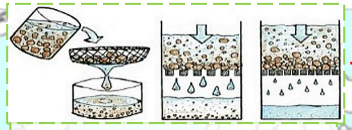
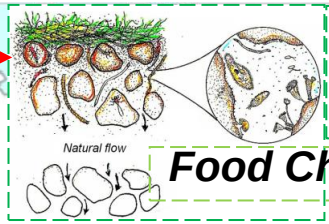
Ecological Purification System (EPS)

Slow Sand Filtration (SSF) to make Safe Drinking Water was developed in London, UK.

Purification mechanism of **SSF** was **misunderstood by the name**.
I proposed **new name** of **EPS** instead of **SSF** in 2004 (20 years ago).



Slow Sand Filtration



Ecological Purification System

Food Chain is Key.

July. 9 (Tue), am 10-12, pm 13-16. 2024
Hiroshima City Waterworks Bureau:
JICA-Hiroshima training on: Operation and Maintenance of **Urban Water Supply** System (Water Distribution and Service) from July 2. to Aug. 7., 2024 都市上水道維持管理（給・配水）

Ukraine
Nepal
Laos
Gambia
Ethiopia

EPS in Nagano, Japan

*People loves **Latest New Technology** for **Urban Environment**.*

St. Vincent and Grenadines

EPS for Fiji village

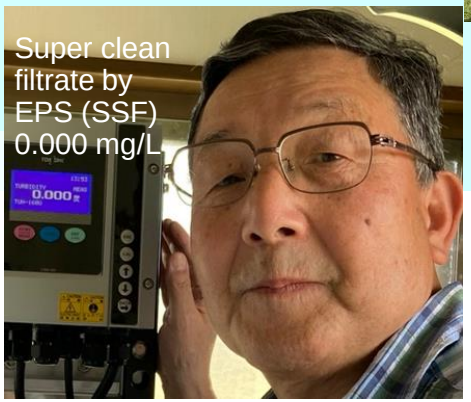
tap

Gravel Sand Storage

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

*In **Rural***

EPS is to make artificial spring water.



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の考えは世界中に広まりだした。

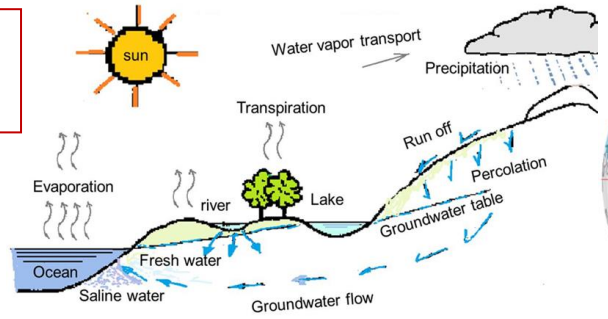
NAKAMOTO Nobutada,
Professor Emeritus of Shinshu University,
Dr. Science cwscnkmt@yahoo.co.jp
中本信忠　信州大名誉教授、理博

Climate and Water Cycle (rain fall, temperature)

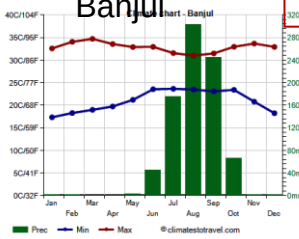
Long Dry Period

How to get water. Underground water ?

Participants from different countries joins in Hiroshima, Japan, in July, 2024.

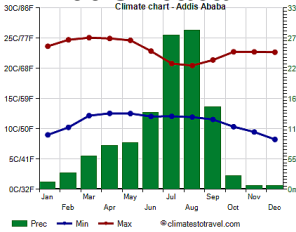


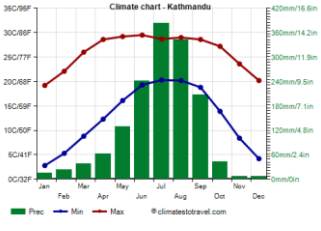
How to get clean water in Towns.

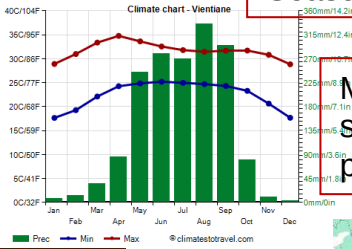


Ethiopia

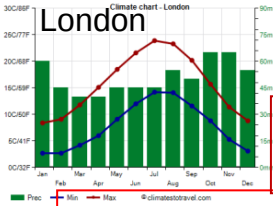
Addis Ababa







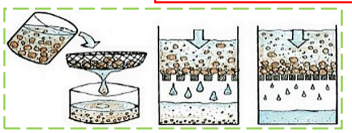
Dry and Rain Seasons



No Dry Period

Mild climate
Not so severe in winter.

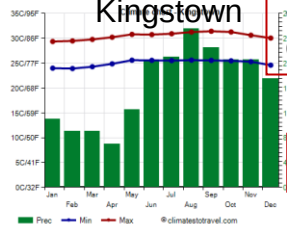
Mountain (river, spring and pressure control)



Slow Sand Filter to make clear water was developed.

Saint Vincent And Grenadines

Kingstown



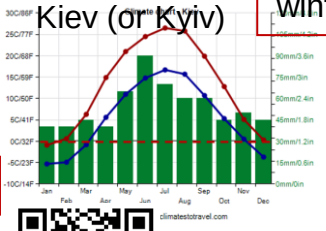
Mountain (river, spring and pressure control)

No Dry Period

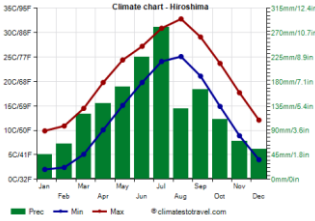
Ukraine

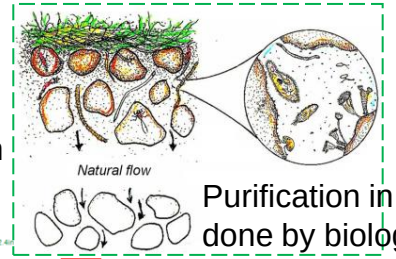
Severe winter

Kiev (or Kyiv)



Hiroshima



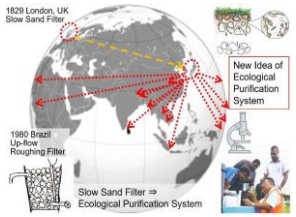


Purification in water was done by biological activity.

Key is Food Chain.

Nakamoto proposed the name of **Ecological Purification System** in 2004 in stead of Slow Sand Filter.

https://www.climatestotravel.com/



Chemical Free
Eco-friendly

Ecological Purification System (EPS)

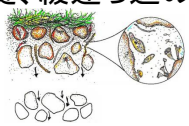
0. Introduction: Phytoplankton, Reservoir study, Meet Slow Sand Filter, Importance of Ecological point. JICA training
植物プランクトン、貯水池研究、緩速ろ過、生態学の視点、JICA研修へ

1-19 | 19

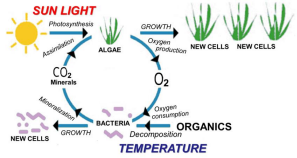
1. Water cycle, Safe water, Acceptable risk. *20-31*
水循環、安全な水、許容できるリスク | 12

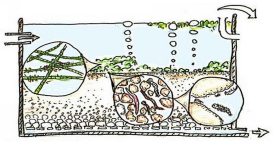


2. Key of purification in nature is food chain. Refocus to Slow Sand Filter. *32-57*
浄化は食物連鎖が鍵、緩速ろ過の再認識 | 26

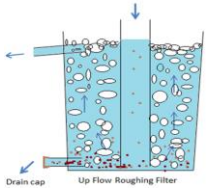




3. Algae and animals in Slow Sand Filter. *58-79*
緩速ろ過池の藻類と動物 | 22





4. Up-flow Roughing Filter to reduce SS *80-108*
濁り対策で上向き粗ろ過、モデルで解説 | 29



5. From JICA training in Miyako-jima, Okinawa to Samoa *109-124*
宮古島JICA研修からサモアへ | 16



6. Safe water for rural people by EPS in Fiji *125-147*
フィジーの展開：生物浄化法で地方給水へ | 23



7. Aerobic condition is essential for EPS. *148-157*
生物浄化法は酸素が必須 | 10



8. Confirm by yourself. Don't believe commercial. Trust your true sense. 自分で確かめよう。 *158-172*
| 15

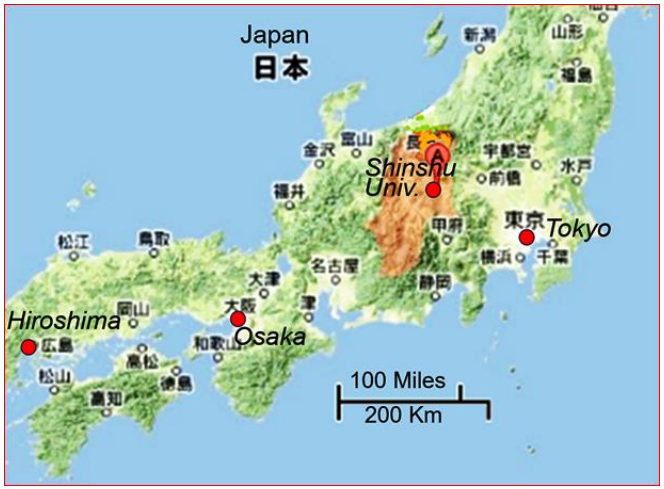


JICA training in Hiroshima in July, 2024.

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

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

I presented the microbial world of protozoa to our school mates at our high school festival in 1960 (64 years ago).



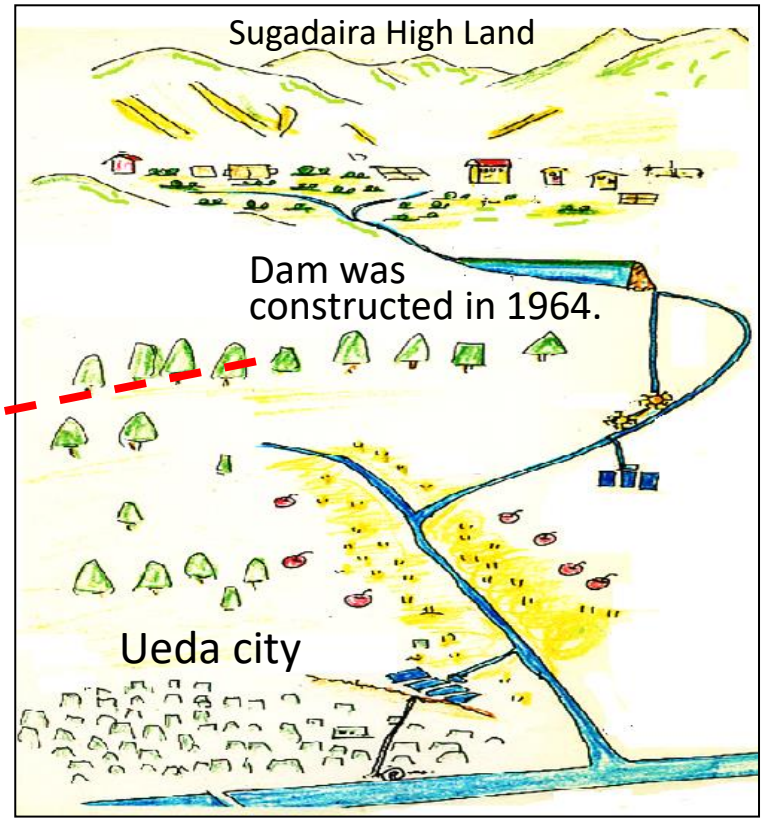
I entered Tokyo Metropolitan University to study biological science. I studied phytoplankton ecology in graduate school.

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

I found that Plankton in all regions in the ocean was same species and under 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.

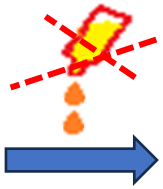


Sugadaira Reservoir and Dam

1964 Algal bloom in reservoir

Odor problem in tap water

They stopped algicide.



Heavy Algal bloom in a slow sand filter pond

Delicious tap water

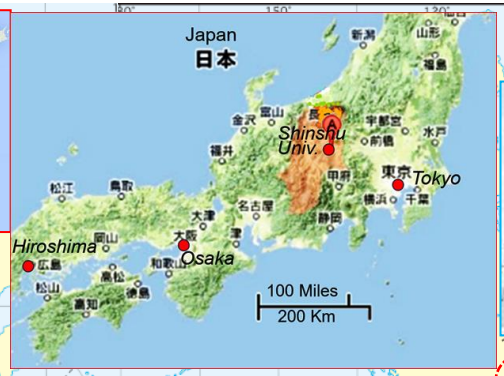
Plant manager said Good Algae in filter pond but Bad Algae in the reservoir.

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.



1994-96
Thames Filter

Plankton study in Pacific 1969 and Atlantic ocean 1970.

Odor problem of tap in Ueda city

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

→Eutrophication study on Sugadaira Reservoir

→Slow Sand Filter (SSF) from 1984

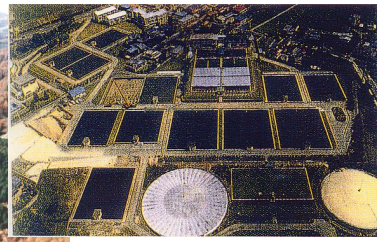
→**Wise Use of Biological Phenomena**

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

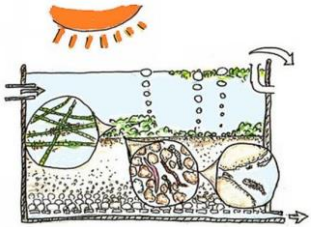
Bad algae

1975: Shinshu univ. Reservoir study

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



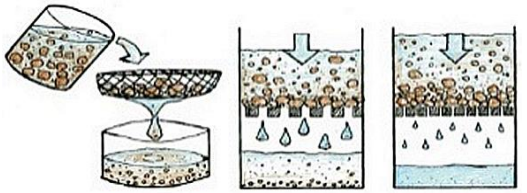
Role of algae



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.

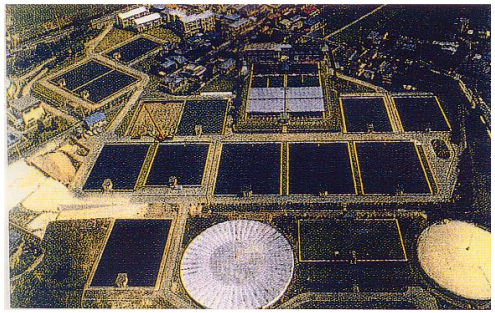
Image of Slow Sand Filter



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.

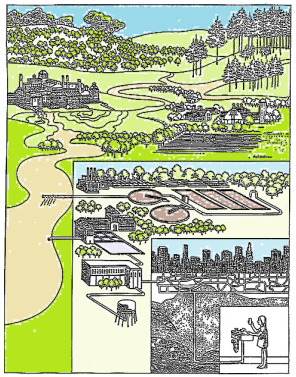
This is due to chemical treatment.

IS THE WATER SAFE TO DRINK?

Harris Report 1974

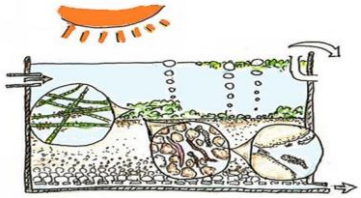
Stop algicide

→Rename to Ecological Purification System



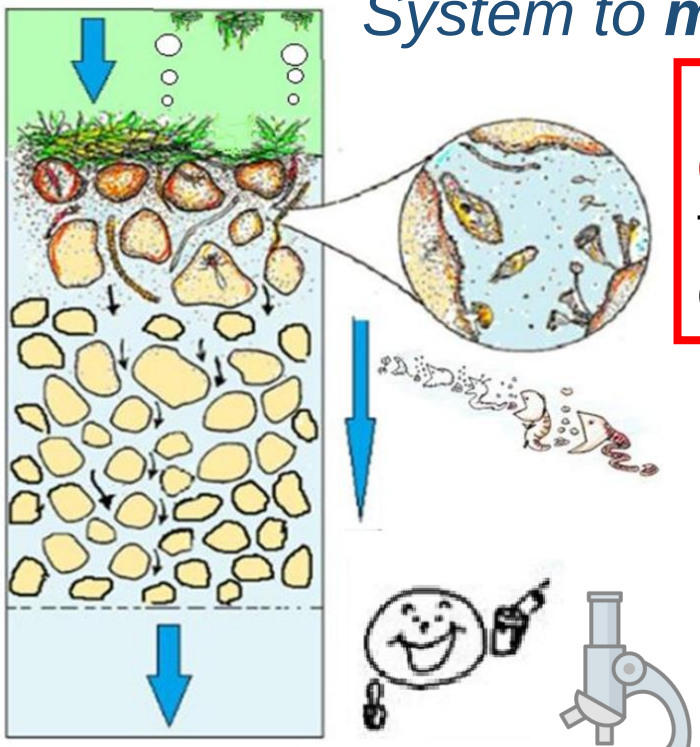
Cancer risk by chlorine addition

Safe and delicious tap water by Ecological Purification System.



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

*Slow Sand Filter 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 (SSF).

Slow Sand Filtration

I noticed that Slow Sand Filter has been **misunderstood** by the name in the world.

I proposed **Ecological Purification System (EPS) in 2004** instead of the name of Slow Sand Filter.

I was a professor of applied biology of Shinshu University.

The filtrate is clean and delicious water.

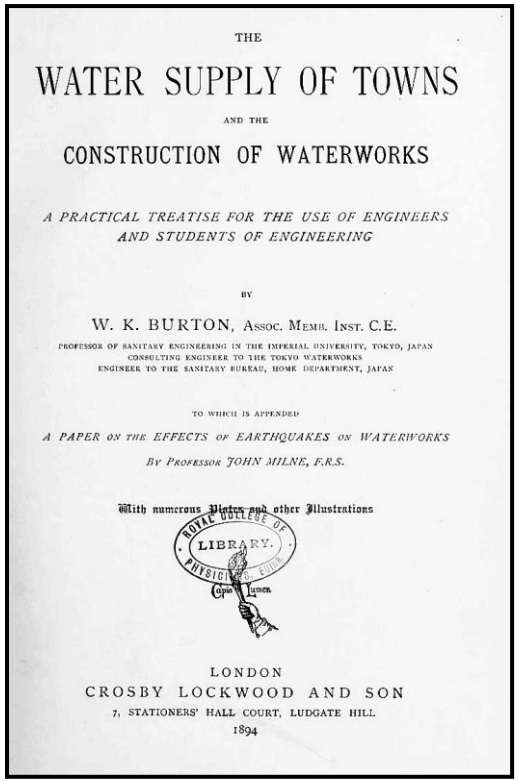
I, applied biologist, taught the students that purification in nature and its application is called **slow sand filtration**.
However, I pointed out that the name of **SSF** gave rise to a misunderstanding of how purification works.
I have been teaching this **EPS** at JICA training **since 2006**.

Modern Water Supply system was developed in Towns.

William Kinnimond Burton was a Scottish engineer, born on 11 May 1856 in, Scotland. He died on 5 August **1899 at the age of 43**, Tokyo.

He (**31 years old**) was invited in **May 1887** by the Meiji government to assume the post of first unofficial professor of sanitary engineering at Tokyo Imperial University. He advised to **major important tows (cities)** in all over Japan **during 12 years** (from 1887 to1899).

Burton published "**The Water Supply of Towns and the Construction of Waterworks**" in **1894** in London.



THE

WATER SUPPLY OF TOWNS

AND THE

CONSTRUCTION OF WATERWORKS

A PRACTICAL TREATISE FOR THE USE OF ENGINEERS AND STUDENTS OF ENGINEERING

BY

W. K. BURTON, Assoc. Memb. Inst. C.E.

PROFESSOR OF SANITARY ENGINEERING IN THE IMPERIAL UNIVERSITY, TOKYO, JAPAN
CONSULTING ENGINEER TO THE TOKYO WATERWORKS
ENGINEER TO THE SANITARY BUREAU, HOME DEPARTMENT, JAPAN

TO WHICH IS APPENDED

A PAPER ON THE EFFECTS OF EARTHQUAKES ON WATERWORKS

By Professor JOHN MILNE, F.R.S.

With numerous Plates and other Illustrations

LONDON
CROSBY LOCKWOOD AND SON
7, STATIONERS' HALL COURT, LUDGATE HILL
1894

In April 1894 (Meiji 27), Hiroshima City asked Burton for guidance and advice to design a water supply system.

He visited Hiroshima from September 16 to 18, 1894 (Meiji 27). He submitted a plan to Hiroshima City in December of the same year.

He submitted a plan to Hiroshima City in December of the same year (1894).

Ushita Plant was completed in 25. Aug. 1889 (Meiji 31).

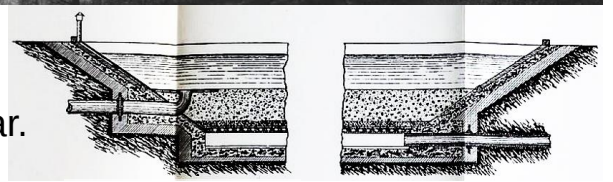


Photo 1930

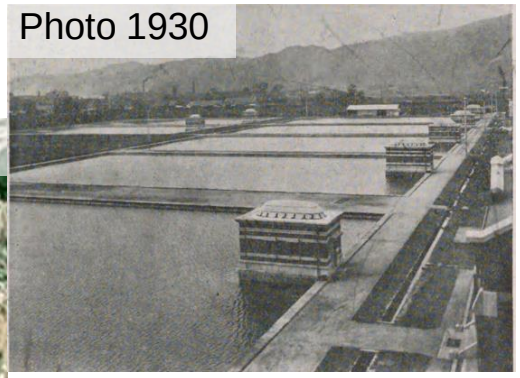


Photo 1974

https://wellcomecollection.org/works/da2p35kj/items

Urban water supply services expanded with the **development of cities**.

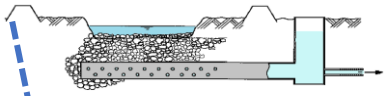
EPS-Use of Natural Process-**Chemical Free** : **Gentle for small organisms**

Surface stream water

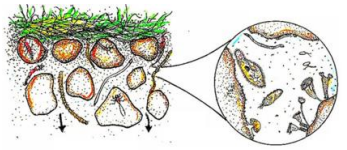
Reservoir

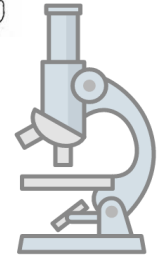
Slow means gentle for small organisms

Clean spring water



Subsurface water





Raw water

Up-flow Roughing Filter (Gravel Filter)

Ecological Purification (Sand) Tank (natural down flow)

Storage Tank Over-flow to keep gentle flow for EPS system

Settling Tank

Drain

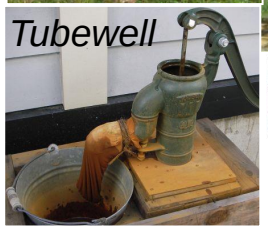
Drain

Public Taps

EPS is simple technology. We can construct and manage EPS by ourselves.

