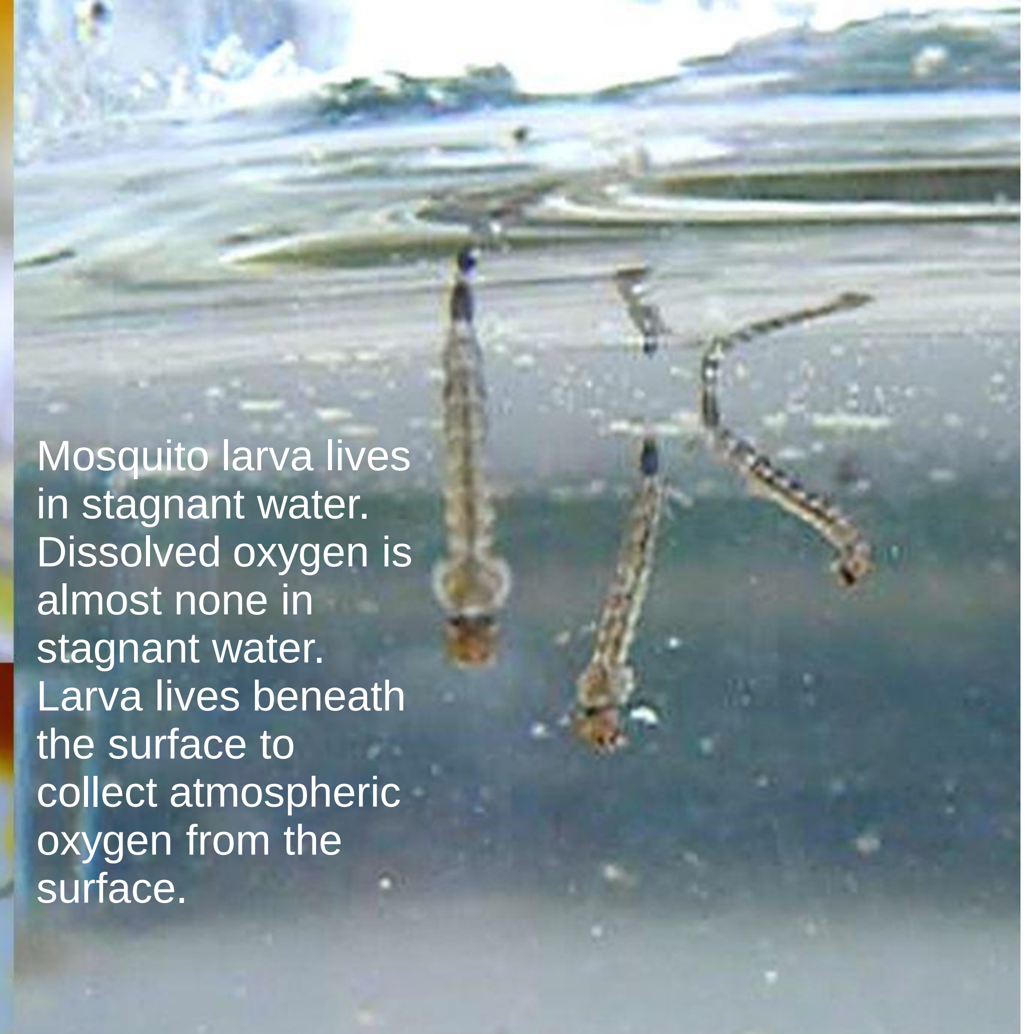
# *Chironomid* is not same as *Mosquito.*



Chironomid (midge) is called non-bite Mosquito.



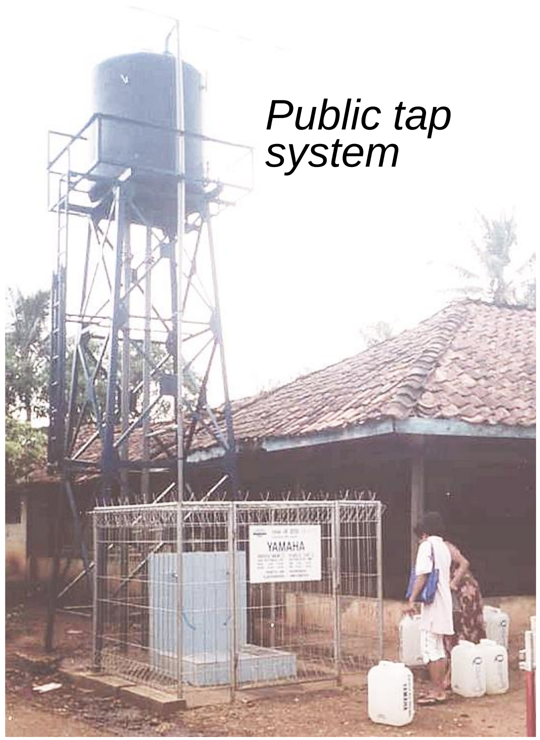
They lives on the bottom in running water. And they make their nest. There is dissolved oxygen.



Mosquito larva lives in stagnant water. Dissolved oxygen is almost none in stagnant water. Larva lives beneath the surface to collect atmospheric oxygen from the surface.

Chironomid : non-bite Mosquito

Mosquito


Villager maintains over 10 years by themselves.