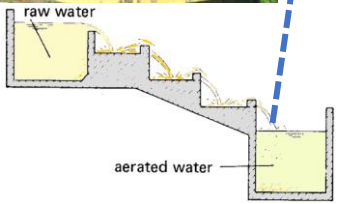
Borehole

Tubewell



Sediment heavy muddy matter

Aeration



Trap & reduce colloidal matter

Complete purification

Store the germ free safe & delicious water

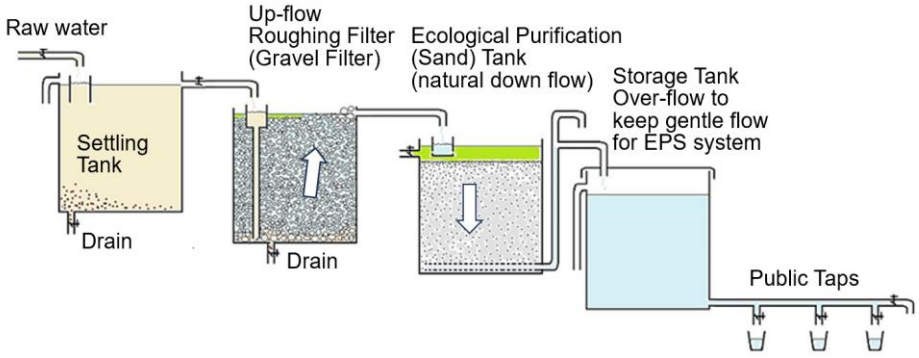
Project in Fiji provides 6 litters/person/day For drink & cook

Food chain

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

JICA-Hiroshima, July, 2018
Microscopic organisms

EPS mini 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

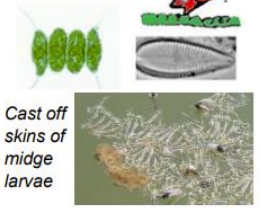
Fig.0. Fijian EPS using rain harvest tanks in a village.

August 2018

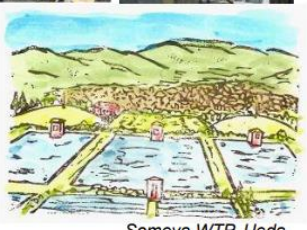
http://www.cwsc.or.jp/files/pdf/EPStext-NC-2019.pdf

Ecological Purification System for Safe Drinking Water

Contents

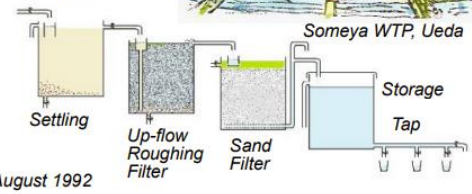


Cast off skins of midge larvae



Someya WTP, Ueda

August 1992



11th Pacific Water and Waste water conference, Nouméa, 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.

This seminar was held at the end of 4 years EPS JICA contribution (Nov.2014 to Dec.2018) in Fiji by Nakamoto.

EPS

Public Seminar/ Workshop

" An approach to securing the safe water "

Reviewing Fiji's successful EPS implementation at Rural Area and future perspective of implementation in PICs

12 & 13 March 2019

@ Japan-Pacific ICT Centre, USP Laucala Campus

Day 1 09:30~17:00 Public Seminar (Inc. refreshments & lunch)

Main Presenter - Dr Nobutada NAKAMOTO*

JICA Expert, EPS advisor for Rural Water Supply
Professor Emeritus of Shinshu University, Japan

* Live lecture from JICA HQ, Tokyo Japan

Day 2 09:00~18:30 Workshop & Study Tour (Inc. lunch)**

Workshop - Demonstration of EPS Construction

By Mr Makoto YANO, Okinawa Blue Water, Japan

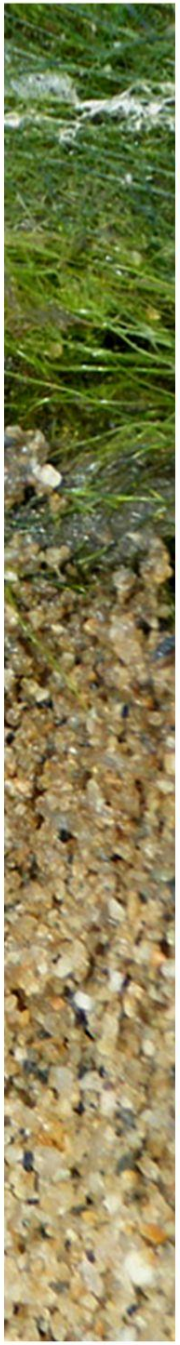
Study Tour - EPS Site Visit to NAKINI Village

18:30~20:00 - Evening Reception (Cocktail Party)

JICA

** Pre-registration is required at Day 1 (close at 11:30) due to limited space.

For further details, please contact JICA Fiji Office by email: jicafj-recept@jica.go.jp or telephone: +679 330 2522



ECOLOGICAL PURIFICATION SYSTEM

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.

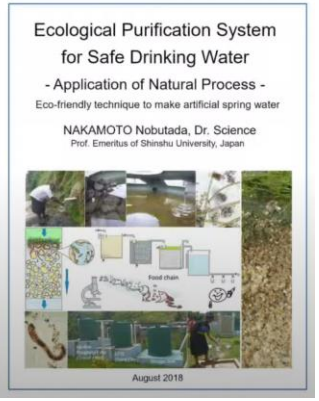
EPS Public Seminar/Workshop 11:30-12:30 Principle of EPS, Q&A

Ecological Purification System for Safe Drinking Water

- Application of Natural Process -

NAKAMOTO Nobutada, Dr. Scinece
Prof. Emeritus of Shinshu University

Eco-friendly technique to make artificial spring water



https://www.youtube.com/watch?v=fEl5ghBzfMw&t=62s 4min 32 sec

EPS to make safe drinking water is real our technology.

https://www.youtube.com/watch?v=vji0ay-7GA8&t=254s 7min 08 sec

CONSTITUTION OF THE REPUBLIC OF FIJI

This Constitution issued on 7 September **2013**.

36: Right to adequate food and water

the right of every person to have adequate food of acceptable quality and to **clean and safe water in adequate Quantities**.

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.

Safe Drinking Water by Ecological Purification System

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

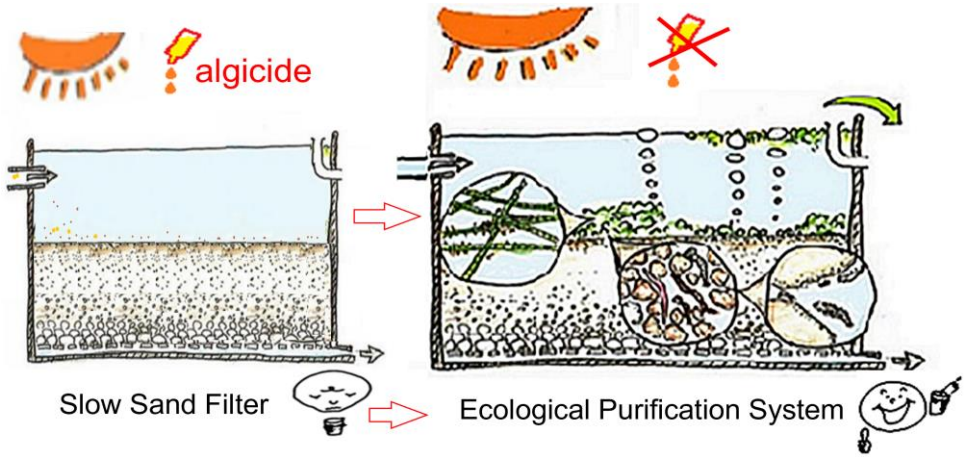


Fig. 1. Delicious water by stopping the algicide

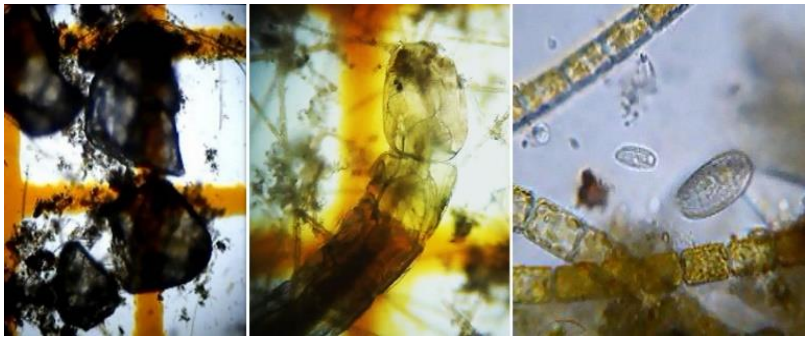


Fig. 2. Attention to the role of algae and micro-animals

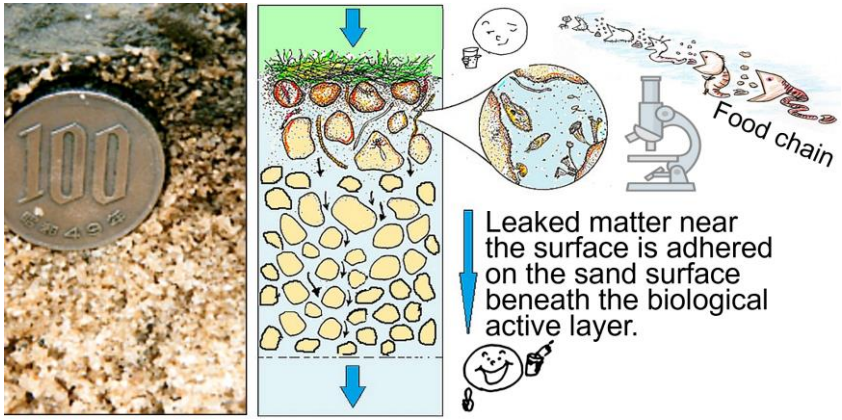


Fig. 3. Algae and small animals are active at the top

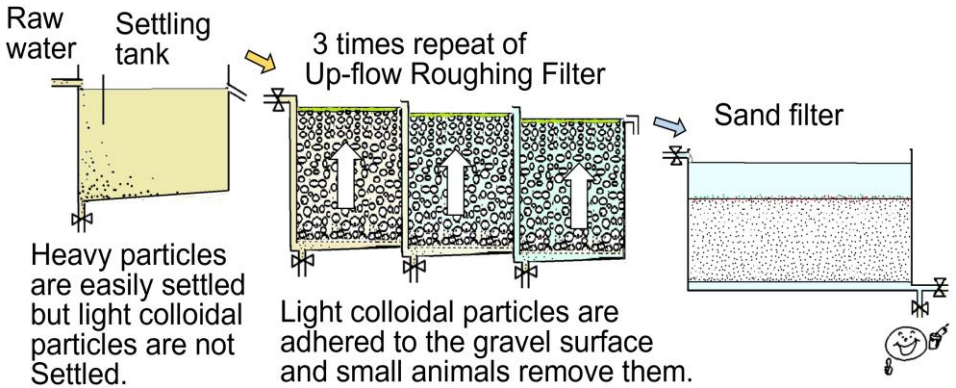


Fig. 4. Settling tank and URF for turbid reduction

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

JAPANGOV THE GOVERNMENT OF JAPAN

KIZUNA Linking Japan and the World

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

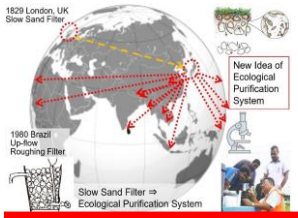
Health & Welfare

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**."



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

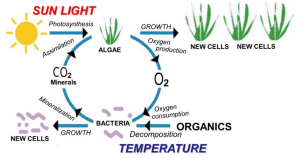
1-19 19

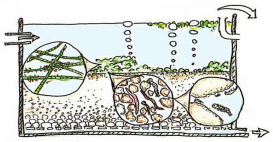
1. Water cycle, Safe water, Acceptable risk. *20-31* 12
水循環、安全な水、許容できるリスク



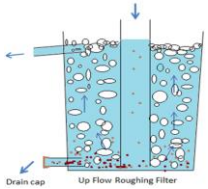
2. Key of purification in nature is food chain. Refocus to Slow Sand Filter. *32-57* 26
浄化は食物連鎖が鍵、緩速ろ過の再認識

3. Algae and animals in Slow Sand Filter. *58-79* 22
緩速ろ過池の藻類と動物





4. Up-flow Roughing Filter to reduce SS *80-108* 29
濁り対策で上向き粗ろ過、モデルで解説



5. From JICA training in Miyako-jima, Okinawa to Samoa *109-124* 16
宮古島JICA研修からサモアへ



6. Safe water for rural people by EPS in Fiji *125-147* 23
フィジーの展開：生物浄化法で地方給水へ



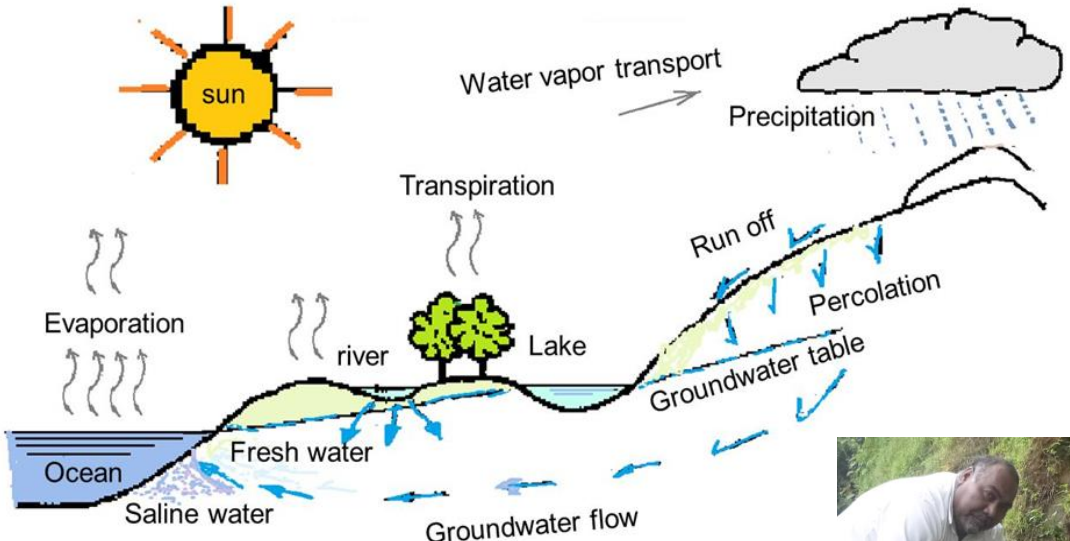
7. Aerobic condition is essential for EPS. *148-157* 10
生物浄化法は酸素が必須

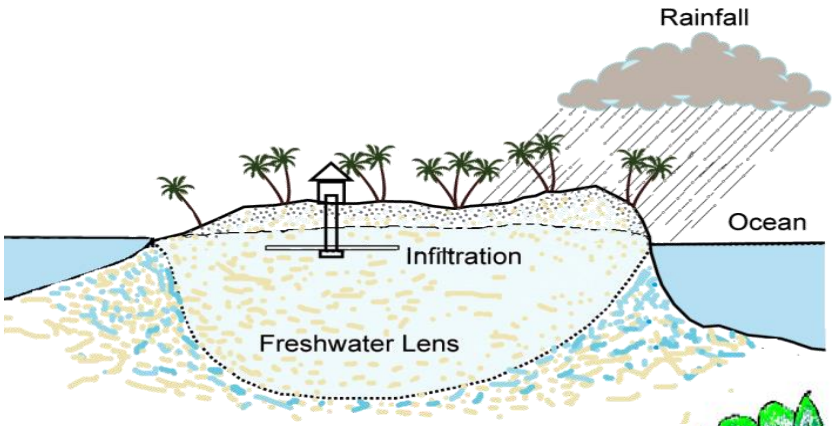


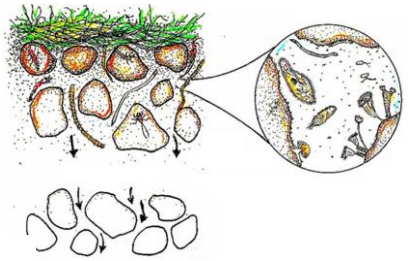
8. Confirm by yourself. Don't believe commercial. Trust your true sense. 自分で確かめよう。 *158-172* 15



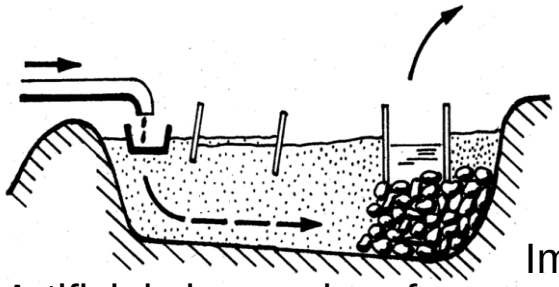
JICA training in Hiroshima in July, 2024.







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.

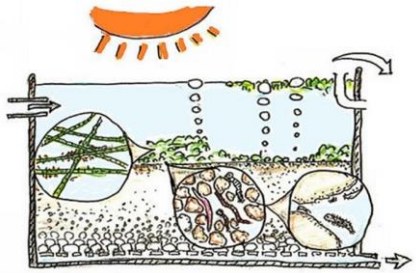
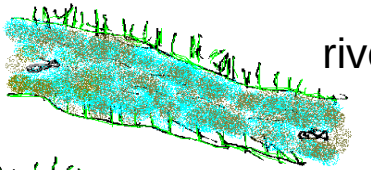
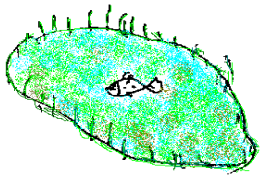


Image of Slow Sand Filter as Ecological Purification System (EPS).

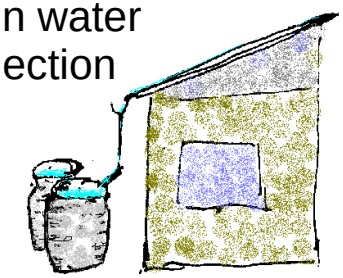
EPS is a new purification system to make artificial safe water. This is wise use of natural phenomena. This is not same as slow sand filter.

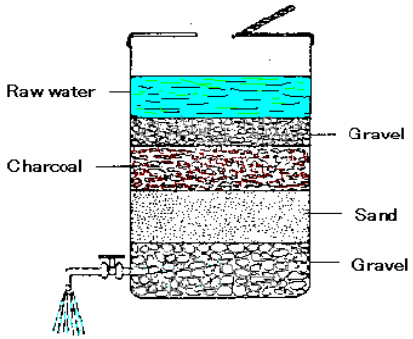
Familiar surface waters are not always safe. How to get safe water.

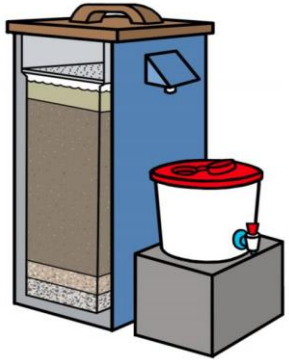

river


pond

Rain water collection

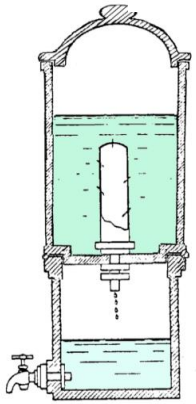




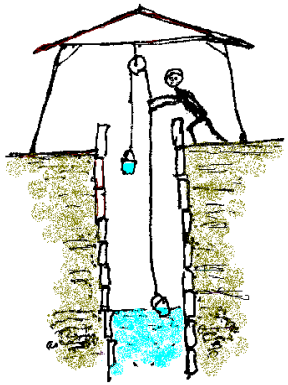


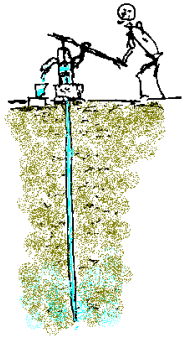
Surface water is easily contaminated by pathogens and other dangerous worms. It is not always safe to drink directly.

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.





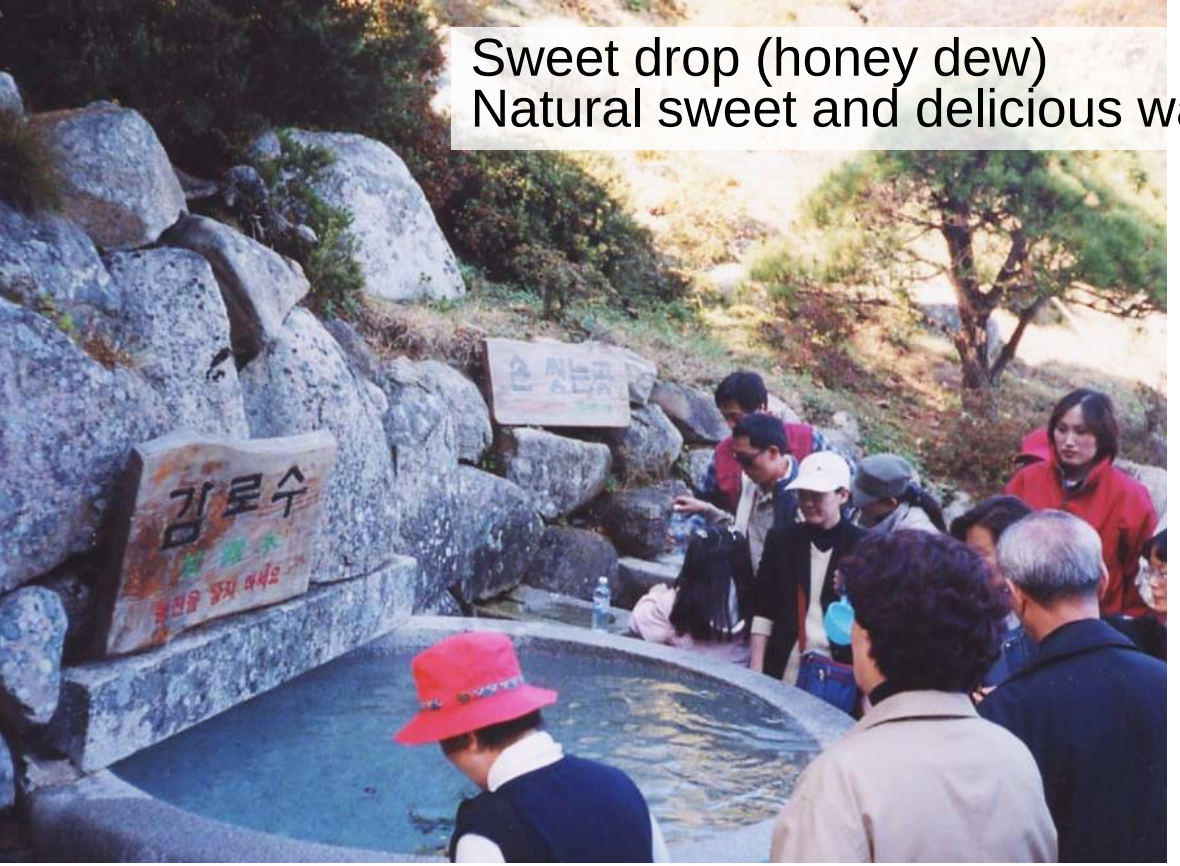
Almost all pathogens may be removed by ceramic filter. The pore size is smaller than 1.5 micron.

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.

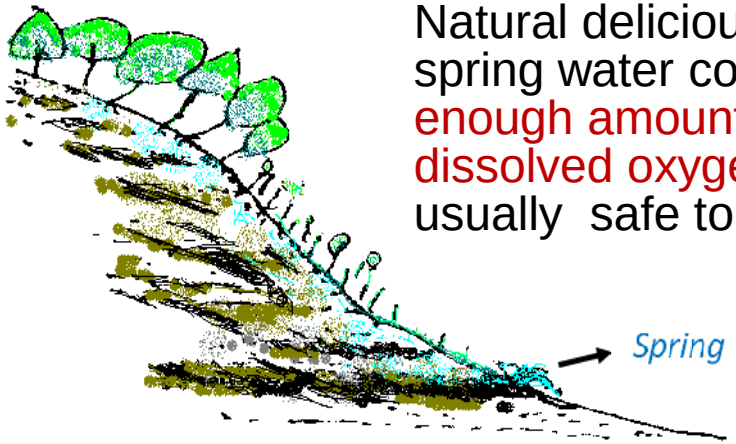
All the contaminated particulate matter can be removed by a membrane filter. But it's running cost is so big.

Sweet drop (honey dew)
Natural sweet and delicious water



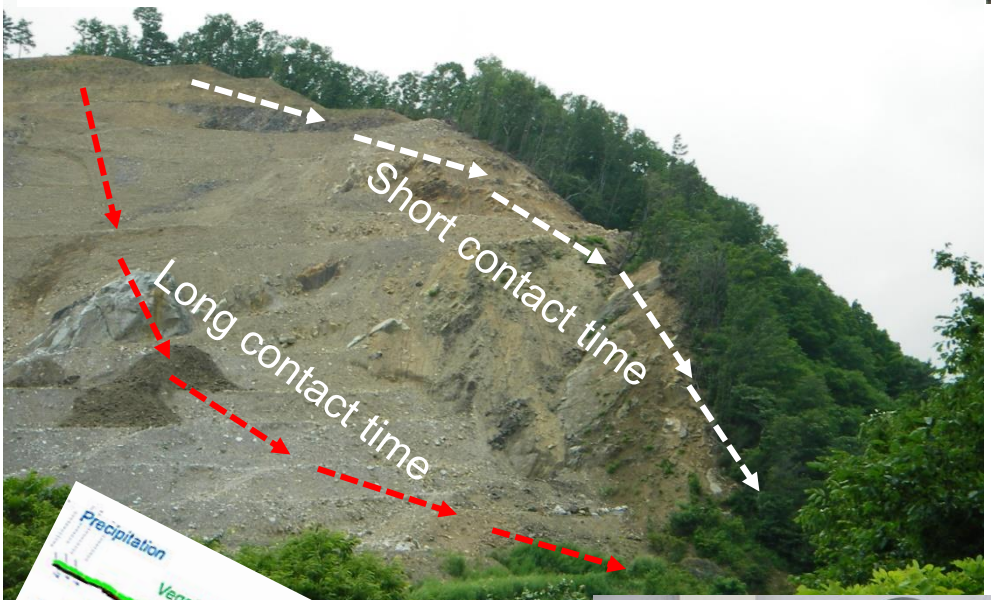
Rain harvesting

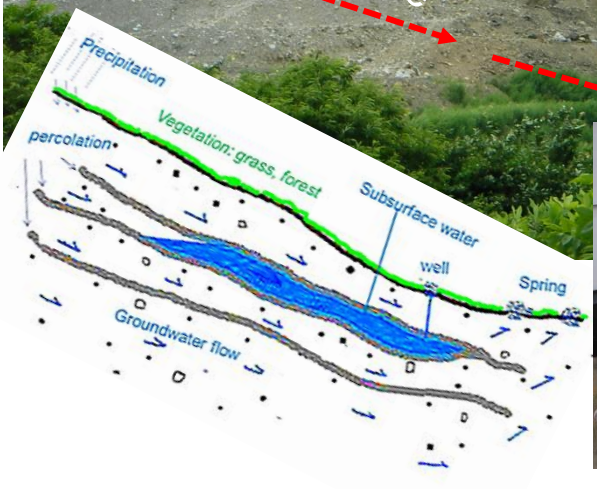
Natural spring water and rain water are usually sweet and delicious.



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

Dissolved oxygen is key.

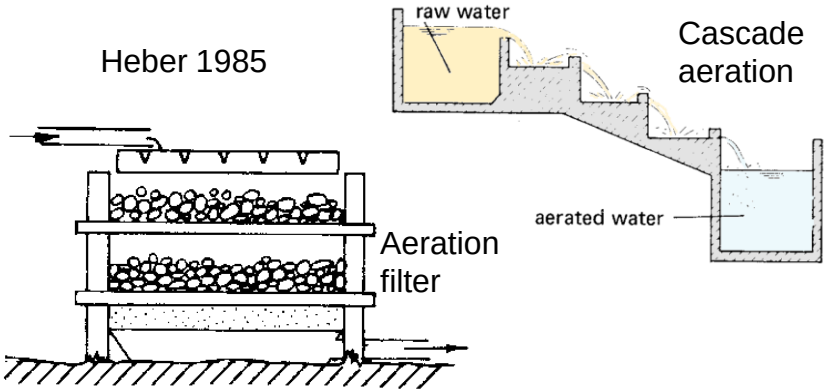




Addition of oxygen:

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

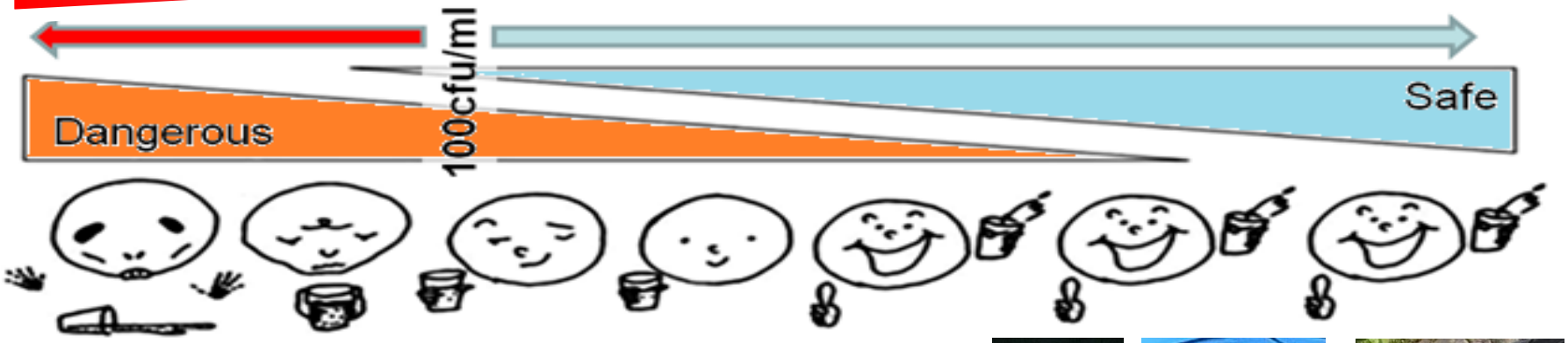
Heber 1985



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

What level of water, we need?

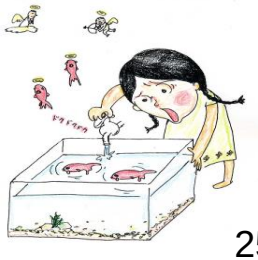
Germ : Cholera → Fecal Coli-form → Coli-form bacteria → General bacteria

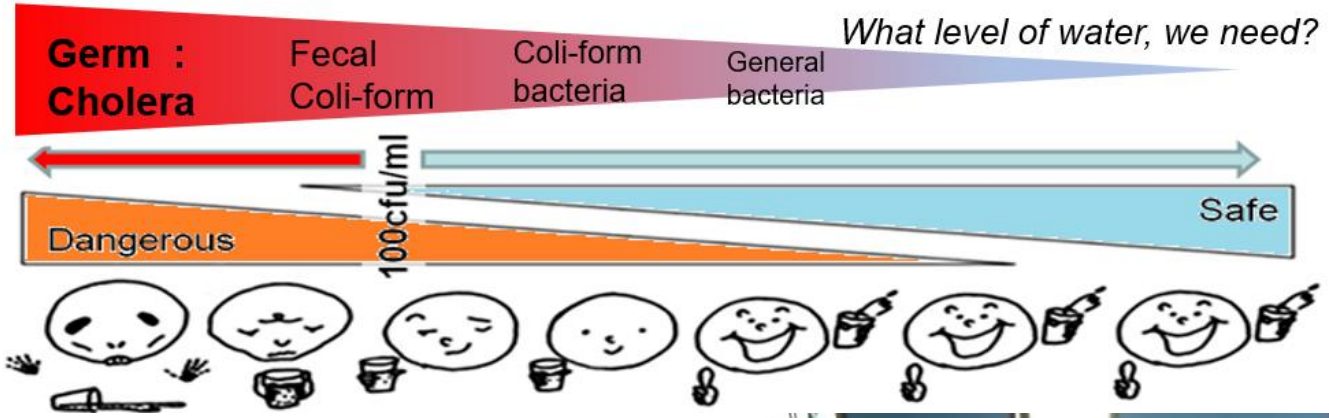


We have to think about acceptable risk and treatment.

Which level of treatment, we need?

Is this, safe or not?





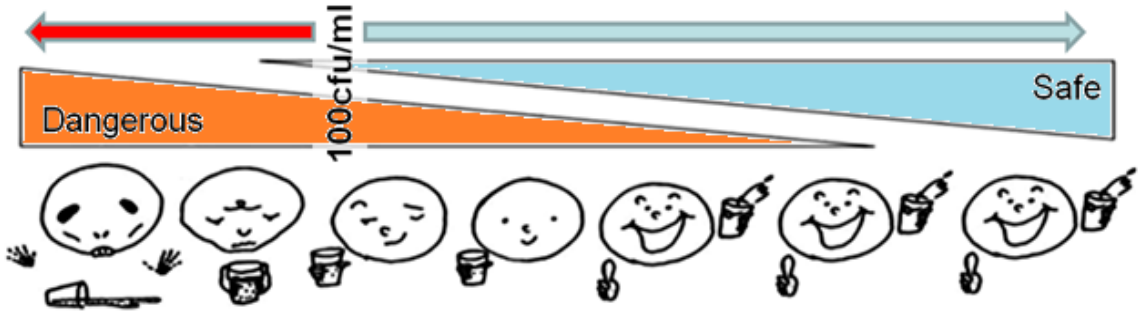
We have to think about acceptable risk and treatment.

Kava ceremony in village in Fiji.

https://www.youtube.com/watch?v=vQxpxhUVkM8

I could not say that bacteria free water is safe.

We have to think about always acceptable risk.



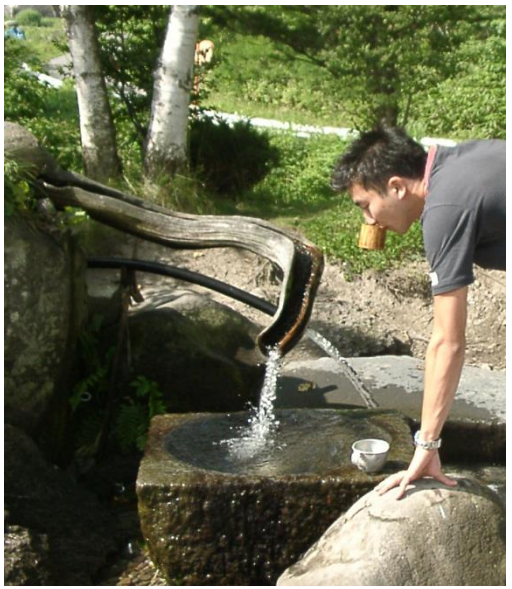
General bacteria: many in the natural environment

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.

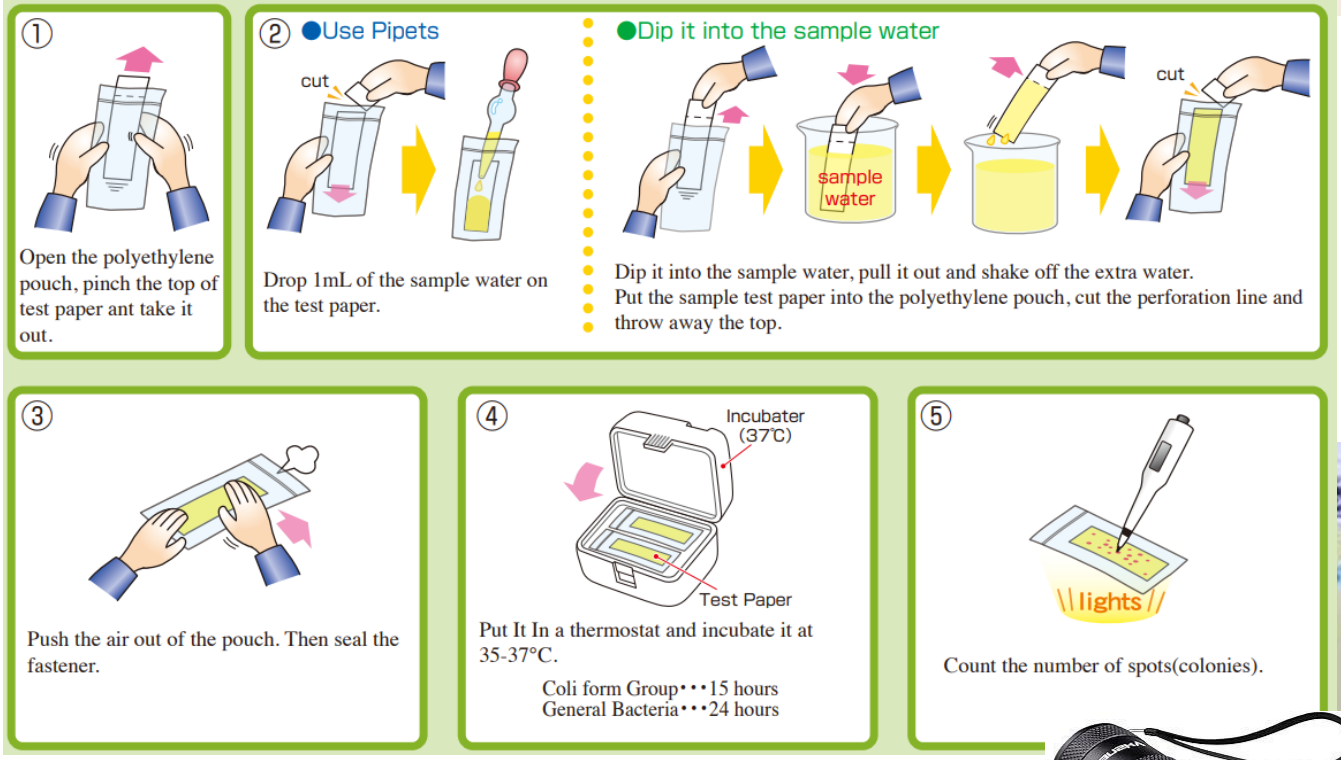
Pathogenic bacteria



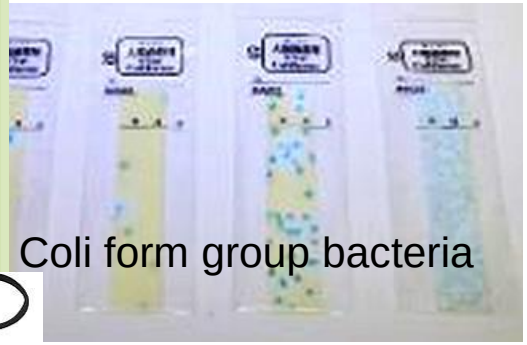
Wash hand!
Reduce the risk.

Easy bacteria test paper of SUNCOLI paper

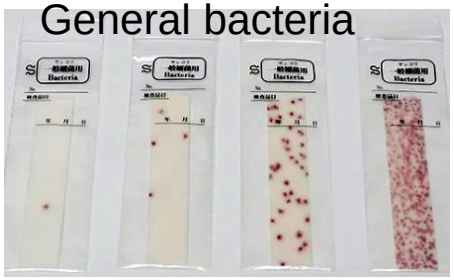
https://www.sibata.co.jp/wpcms/wp-content/themes/sibata/en/pdf/test_paper.pdf



Incubate at 35-37 C.
Coli form bacteria: 15 hrs.
General bacteria: 24 hrs.



General bacteria



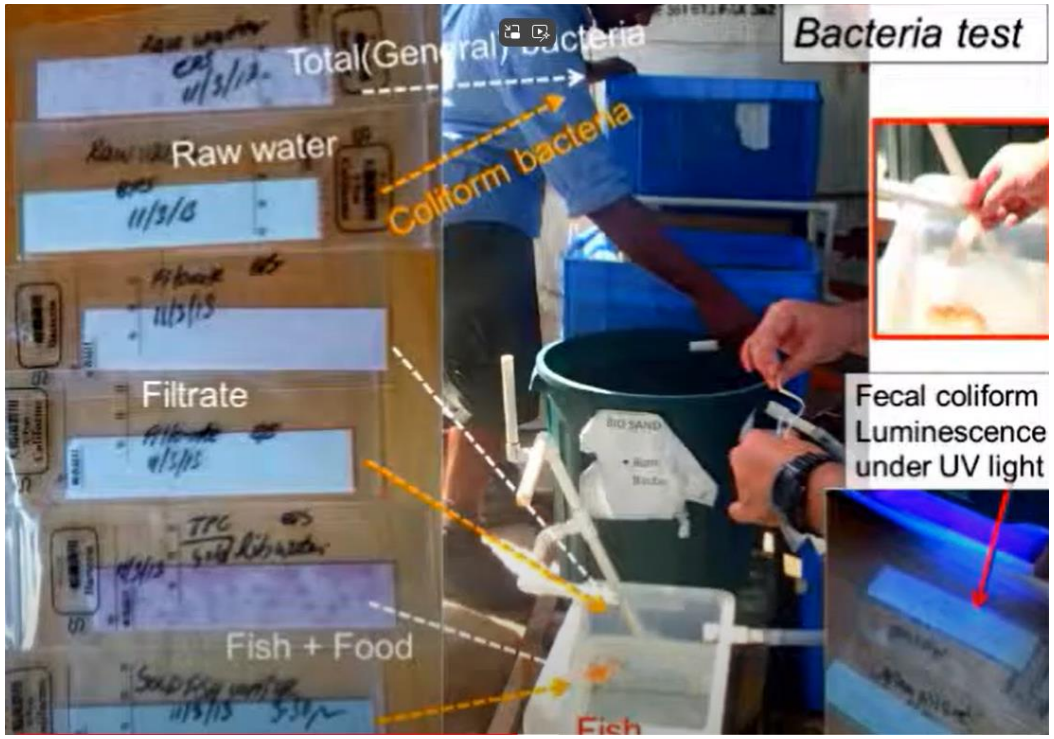
Fluorescence emitted when exposed to ultraviolet rays in case of Coli form bacteria paper.

https://www.youtube.com/watch?v=Vrr2EOS1PMA&t=49s

Total length **7:43**

Bacteria Test by SUNCOLI test in Fiji

Watch 3:21- 4:22



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

Logarithmic bacteria number in 1 ml

100,000,000	10,000,000	1,000,000	100,000	10,000	1,000	100	10	1	0.1	0.01	0.001	0.0001	0.00001
10^8	10^7	10^6	10^5	10^4	10^3	10^2	10^1	10^0	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}

General bacteria | soil | Coli-form bacteria | Fecal Coli-form | **Germ : Cholera**

Coli-form bacteria are abundant in soil and are not germ bacteria.

Wash hand

General bacteria | water | Coli-form bacteria | Fecal Coli-form | **Germ : Cholera**

Please compare the size and number of Cryptosporidium with bacteria in water. Risk?

Risk of germ bacteria in water.

Elimination **by chemical**

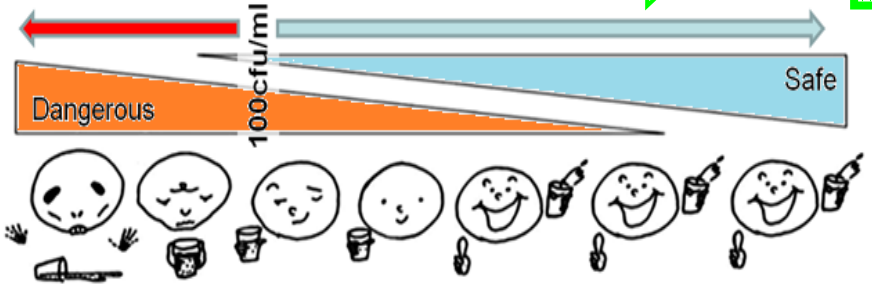
General bacteria | RSF | Coli-form bacteria | Fecal Coli-form | **Germ : Cholera**

Sterilize by chlorine

Toxicity of chlorine?

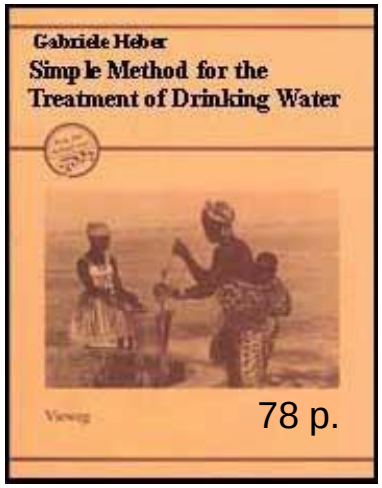
Elimination **by biological community**

General bacteria | EPS (SSF) | Coli-form bacteria | Fecal Coli-form | **Germ : Cholera**



We have to think about acceptable risk.