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

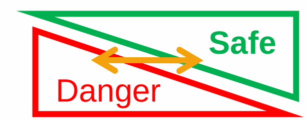
Two bottles of 20liters per 1 family. This water is used for drinking and cooking only. This water is not used for bath and washing hands. Diarrhea and eye sickness are disappeared.

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

→This acts to protect against sickness.

*Application of the mechanism how to turn clean water in a paddy field.*

*Acceptable Risk*

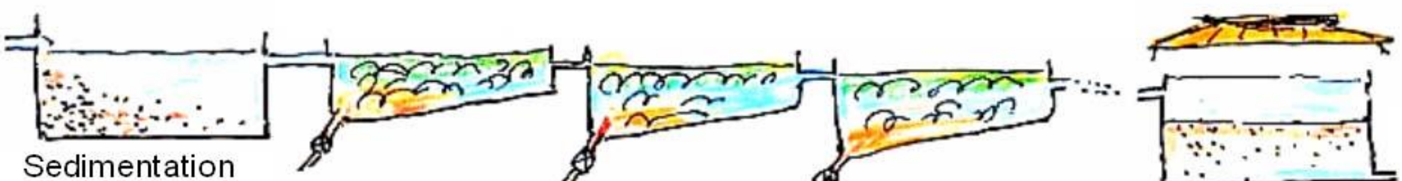



New biological pre-treatment for SSF

Active growth of algae : holding stick (code) for filamentous algae

$O_2$ ↑ →bubbles →keep aerobic condition

pH ↑ → precipitate oxide and hydroxide complexes.



Sedimentation sink

Periodical small drain to eliminate precipitate material and unhealthy organisms.

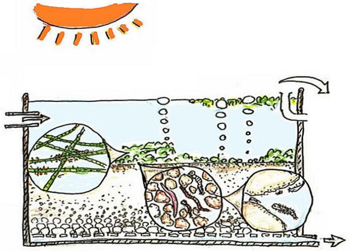
Metal-OH ↓ Oxide complexes can react with anions and precipitate.

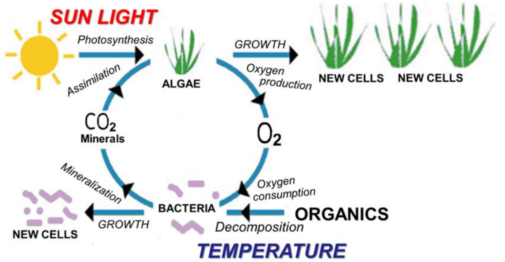
Animals grazed particulate matter (living and non-living).

Slow sand filter

Safe drinking water

Slow velocity of water for microbe to eliminate bacteria.




Wise application of natural purification system in a paddy field. Turbidity reduction by small animals.

1. Safe drinking water system which can maintain by local villagers as a **Social Contribution** of Yamaha Motor Company.

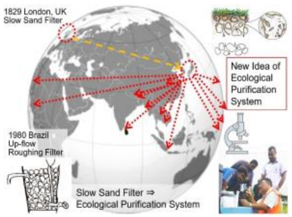

2. Pilot test plant with several public taps was donated from Yamaha Company to Kagawong village near Jakarta, Indonesia.

3. Villagers discussed how to maintenance this plant by villagers.

4. Villagers decided to collect money from the users in order to stock for maintenance cost.

5. Water committee started a delivery service to other villages.

6. Water committee maintains more than 15 years without any trouble.




Chemical Free
Eco-friendly

# Ecological Purification System (EPS)

0. Introduction: Phytoplankton, Reservoir study, Meet Slow Sand Filter,
   Importance of Ecological point.  JICA training
   植物プランクトン、貯水池研究、緩速ろ過、生態学の視点、JICA研修へ

1-17 | 17

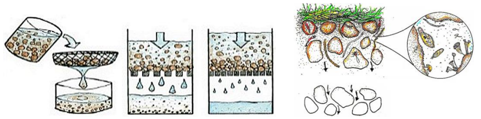
1. Water cycle, Safe water, Acceptable risk.
   水循環、安全な水、許容できるリスク

18-26 | 9



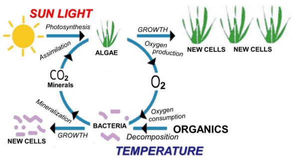
2. Key of purification in nature is food chain.
   Refocus to Slow Sand Filter.
   浄化は食物連鎖が鍵、緩速ろ過の再認識

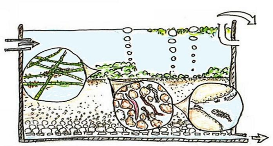
27-51 | 25




3. Algae and animals in Slow Sand Filter.
   緩速ろ過池の藻類と動物

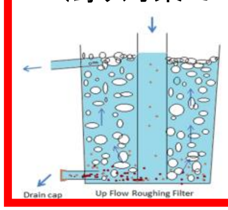
52-73 | 22



4. Up-flow Roughing Filter to reduce SS
   濁り対策で上向き粗ろ過、モデルで解説

74-100 | 27



5. From JICA training in Miyako-jima, Okinawa to Samoa
   宮古島JICA研修からサモアへ

101-116 | 16



6. Safe water for rural people by EPS in Fiji
   フィジーの展開：生物浄化法で地方給水へ

117-138 | 22



7. Aerobic condition is essential for EPS.
   生物浄化法は酸素が必須

139-148 | 10



8. Confirm by yourself. Don't believe commercial.
   Trust your true sense.  自分で確かめよう。

149-163 | 15