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

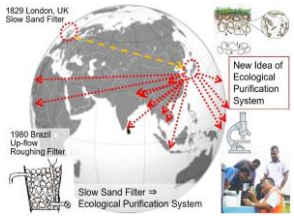


https://www.nzdl.org/cgi-bin/library.cgi?e=d-00000-00---off-0hdl--00-0----0-10-0---0---0direct-10---4-------0-0l--11-en-50---20-about---00-0-1-00-0-0-11-1-0utfZz-8-10&cl=CL3.21&d=HASH175e57dd8f453120fc2d5d&gt=2

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 oxygen content in water. 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)

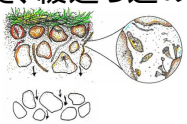
0. Introduction: Phytoplankton, Reservoir study, Meet Slow Sand Filter, Importance of Ecological point. JICA training
植物プランクトン、貯水池研究、緩速ろ過、生態学の視点、JICA研修へ

1-19 | 19

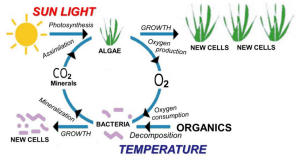
1. Water cycle, Safe water, Acceptable risk. *20-31* | 12
水循環、安全な水、許容できるリスク

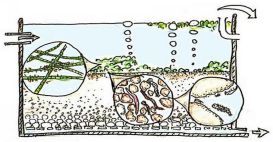


2. Key of purification in nature is food chain. Refocus to Slow Sand Filter. *32-57* | 26
浄化は食物連鎖が鍵、緩速ろ過の再認識

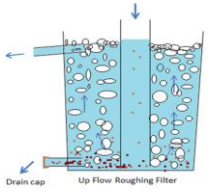




3. Algae and animals in Slow Sand Filter. *58-79* | 22
緩速ろ過池の藻類と動物





4. Up-flow Roughing Filter to reduce SS *80-108* | 29
濁り対策で上向き粗ろ過、モデルで解説



5. From JICA training in Miyako-jima, Okinawa to Samoa *109-124* | 16
宮古島JICA研修からサモアへ



6. Safe water for rural people by EPS in Fiji *125-147* | 23
フィジーの展開：生物浄化法で地方給水へ



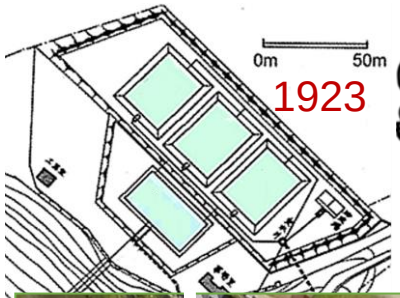
7. Aerobic condition is essential for EPS. *148-157* | 10
生物浄化法は酸素が必須

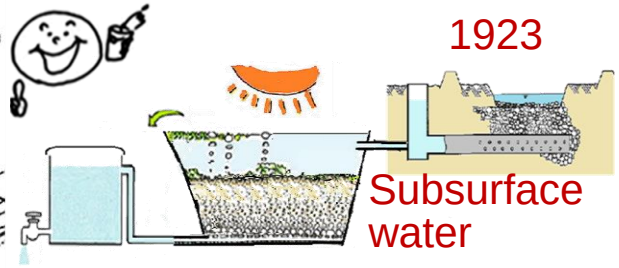


8. Confirm by yourself. Don't believe commercial. Trust your true sense. 自分で確かめよう。 *158-172* | 15

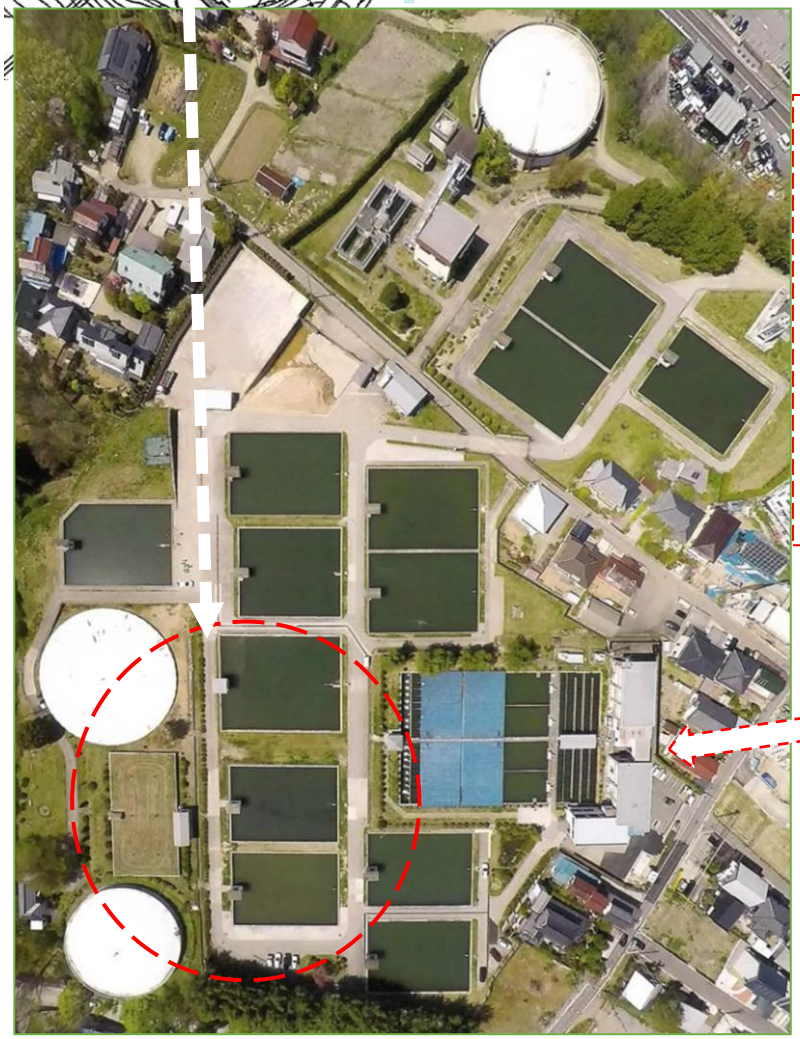


JICA training in Hiroshima in July, 2024.





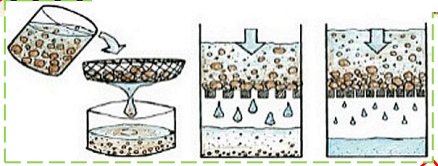
The original water source was a **subsurface water** in a flood plain of the River Chikuma from **1923**.



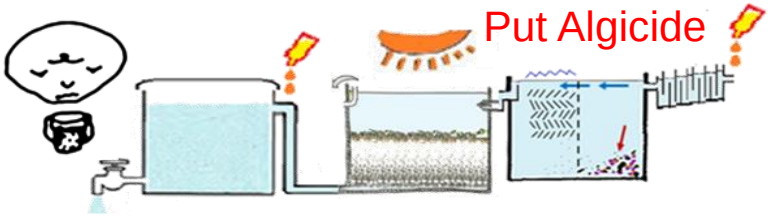
Odor problem of tap water appeared, after the construction of the Sugadaira Reservoir in **1968**.

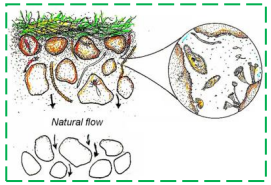
Bad Algae in the reservoir.

Slow Sand Filter Image

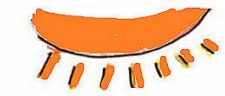


Purify by small organisms



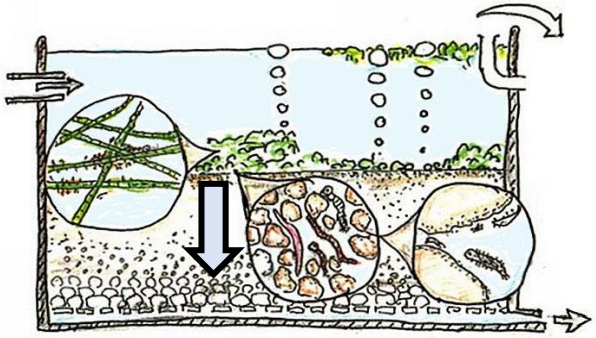


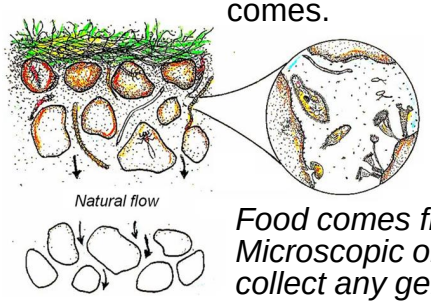
They made a mistake the biological purification mechanism due to the name of Slow Sand Filter.



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.

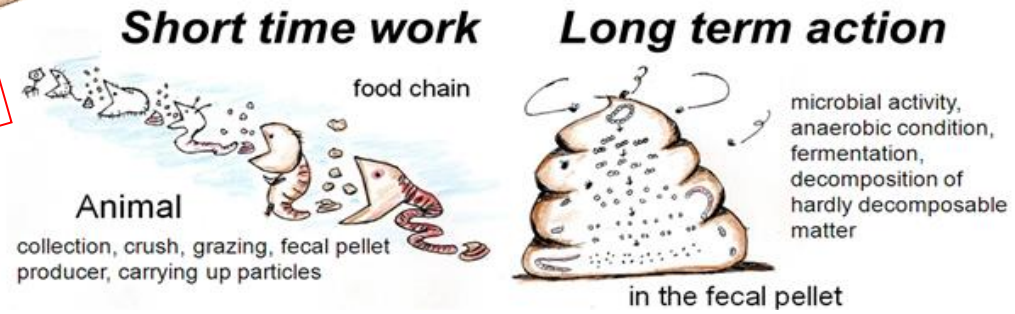
Small animals collect any turbid matters near the surface where food comes.

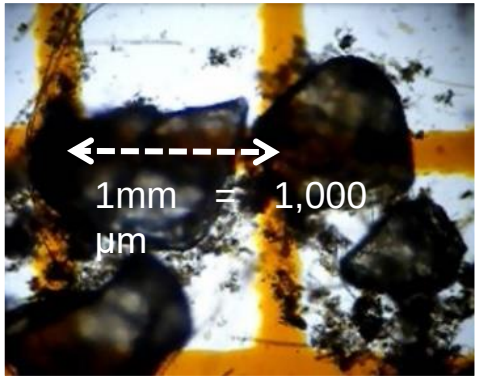
Germ free safe water to drink

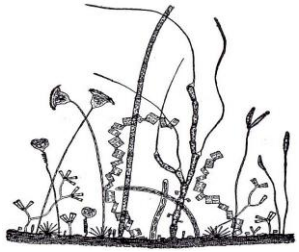
Trap and collection time of particle by small organisms is very short. Passing time of food in body is also very short.

There is no food in deep place.

Oxygen is necessary for small animals.



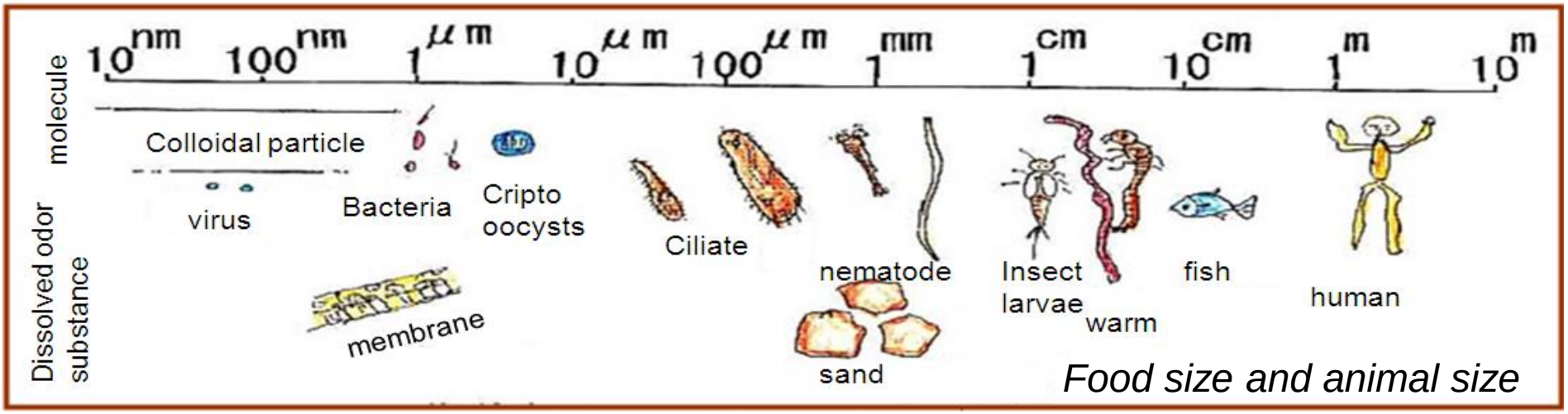




Food chain by small animals is the key for purification system.

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.



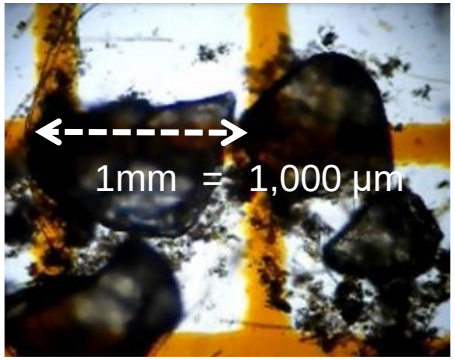
Short time work

Passing time of food in body is also very short.

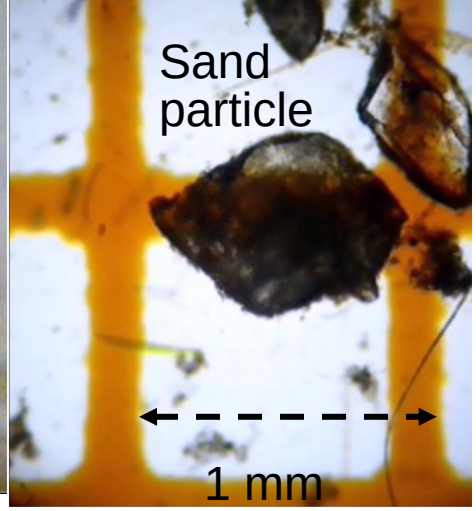
Long term action

Complete decomposition (mineralization) in the faecal pellet.

Anaerobic condition inside of fecal pellet.



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

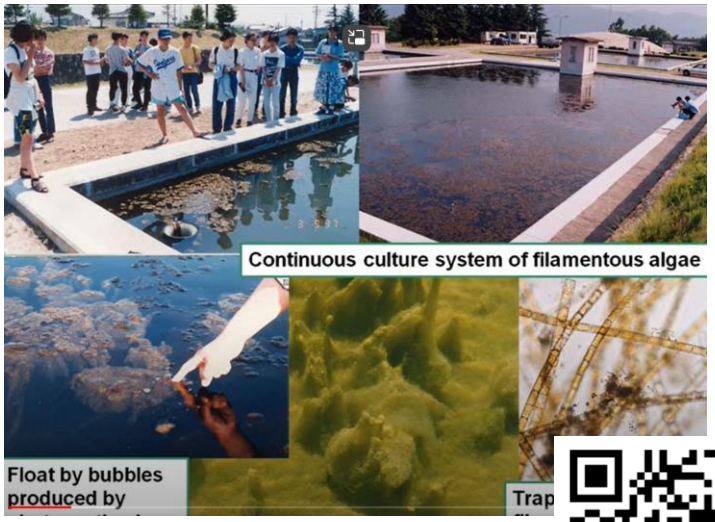


Fecal pellet of
Chironomid larva

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

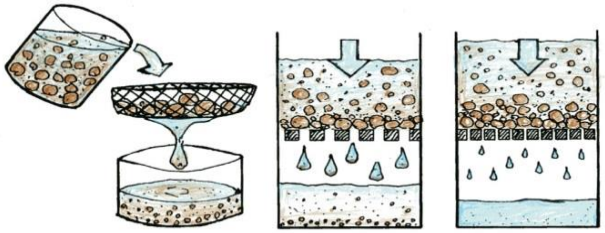


https://www.youtube.com/watch?v=Pk_JNC6RTyo

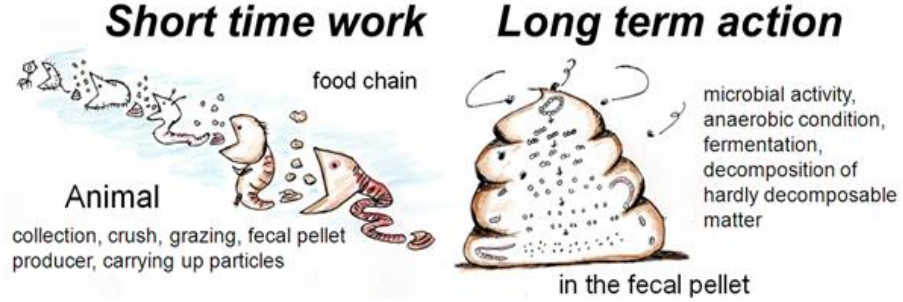
THIS is FOOD CHAIN

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***

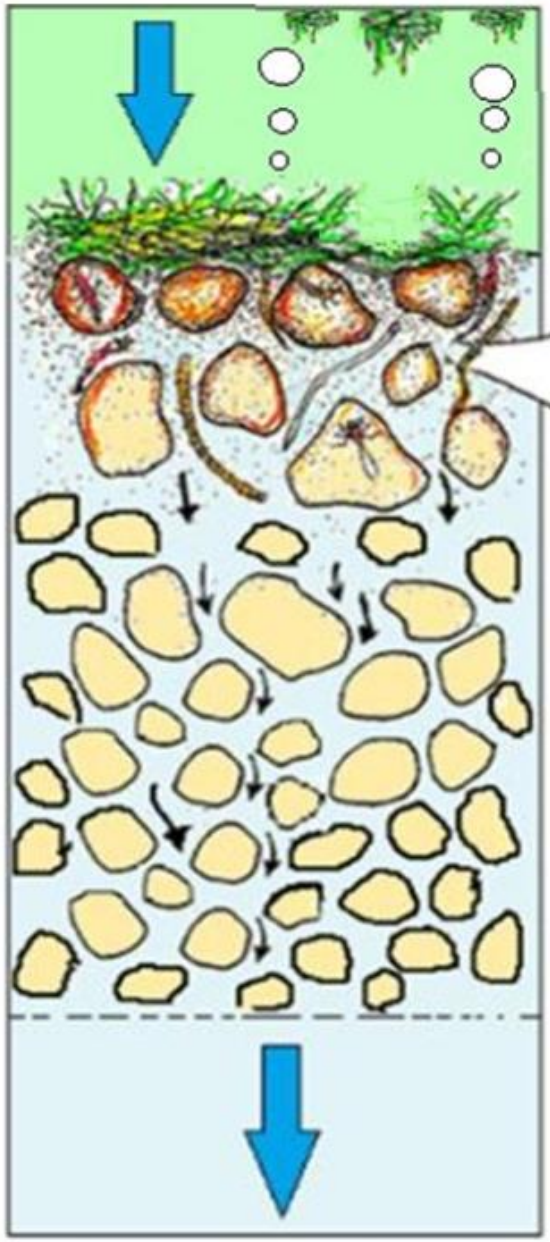


English Filter : Mechanical filter

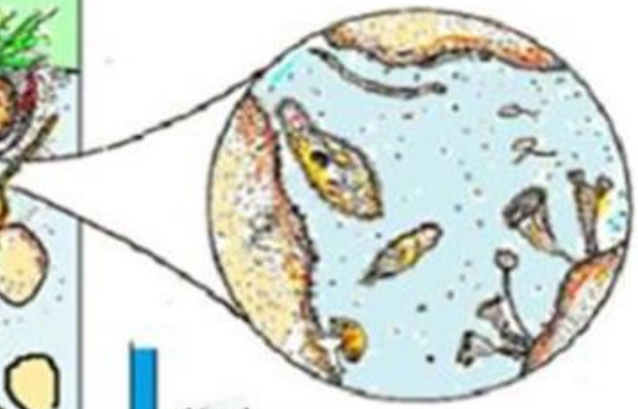


New Concept and New Name

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.

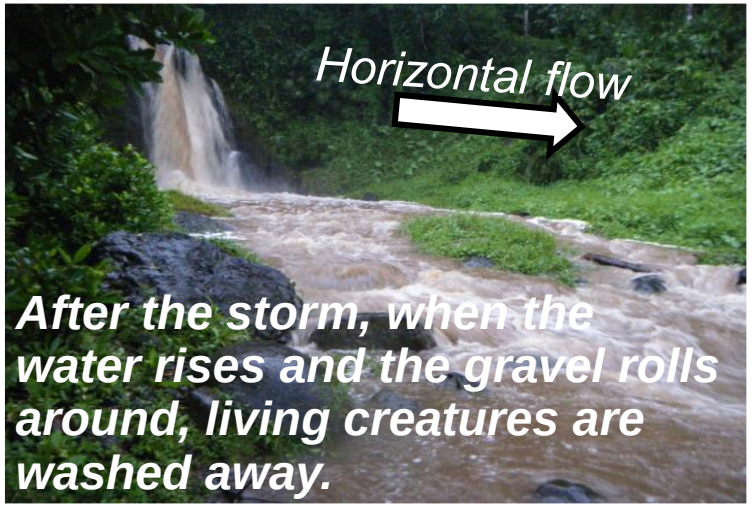
Purification time is very short near the surface.

Guarantee and insurance layer for emergency

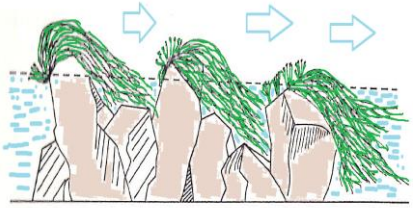
When the porosity is 50% in sand layer, filter rate becomes double. 9.6m/d (40 cm/h)

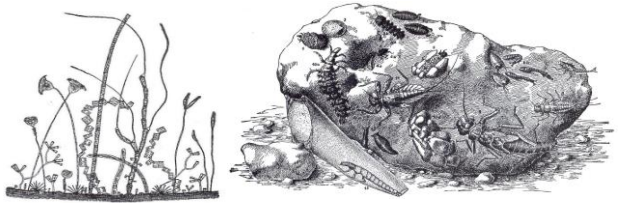
English standard filter rate 4.8m/d (20 cm/h)

Where is clear water?



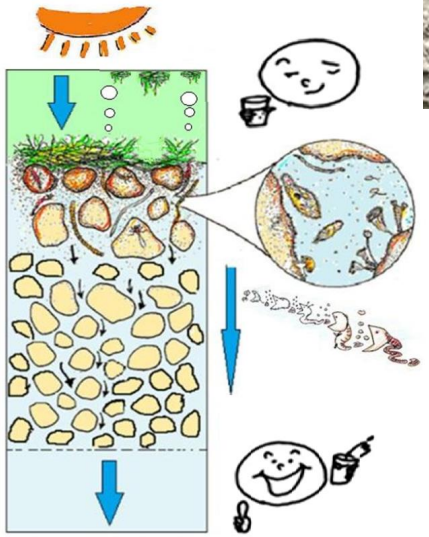
After the storm, when the water rises and the gravel rolls around, living creatures are washed away.





Sand, stone and soil are not moved.

Spring water is always clear.

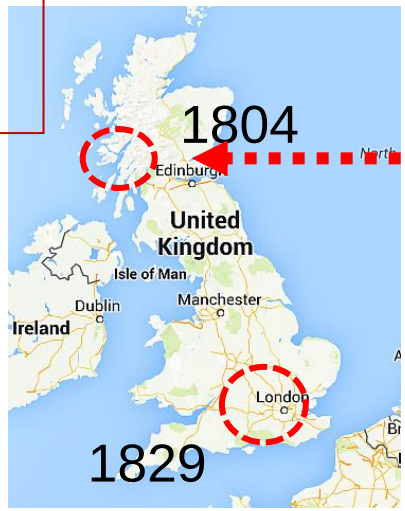


vertical current.

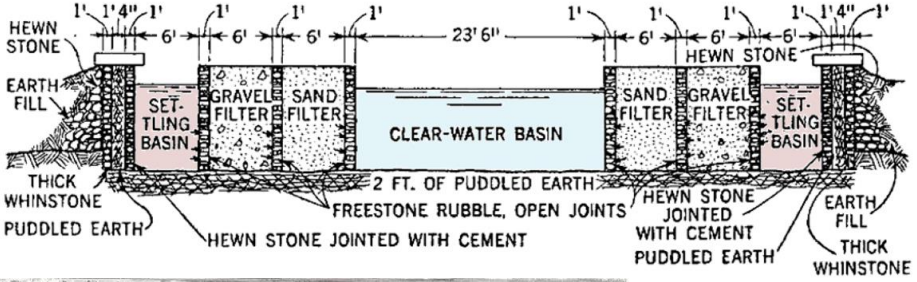
Sand and stone are not moved.

Industrial Revolution in 18 century

Textile Industry developed.



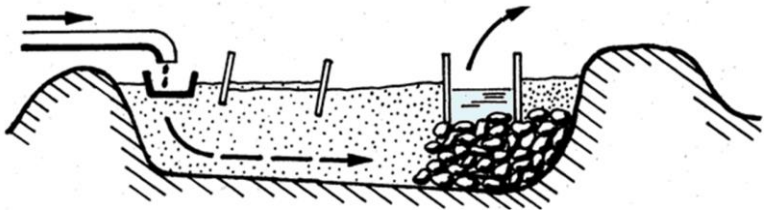
John Gibb poured muddy river water horizontally into gravel and sand tanks to obtain a large amount of clean water in 1804.

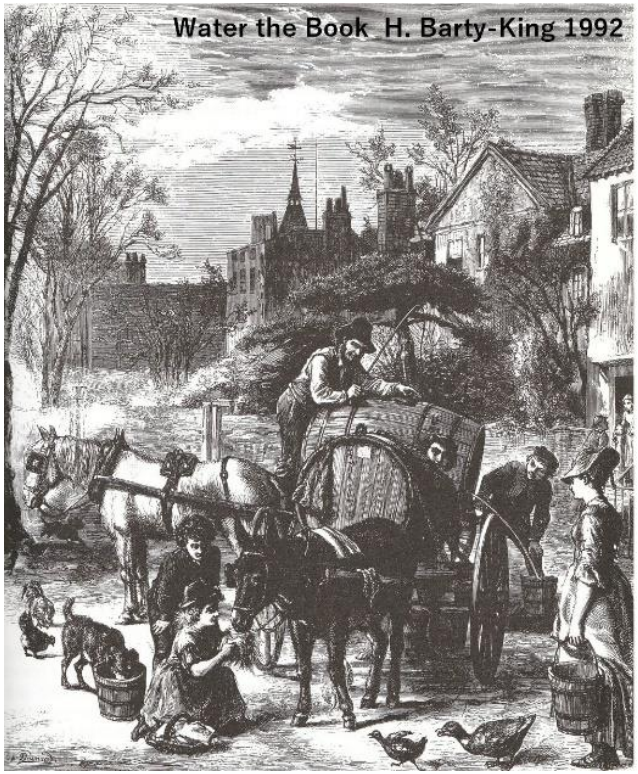


John Gibb worked as a bleachery of textile, in Paisley near Glasgow.

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

He took a hint from the clear water that springs up from the riverbed.

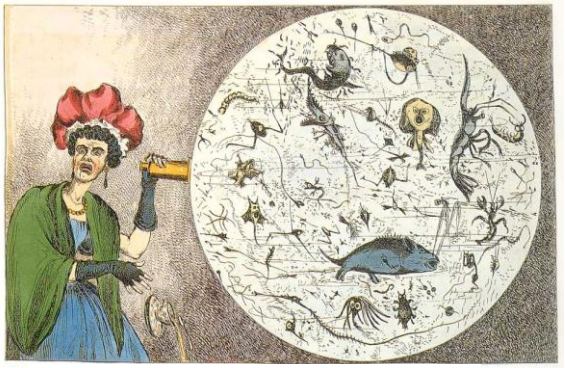


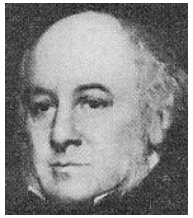


He sold surplus amount of clean water to the people in all over the city.

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.

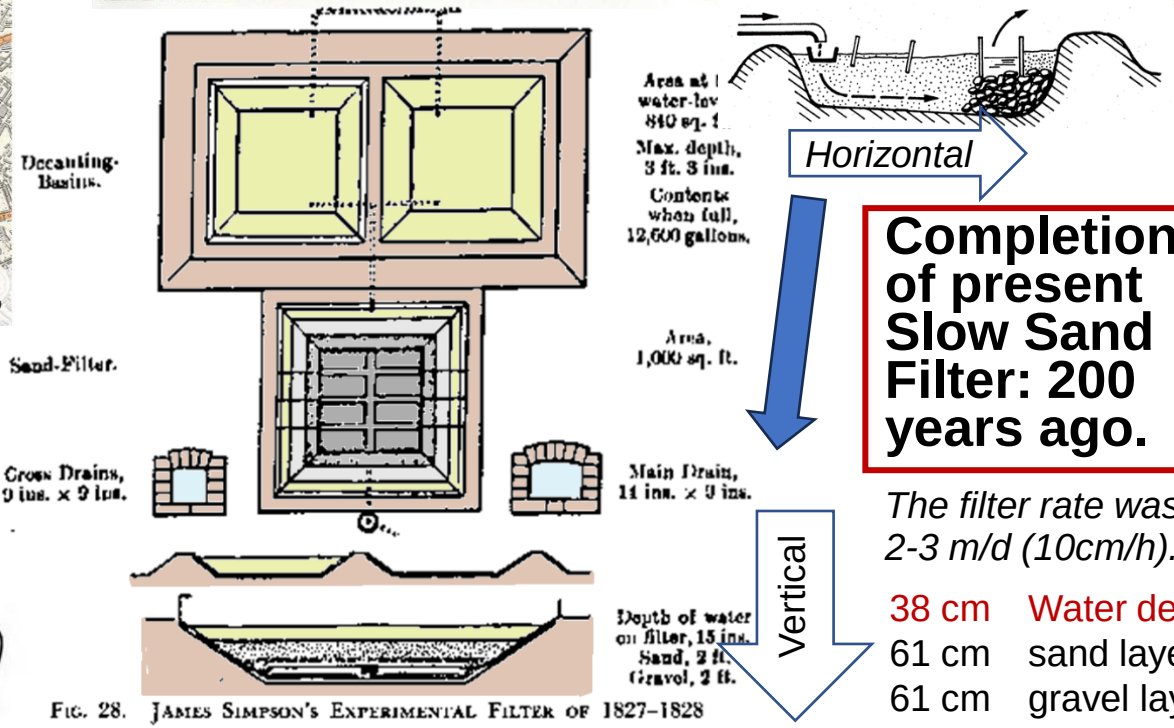


FIG. 28. JAMES SIMPSON'S EXPERIMENTAL FILTER OF 1827–1828

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

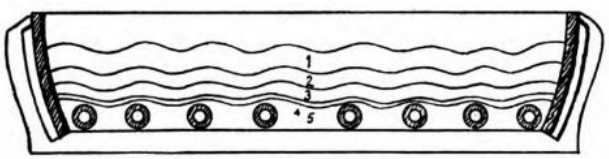
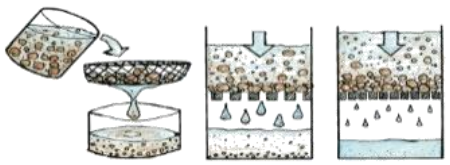


FIG. 29. CROSS SECTION OF SIMPSON'S ONE-ACRE FILTER FOR CHELSEA WATER WORKS CO., 1829

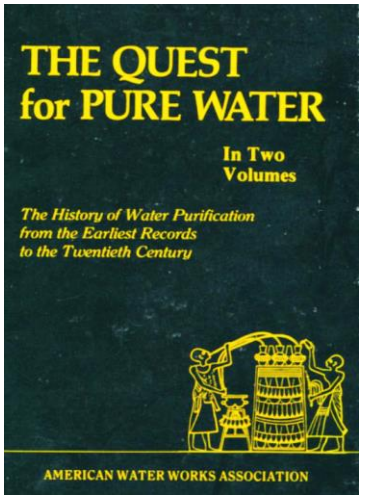
Media were: 1. fine sand; 2. loose sand; 3. pebbles and shells; 4. fine gravel; 5. large gravel, containing "brick tunnels" or underdrains.



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



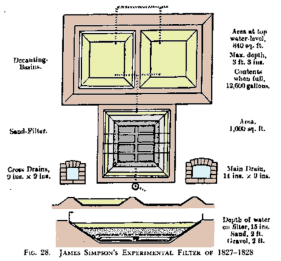
https://babel.hathitrust.org/cgi/pt?id=mdp.39015007372272&seq=10

James Simpson and the Chelsea Water Works Company

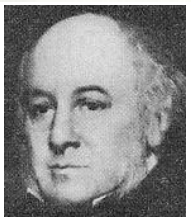
Best known of all the filtration pioneers is James Simpson. He was born July 25, 1799, at the official residence of his father, who was Inspector General (engineer) of the Chelsea Water Works Co. The house was on the north bank of the Thames, near the pumping station and near what was to become the site 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.



Contaminated well by cholera

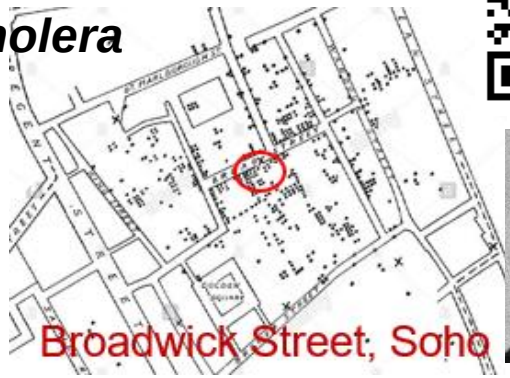


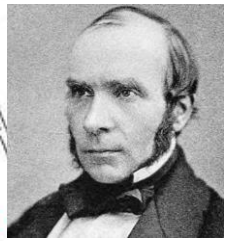
*James Simpson made an **artificial clear spring water** from polluted Thames water in **1829**.*

https://www.youtube.com/watch?v=lNjrAXGRda4

*In 1854, cholera struck Broad Street in London. **John Snow** could finally prove how this killer spread.*
We can understand the state of London during the Industrial Revolution.

A Large Outbreak Cholera in London in 1854

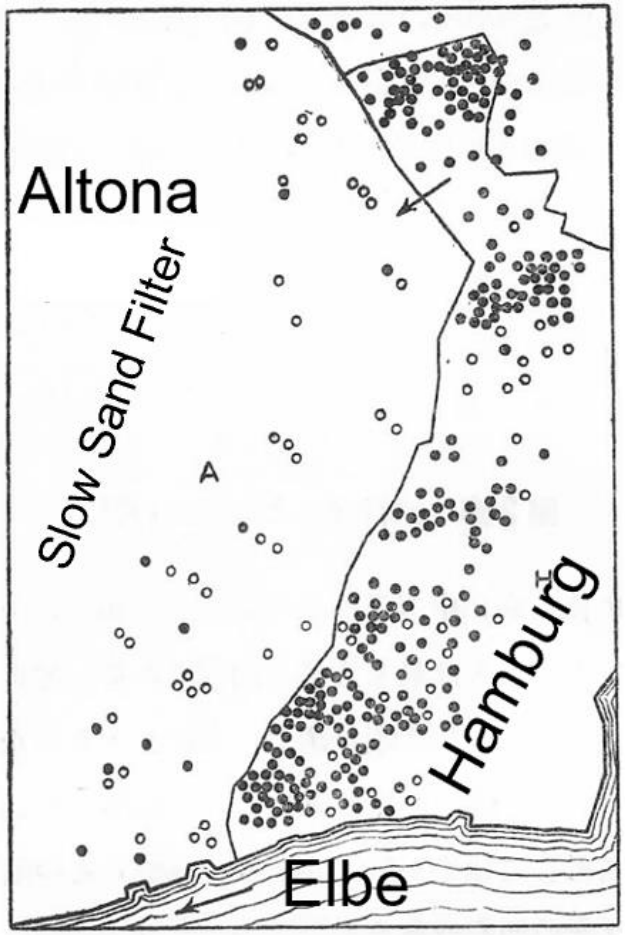




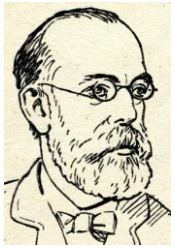
https://www.pbslearningmedia.org/resource/envh10.sci.life.nathis.johnsnow/john-snow-pioneer-of-epidemiology/

*How **John Snow**, a London physician, traced a major outbreak of cholera in the 1850s to its source. Using logic, statistics, and mapping, Snow rejected the idea that cholera was carried in a cloud of bad air. Instead, he believed contaminated water was responsible for spreading the disease among the local population.*

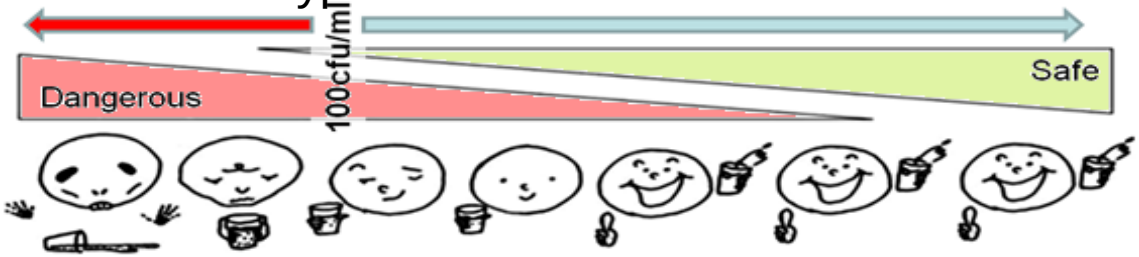
Simpson's SSF, which created clean water from river water contaminated with sewage, was spreading throughout London. And SSF expanded to other countries.



The clear proof of the filtration was provided in **1892**. This was **132 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.



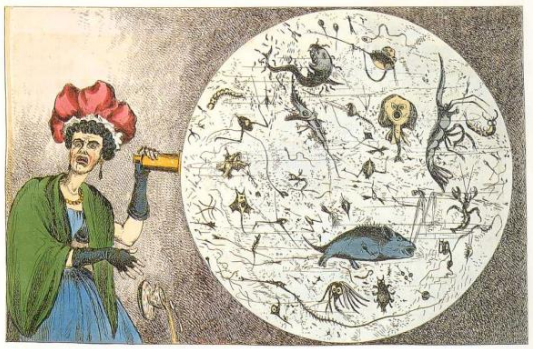
*They believed SSF was **mechanical reduction** of impurity by **slow** filtration with **fine sand**.*

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

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

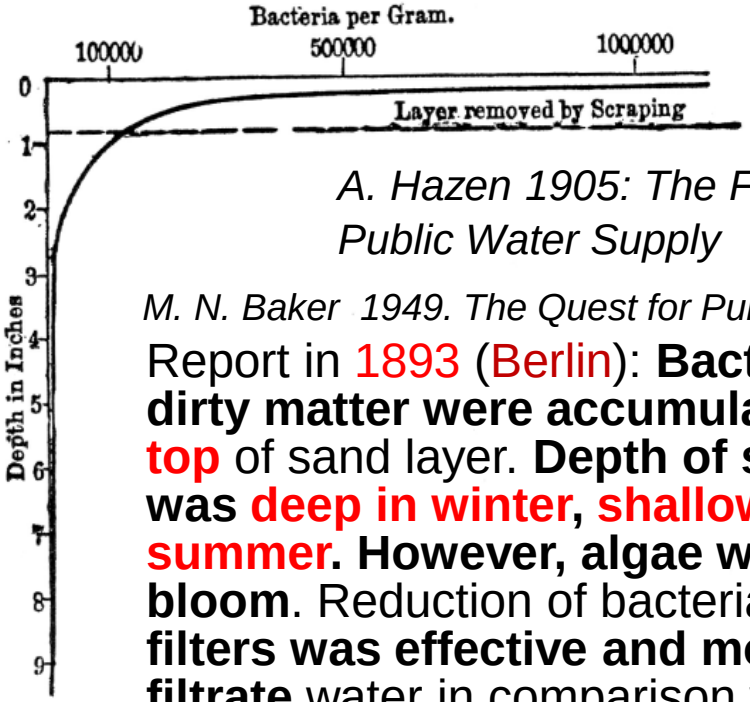
Wash our hands!
Reduce the risk.

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



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.



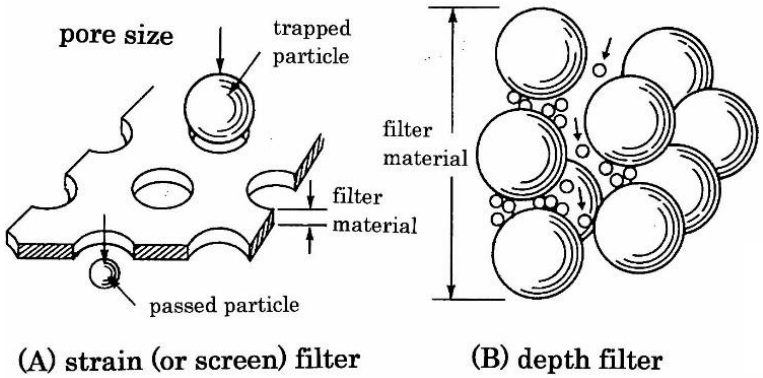
Lawrence, Massachusetts, USA

A. Hazen 1905: The Filtration of Public Water Supply

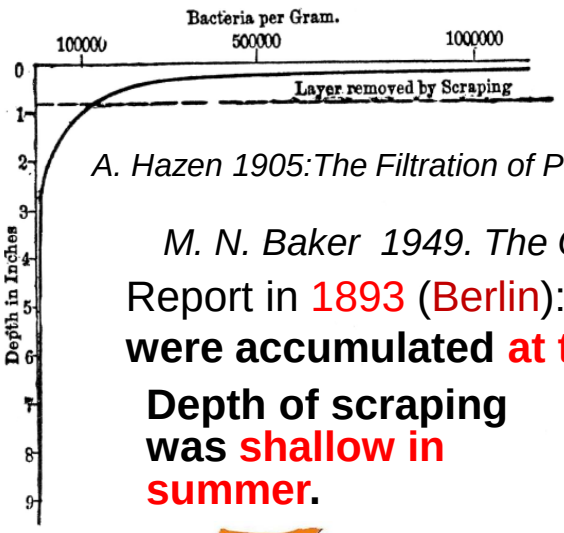
M. N. Baker 1949. The Quest for Pure Water

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 was effective and more clear filtrate** water in comparison with open and covered filters during 20 years. *But it may be especial case.*

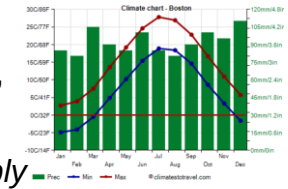
It was notified to biological phenomenon. However, he said that physical process was main.



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.**



Lawrence: Massachusetts, USA



A. Hazen 1905:The Filtration of Public Water Supply

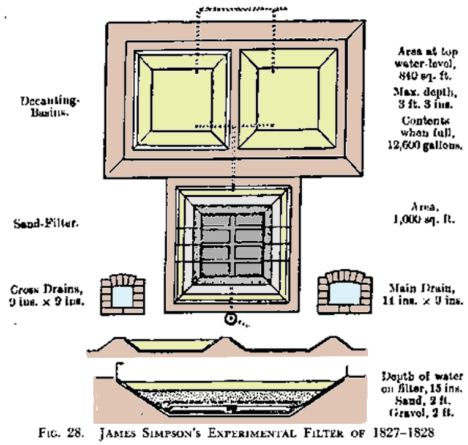
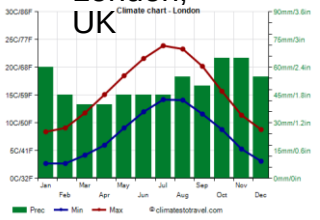


FIG. 28. JAMES SIMPSON'S EXPERIMENTAL FILTER OF 1827–1828

London, UK

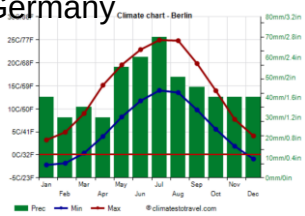


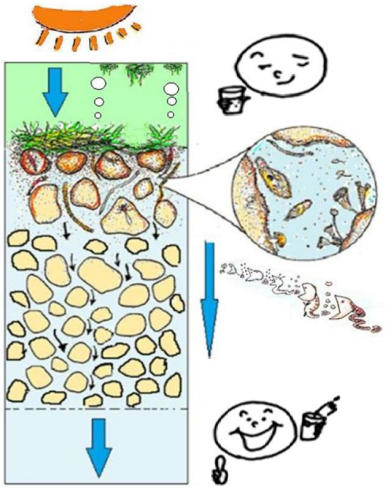
M. N. Baker 1949. The Quest for Pure Water

Report in 1893 (Berlin): **Bacteria and dirty matter were accumulated at the top** of sand layer.

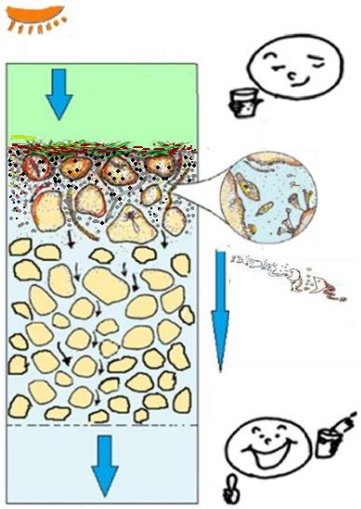
Depth of scraping was shallow in summer.

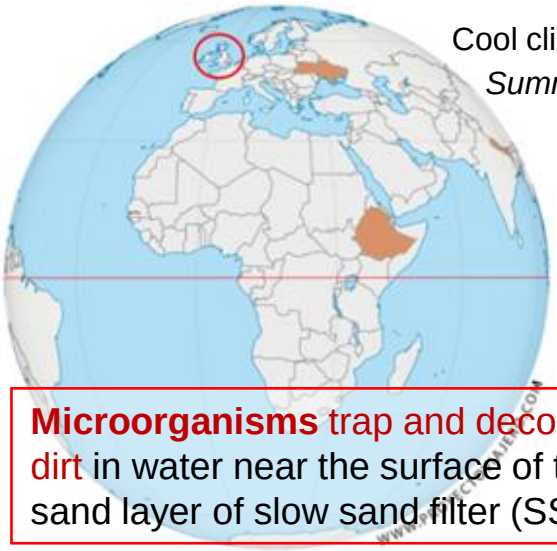
Berlin, Germany





Depth of scraping was deep in winter.





Cool climate region

Summer and winter

Warm (hot) region

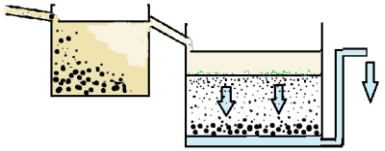
Always high biological activity

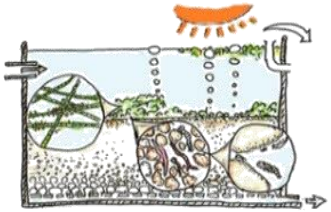
However, algae was in bloom. Reduction of bacteria in **open filters is effective and more clear filtrate** water in comparison with open and covered filters during 20 years.

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

I proposed **Ecological Purification System (EPS) in 2004** instead of the name of Slow Sand Filter.

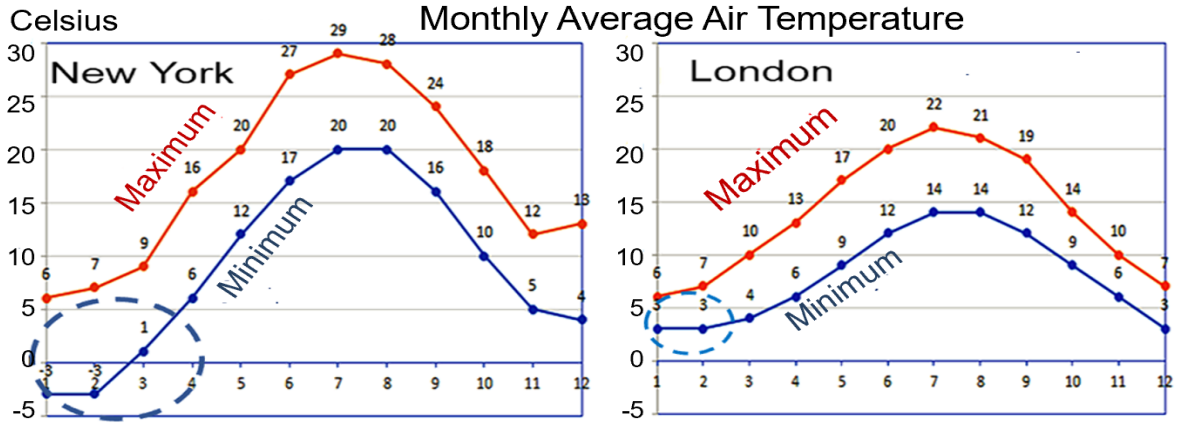
Covered filter,
Albany, NY, US





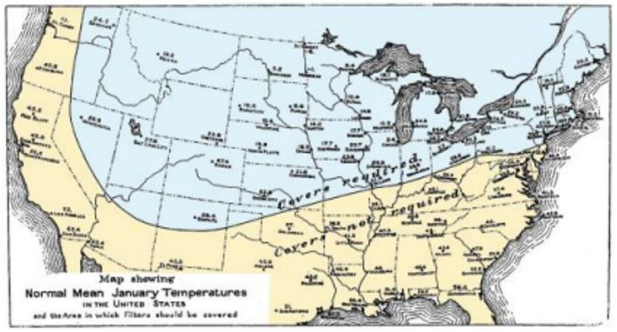
Safe drinking water was made by the biological activity.

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

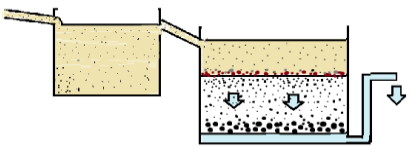


New York has cold winters and hot summers.

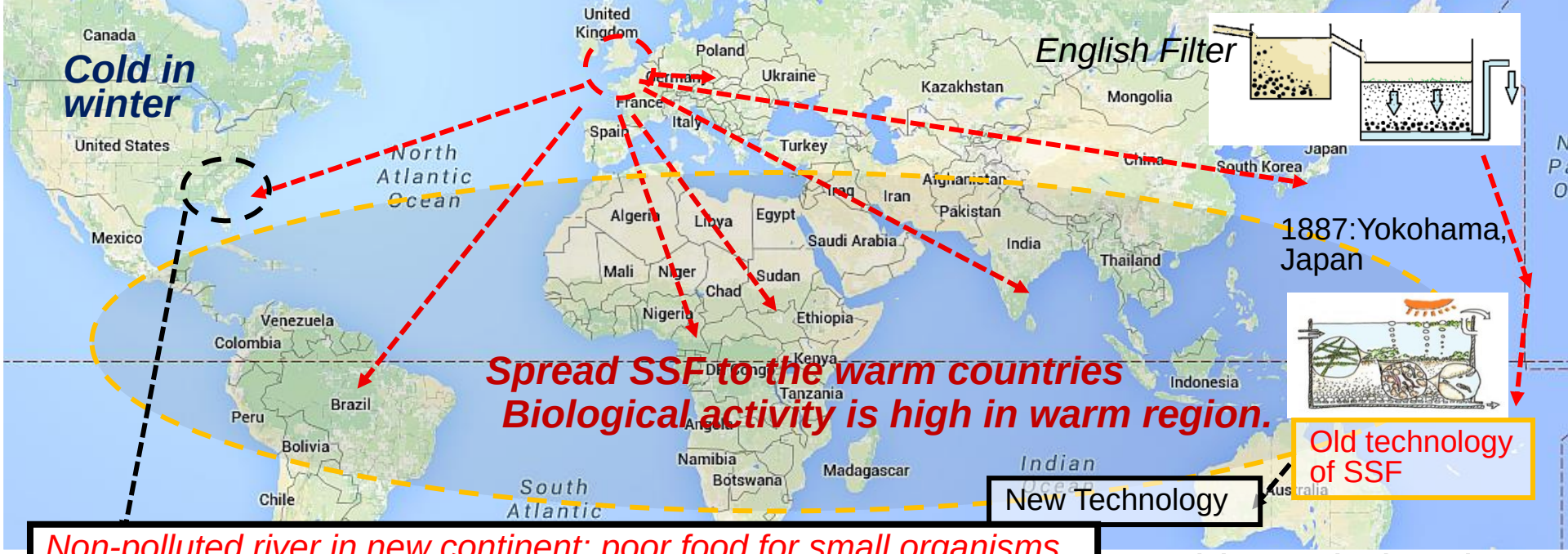
London is not cold even in winter due to the warm current.



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



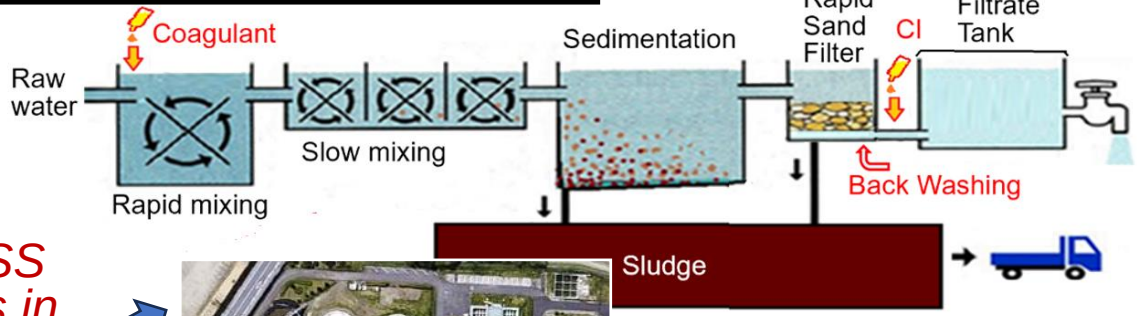
Winter temperature in North America is **cold** and the **biological activity** is **weak**.
And the **viscosity** of water is **high in winter**.



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

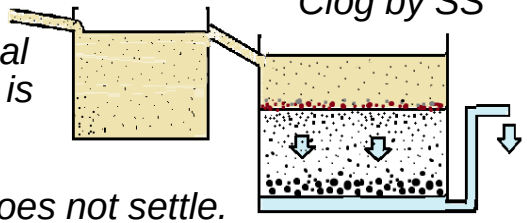


Non-polluted water contains fine SS and poor food for small organisms in continent river in USA.

Clog by SS

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

Does not settle.

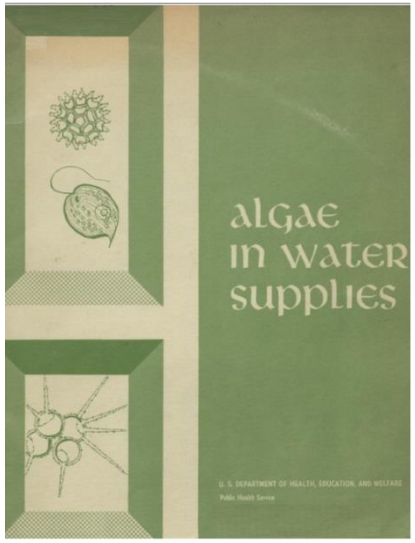


Filter easy to brock by suspended solid.

People loves new technology.

RSF spread to the world.

This is American Commercial Filter.

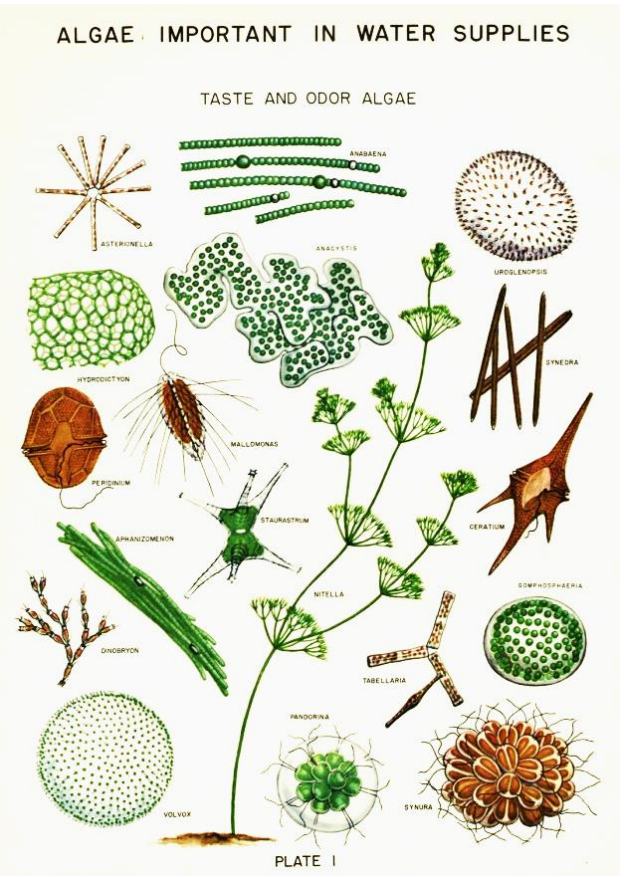


Algae in water supplies: an illustrated manual on the identification, significance, and control of algae in water supplies. C. M. Palmer 1962

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).*

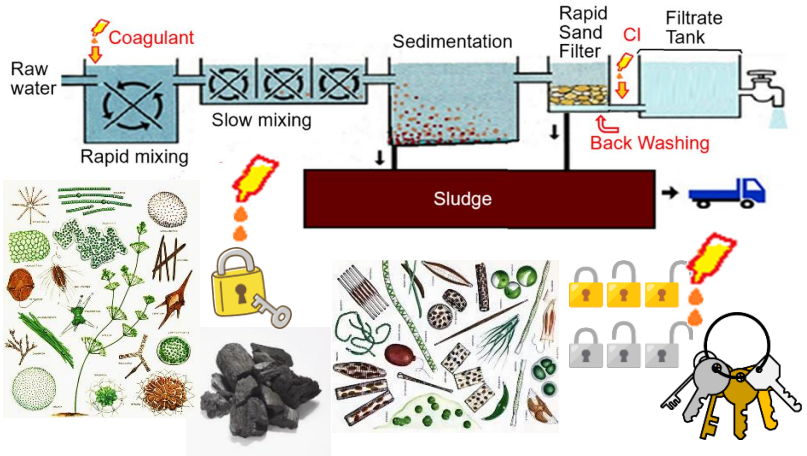
In slow sand filter, the algae and other aquatic microorganisms may play a ***useful part in the treatment process.***



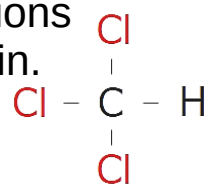
They form a loose, slimy layer over the surface of the sand and ***act as a filter****. The algae in this layer release oxygen during photosynthesis, and the oxygen in turn is utilized by aerobic saprophytic bacteria, fungi, and protozoa which establish themselves in and on the filter. This permits the 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.

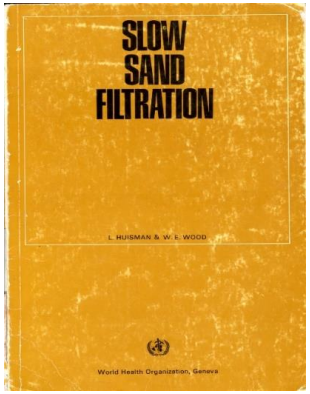


Rachel Carson 1962
Silent Spring.
Pesticides and herbicides have been pointed out the risk of chemical hazards through biological concentrations through the food chain.

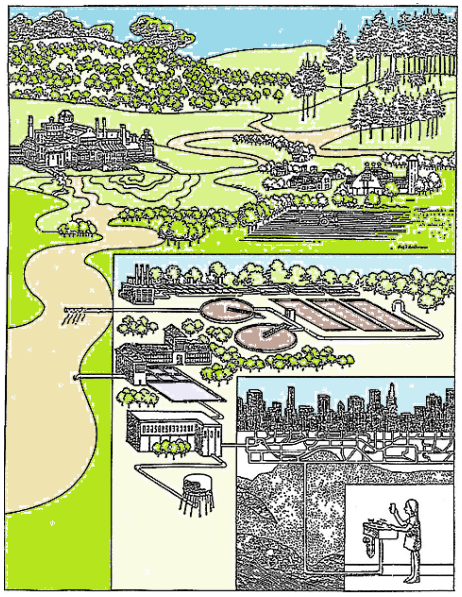


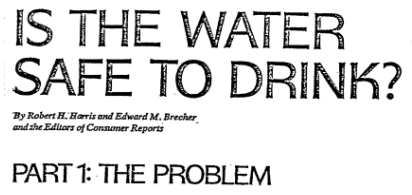
That was Chlorine compound.

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

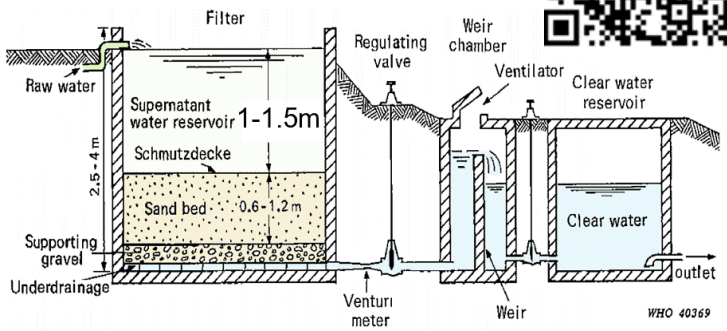


WHO published a manual of Slow Sand Filtration which is chemical free treatment for safe drinking water in 1974.



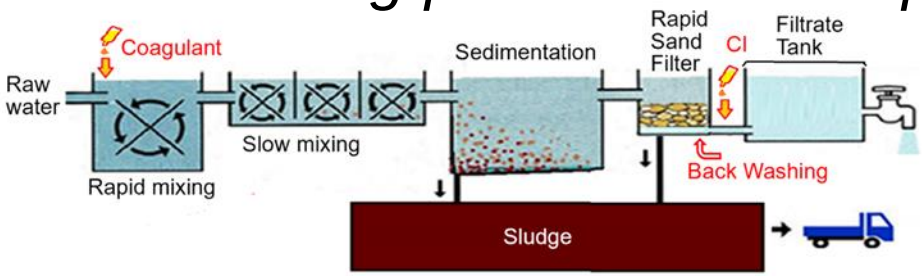


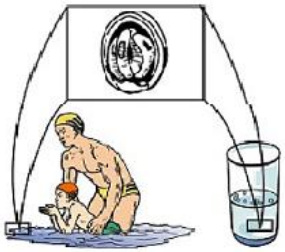
Robert H. Harris et. al. 1974 Consumer Report.
Chlorine sterilization is essential for rapid filtration of chemical treatment. There is a warning that trihalomethanes, which are carcinogenic substances, are generated by adding chlorine.

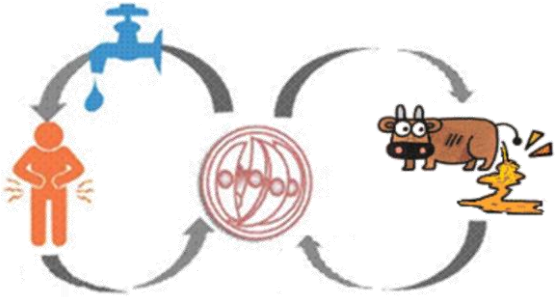


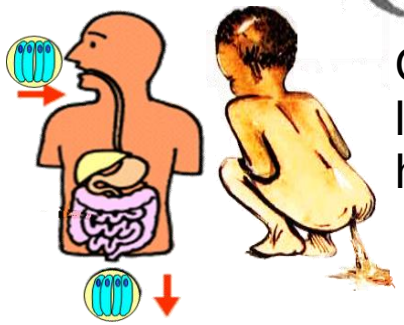
*Water depth is **1-1.5 m**.*
*Simpson's filter in 1827 is only **38 cm**.*

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









Only mammals with long intestinal tracts had watery diarrhea.

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.

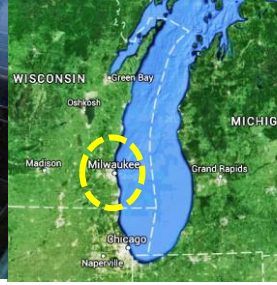
In In September 1994, the American Water Works Association held a slow filtration workshop in Salem, Oregon.

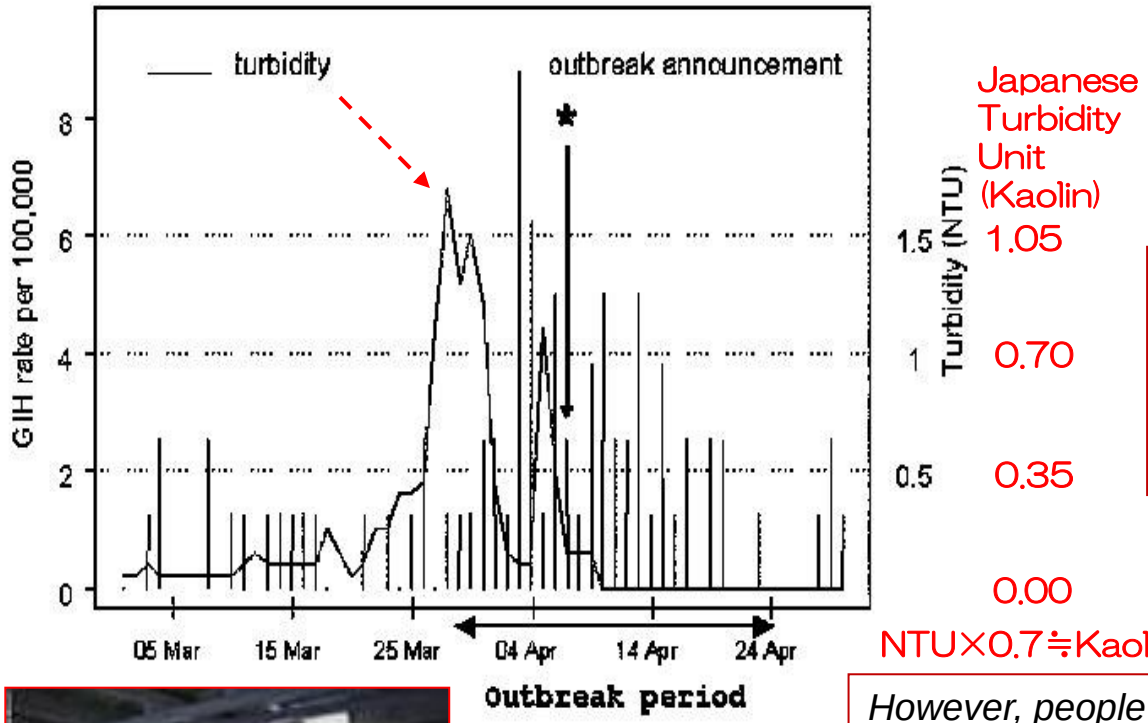
They said Refocus, Re-discovery, Timeless Technology for Modern Application.

It became clear that RSF was a deadly treatment.

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.

Membrane filtration was recommended in Japan after the diarrhea outbreak by cryptosporidium.

Refocus, Rediscovery, Timeless Technology for Modern Application.

JournalAWWA
Volume 88, Issue 12 December 1996
Pages 8-8

Acceptable Microbial Risk

Charles N. Haas

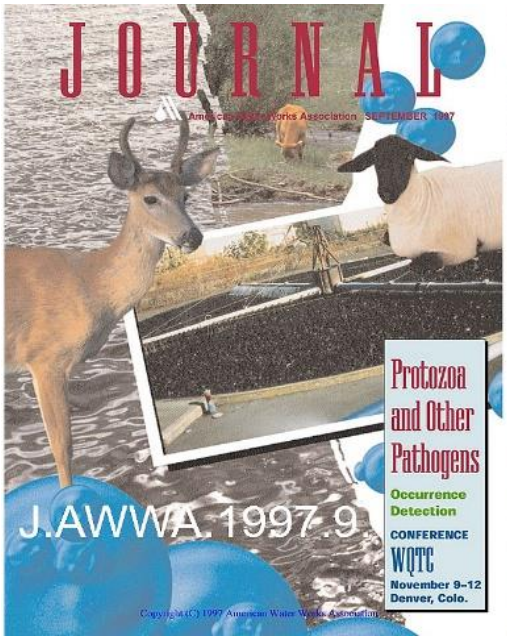
JournalAWWA
Volume 89, Issue 12 December 1997
Pages 14-15

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.



Opflow
American Water Works Association
Vol. 23 No. 10 October 1997

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.

VIEWPOINT

J. Am. Water Wks Assoc.
1997;89(12):8–9.

So Many Oocysts, So Few Outbreaks

Floyd Frost, Gunther F. Craun, Rebecca Calderon, and Stephen A. Hubbs

What is real risk?

What is more safe treatment?

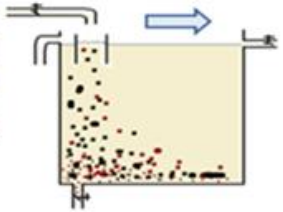
So many oocysts are detected everywhere, but there are almost no diarrheal infections.

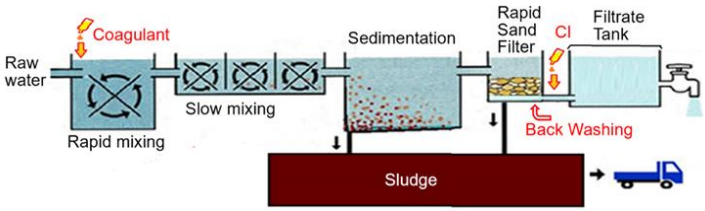
Turbidity mg/L

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.





Coagulant＋Chlorine
Rapid Sand Filter

SS passes by backwash.

2 degrees
Jap. standard

After Crypto outbreak.

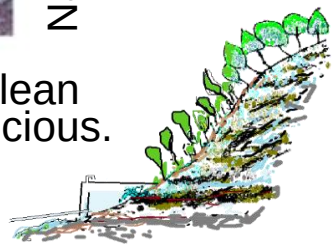
Recommended to 0.1 degrees

Chlorination is essential.

Purified by small organisms

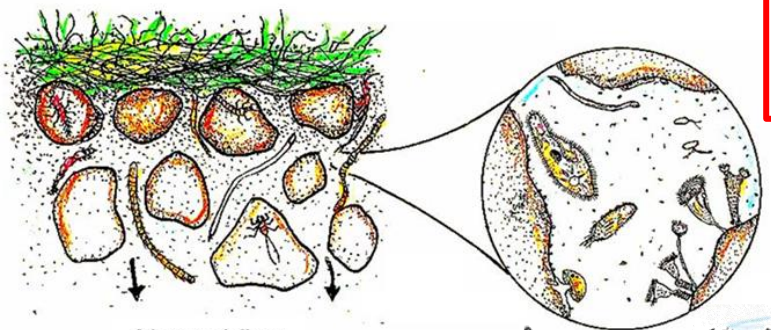
Natural spring

Super clean and delicious.



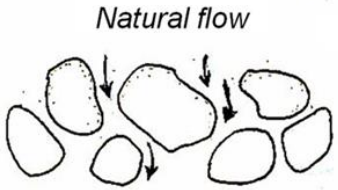
Artificial Natural spring water

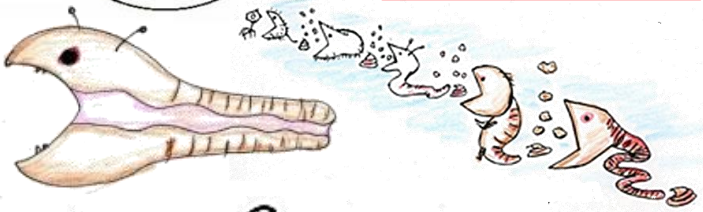
Purification by small organisms is done near the surface.



Food Chain is the key of Purification.

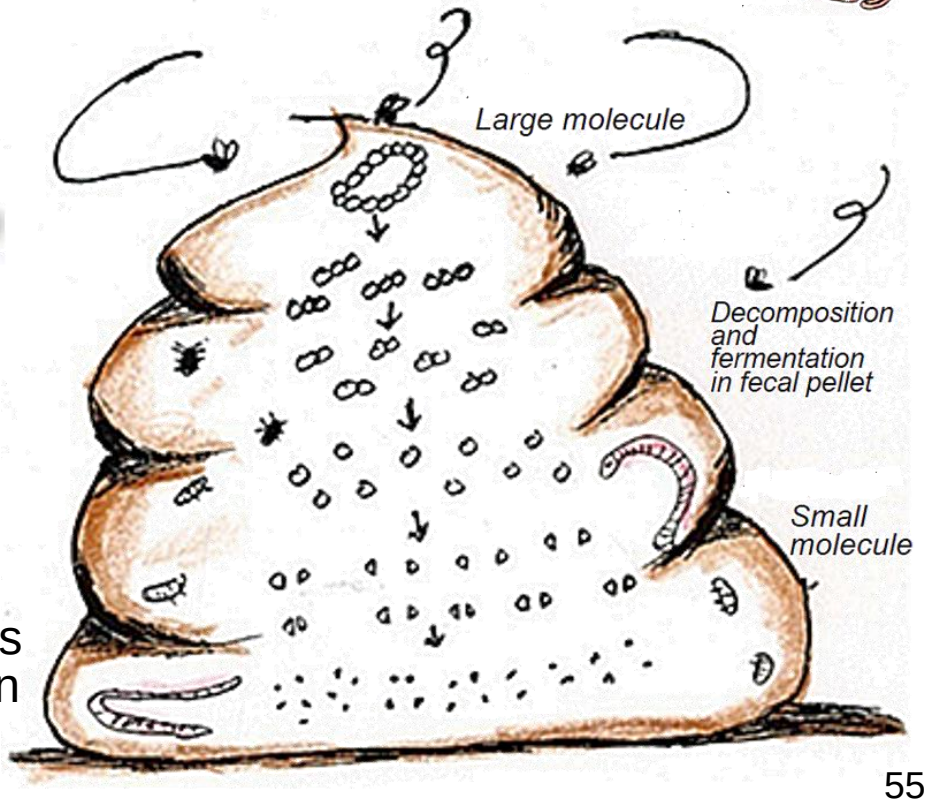
Gentle for every small organisms.





Living organisms has an ability to escape from risks.

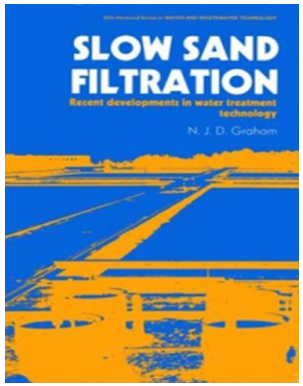
Hard surface to protect for risks.
Dry period, escape from grazer, escape to cold season.



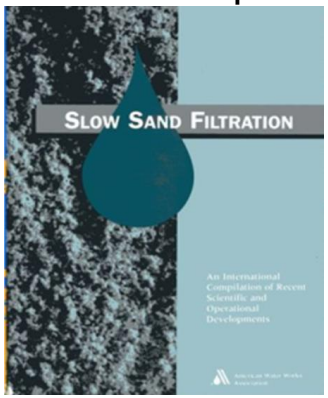
Large molecules are broken to small molecules under anaerobic condition in fecal pellets.

Focus to Slow Sand Filter from Chemical treatment of Rapid Sand Filter in the world.

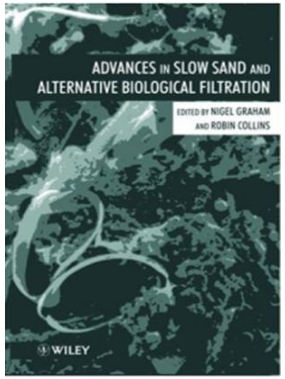
My first visit to Thames Filter was Aug. 1991.



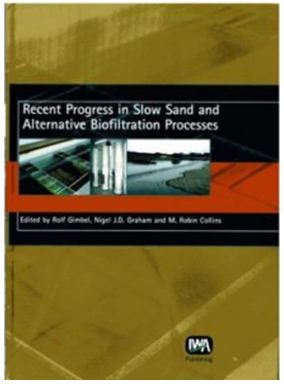
1988, Nov. 1st. SSF Conf. in London, UK



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



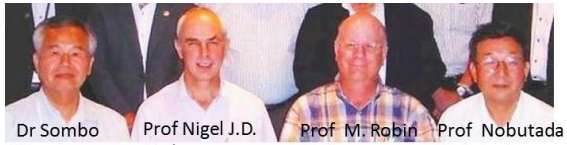
1996 April, 3rd SSF Conf. in London, UK



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

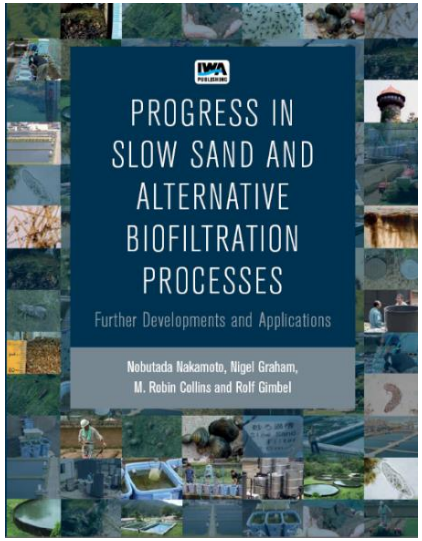
I could study on Thames Filters during 1994 to 1996.

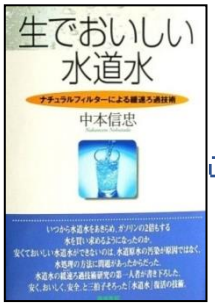
Eco-Tech Award. World Expo. 2005. Aichi, Japan.



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

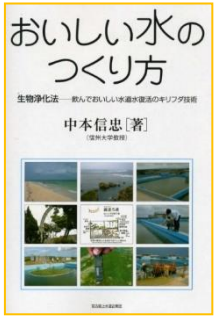
https://www.youtube.com/results?search_query=5ssabc





May, 2002.

Aug. 2005.



Aug. 2005.

May, 2009.

Chinese, China

For Miyako wks.

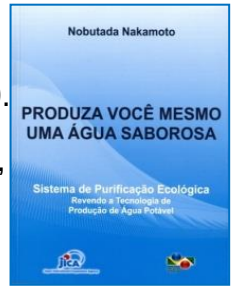
***Natural** filter of slow sand filter*

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

March, 2009.

Internet text by JICA

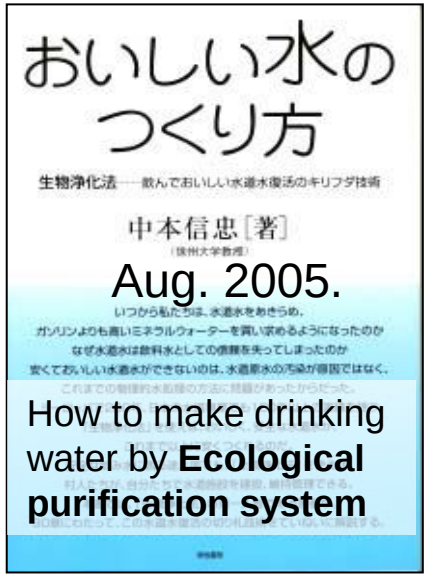
July, 2010.

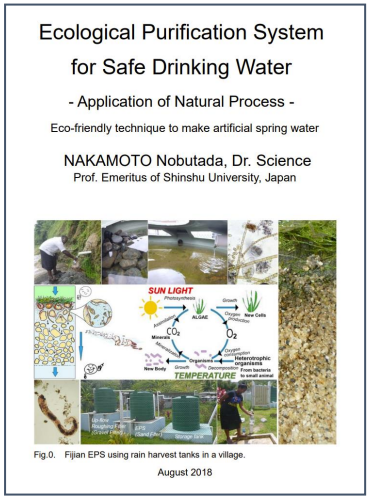


Portuguese, Brazil

Ecological Purification System was focused and recognized.

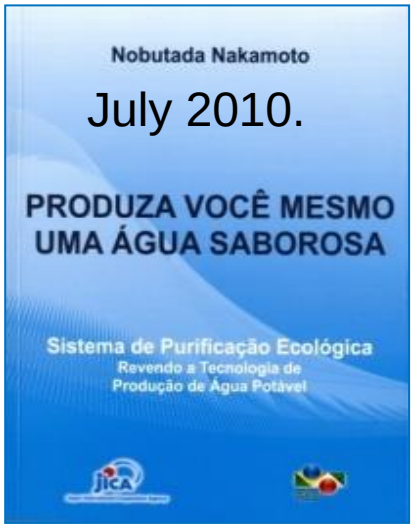
JICA supports EPS as Japanese innovation for the people.





August, 2018

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



Internet text by JICA

Slow sand filtration: creating clean, safe water

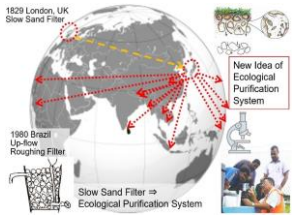
(26 min Full)

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

(3 min Digest)

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

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



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

1-19 | 19

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

20-31 | 12

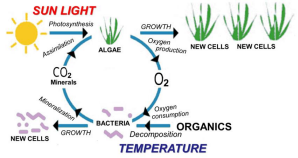


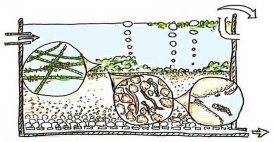
2. Key of purification in nature is food chain. Refocus to Slow Sand Filter.
浄化は食物連鎖が鍵、緩速ろ過の再認識

32-57 | 26

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

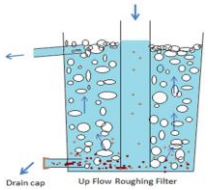
58-79 | 22





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

80-108 | 29



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

109-124 | 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

125-147 | 23



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

148-157 | 10



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

158-172 | 15



JICA training in Hiroshima in July, 2024.

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

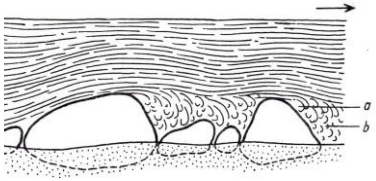
Just after storm event, stone and sand became clear.

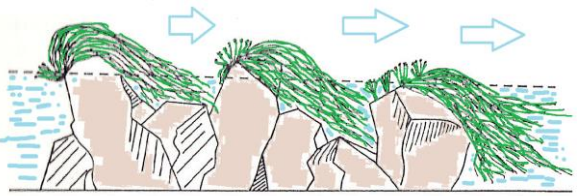
Small organisms on and among rocks were flushed out.

Gentle for small organisms is the key to make **clean water**.

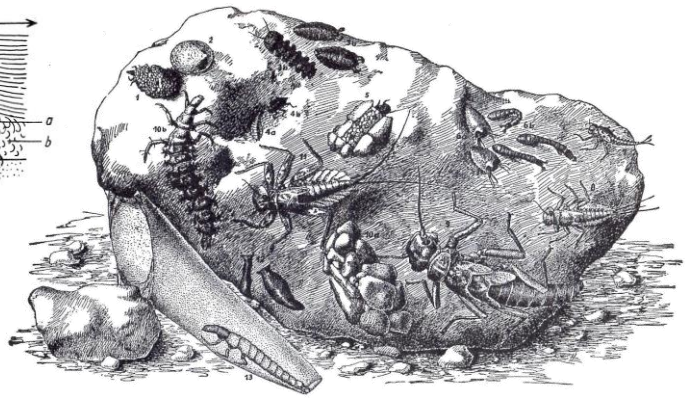
*Sand, stone and rocks **don't role and move** in a small creak among dense forest.*

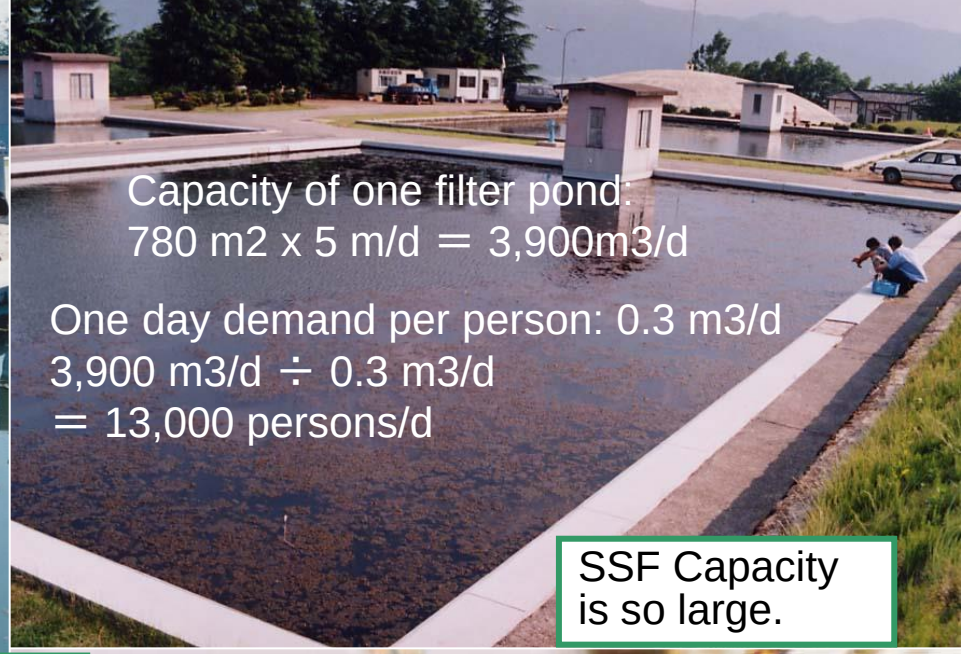
When plants and animals do not flush out, water is always clear.





Small animals on the surface of rocks collect turbid matters.





Capacity of one filter pond:
780 m2 x 5 m/d ＝ 3,900m3/d

One day demand per person: 0.3 m3/d
3,900 m3/d ÷ 0.3 m3/d
＝ 13,000 persons/d

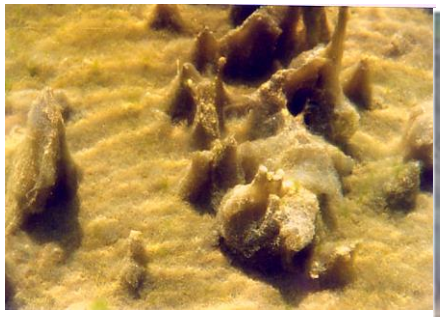
SSF Capacity is so large.

Continuous Culture system of filamentous diatom

Algal mat lifts by oxygen bubbles produced by photosynthesis.

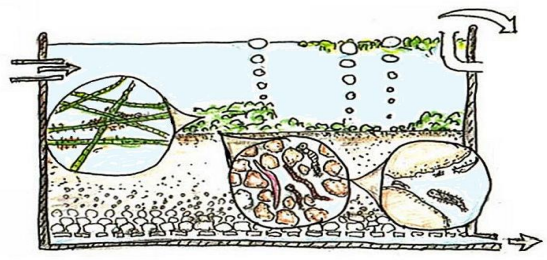
Particles were trapped to the filamentous algae.

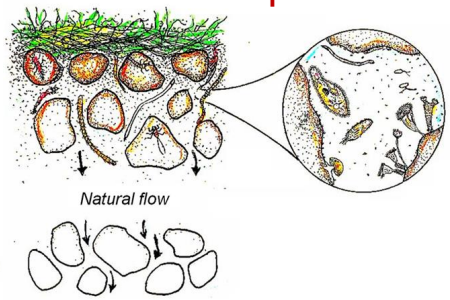
There is a thin **slimy (gelatinous) mat** known as the *Schmutzdecke*, or filter skin on the surface of the sand layer in many textbooks. *This explanation is not correct.*

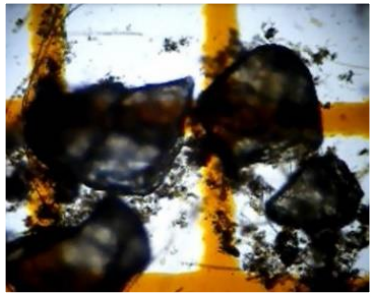


On the surface of sand layer, there is a **soft mat like light feather** mat. Filamentous algal mat is just lay down.

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.

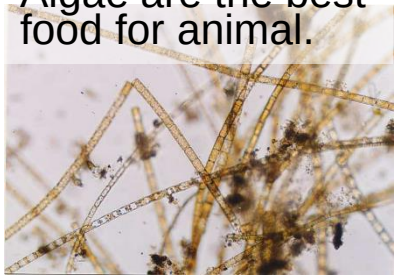


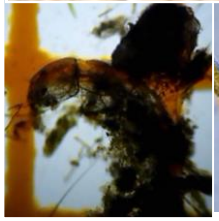


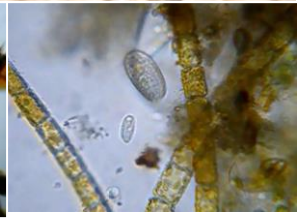


On the shallow bottom, filamentous algae grow well.

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

Nobutada Nakamoto
Department of Applied Biological Science
Shinshu University
Ueda, Japan

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

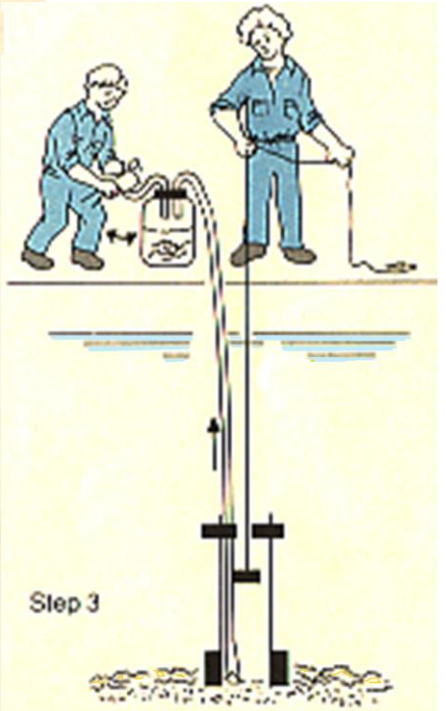
2. Drill a hole in the inner hammer rod for the hanger string.

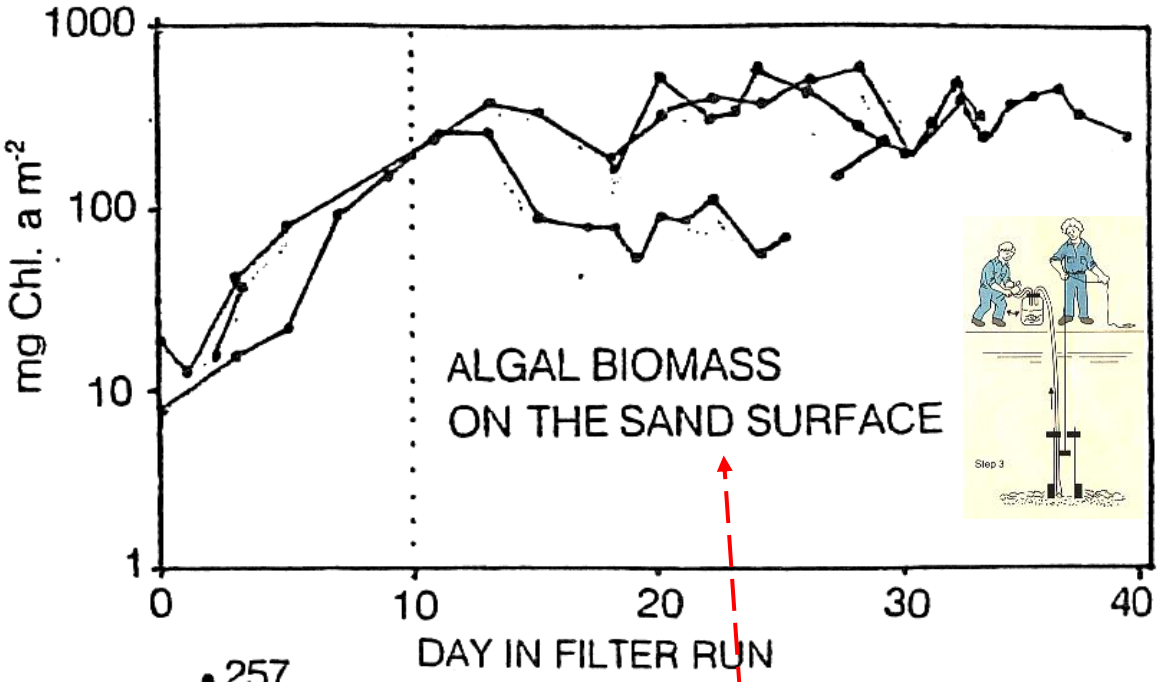
3. In the stopper rod, drill 0.18-in. (4.5-mm) diameter holes in the center for

(continued on page 4)

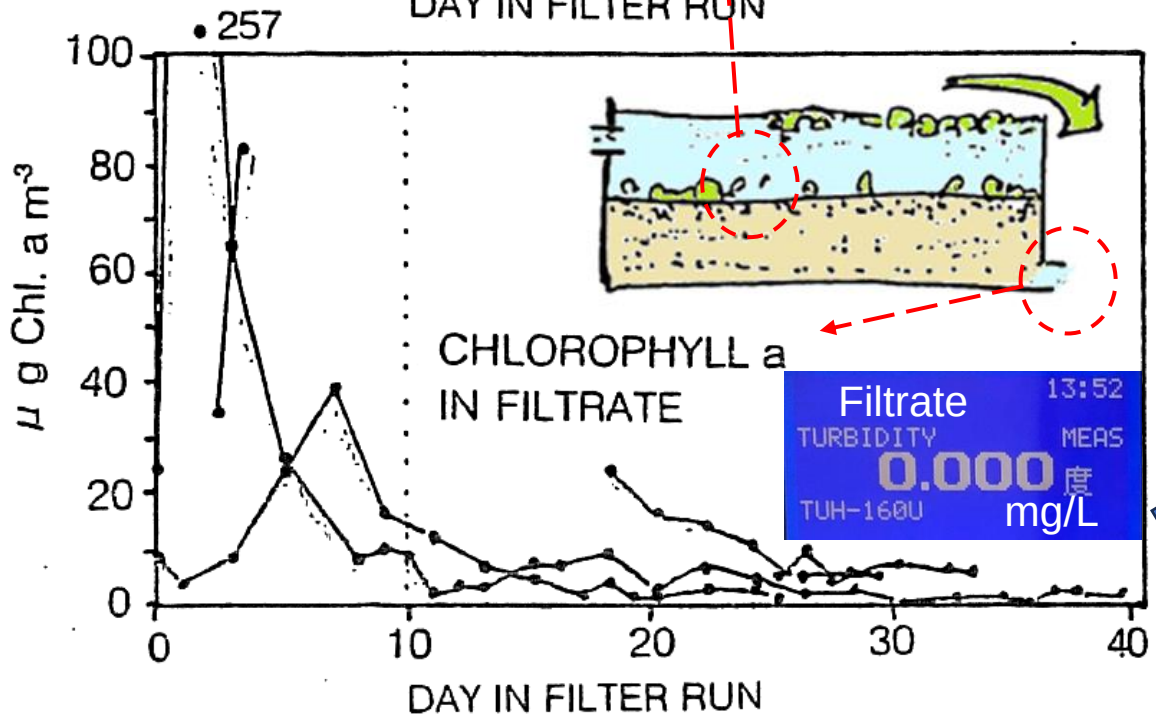
Materials and Costs of the Schmutzdecke Sampler

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.



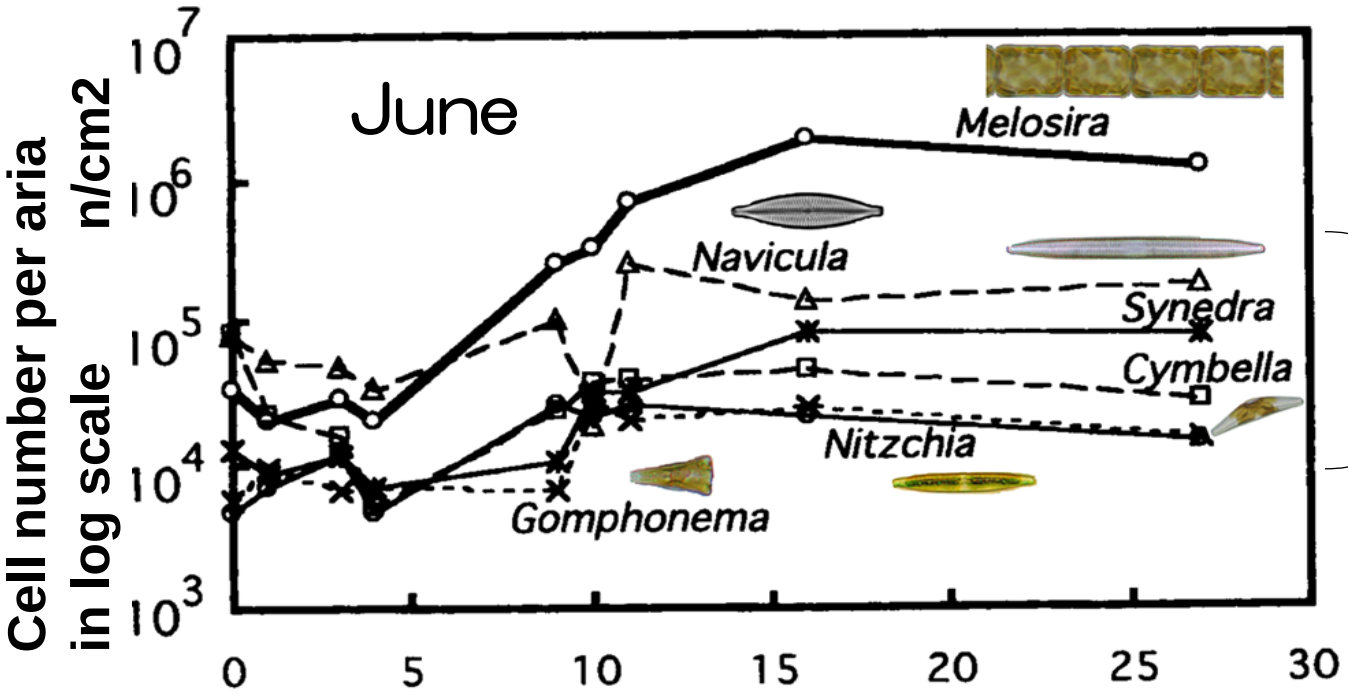
Filtrate water became clear water in 10 days. Grazing animal community grew well within 10 days.

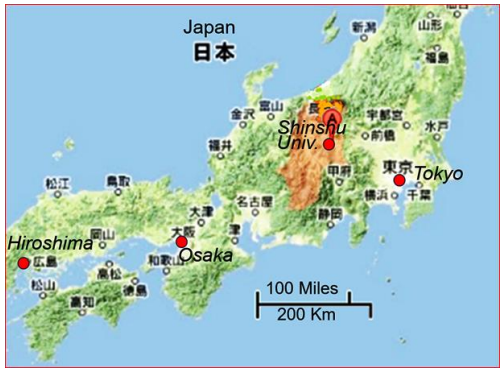
In summer, scrapping of surface mud is not necessary.

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

Super clean filtrate.

Development of algae on the sand bed during filter run in June in Ueda, Japan.



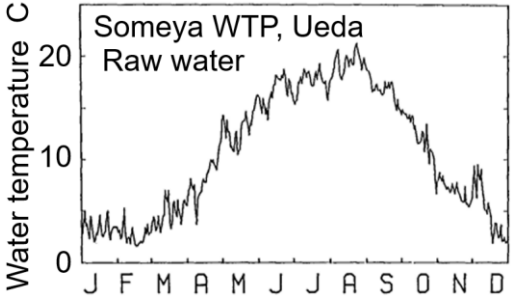


From a river

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

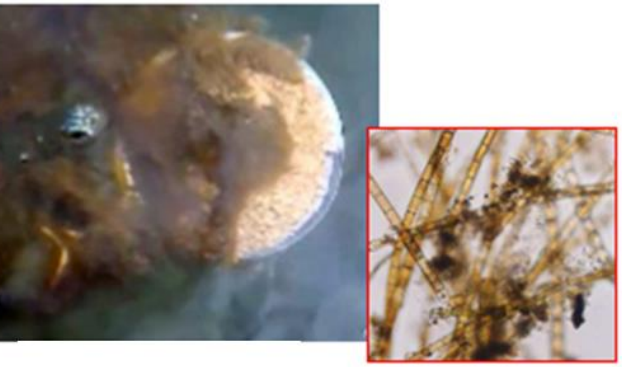
Filamentous algae grow well on the sand filter bed.

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

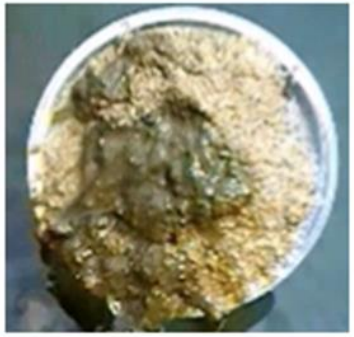


Seasonal change of temperature

My city (Ueda, Nagano, Japan) is located in cool region in Japan.



Algal mat on the sand surface in water.



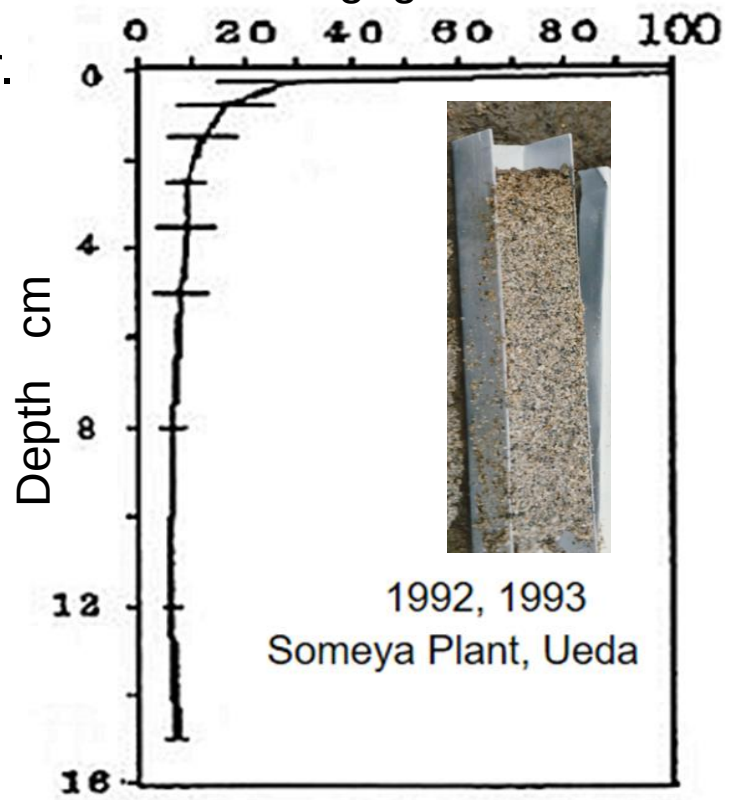
Lift up in air.

At scraping time, we took sand sample.

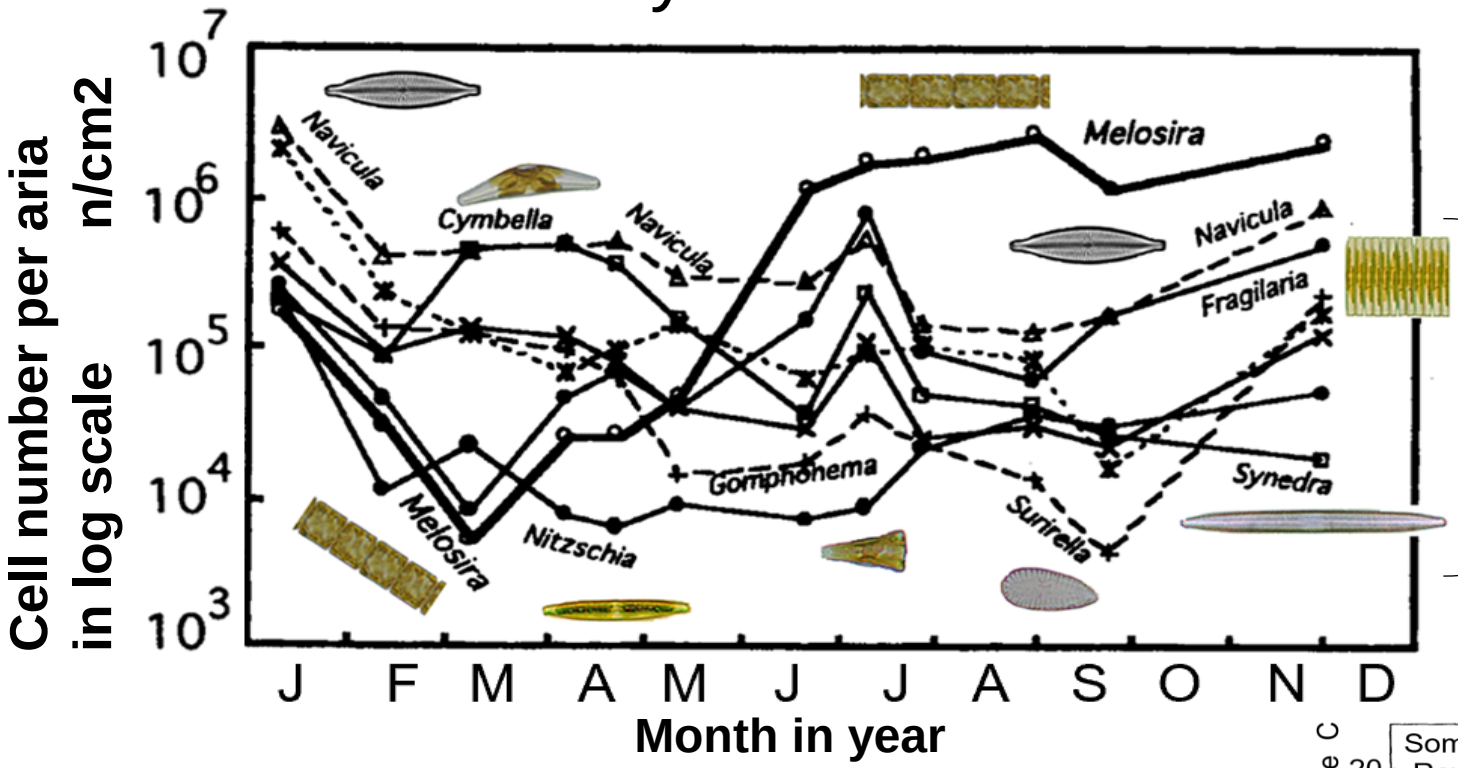
Sand beneath the surface in water is clean.
When the supernatant water drain off, the trapped SS releases and drops into sand layer.

Dirty Suspended matter is only near the surface.

Suspended Solid in washed sand.

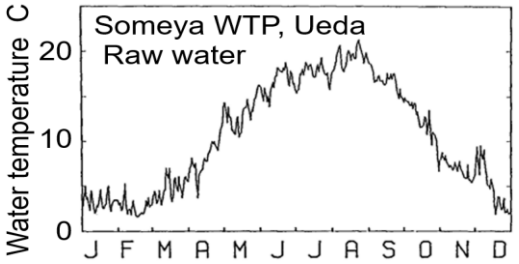


Seasonal changes of the algal mat after 10 days of filtration run.



From a river

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



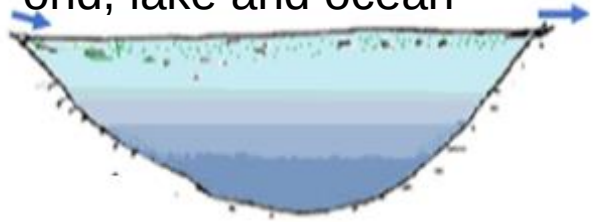
Weak biological activity in cold water.

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

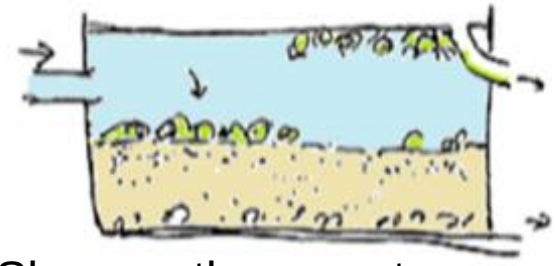
Different type of algae grow in different environment.

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

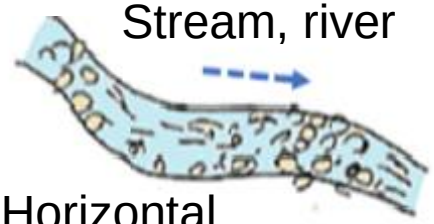


Stagnant water



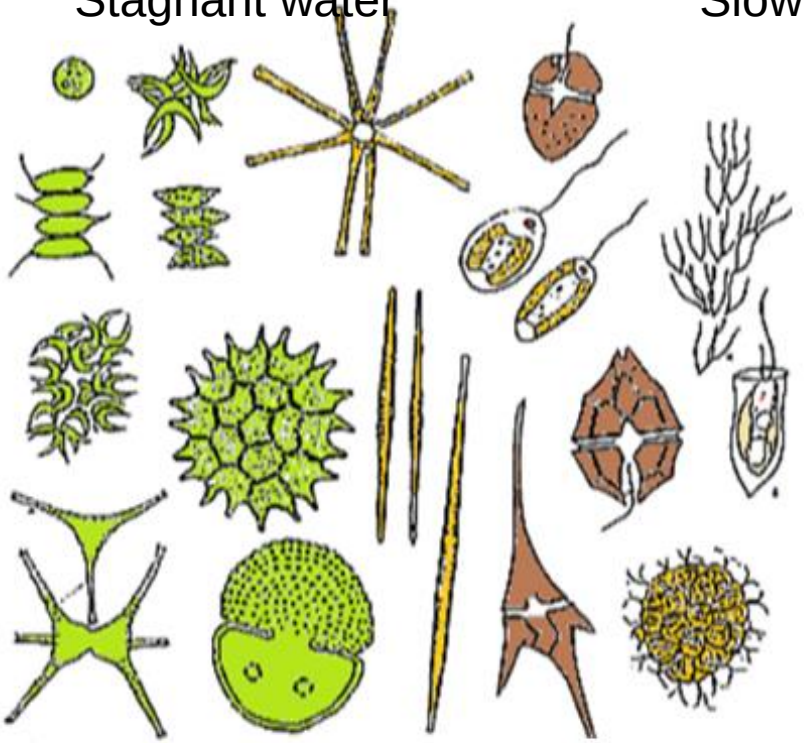
Slow gentle current

Stream, river



Horizontal running water

Occasional storms and rapid currents.



Float and drift algae

Phytoplankton

Flagellated algae

Filamentous algae

Periphyton

Attached algae

Try to accelerate algal growth in winter.

Algal growth made delicious tap water.

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

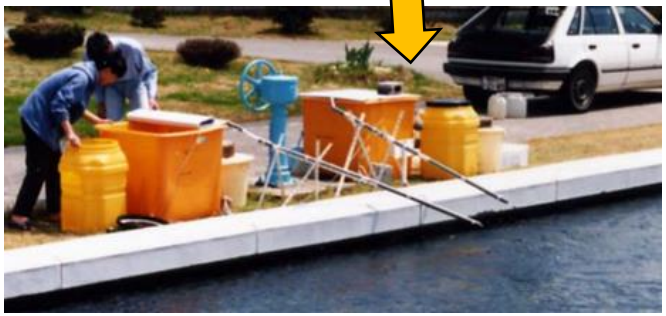
I thought that the nutrient concentration in rivers in Ueda city was poor than in London.

I thought the nutrient concentration was too low.

I put nutrient to the filter pond in cold winter.

But no growth of algae in the filter pond.

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



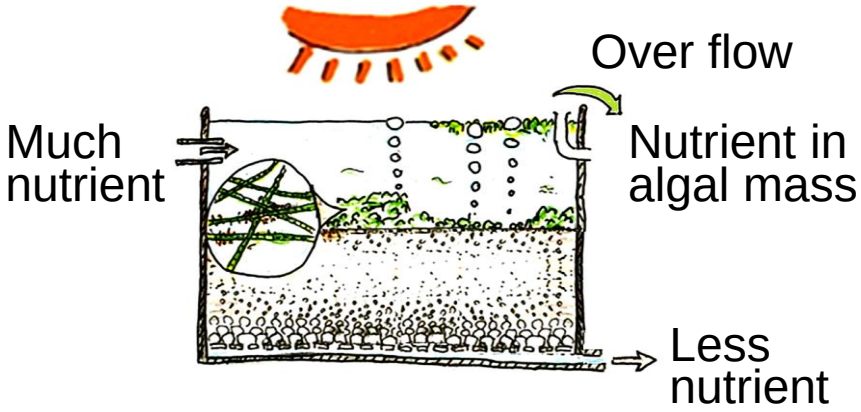
In March when snow melt period, algae did not grow in the filter pond.

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 is a nutrient reducing system.

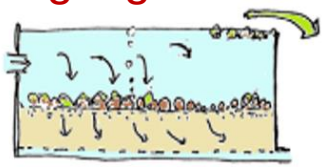


Harvest experiment was done.

Average daily harvest during 11 days in July

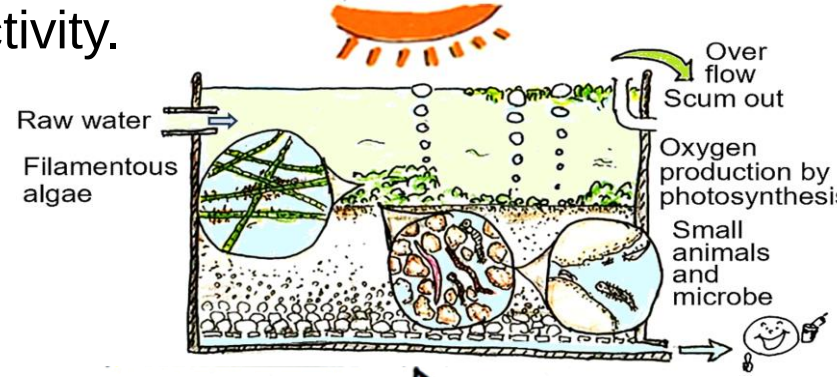
Wet matter	173 g/m2
Dry matter	25.9 g/m2
Organic matter	7.81 g/m2
Nitrogen	373 mg/m2
Phosphorous	32 mg/m2

Nutrient reduction from inflow water to filtrate by algal growth.



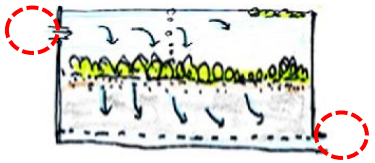
Nutrient removal as
Nitrogen 4.6 %
Phosphorous 27%

Aerobic condition is essential for biological activity.



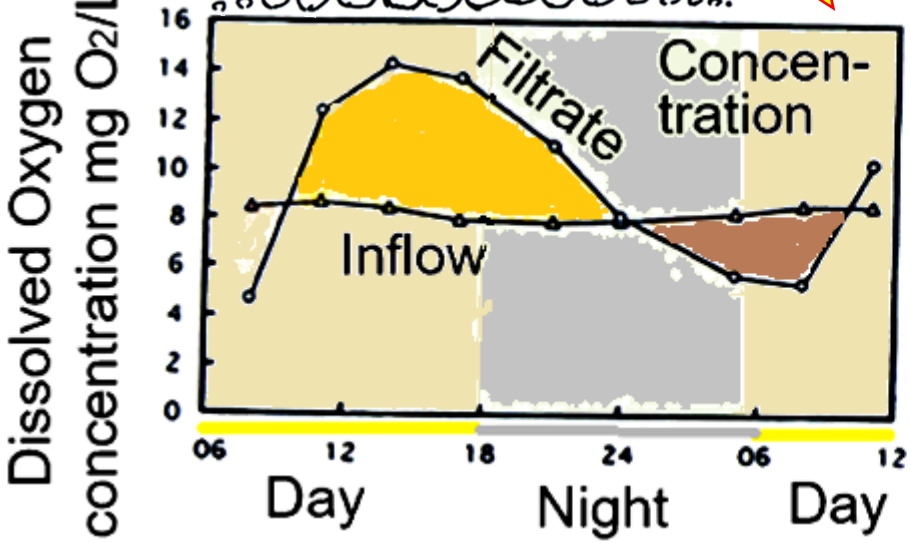
$$CO_2 + H_2O \rightleftharpoons CH_2O + O_2$$

There is down ward current.



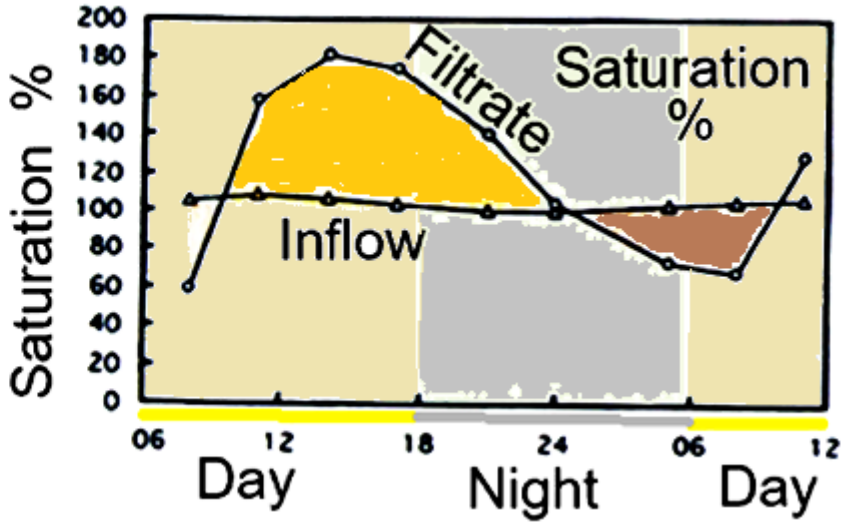
Diurnal change of dissolved oxygen (DO) was measured.

Partial pressure of oxygen in bubbles was also measured.



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

Algal photosynthesis accelerates purification process.



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

Bubbles keep aerobic condition after sunset.

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

Ashford Common WTP, Thames Water

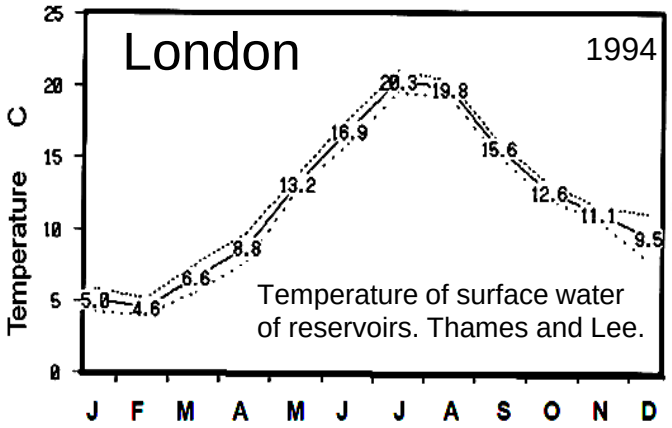
Nutrient rich water

Biological roughing filter without chemical.

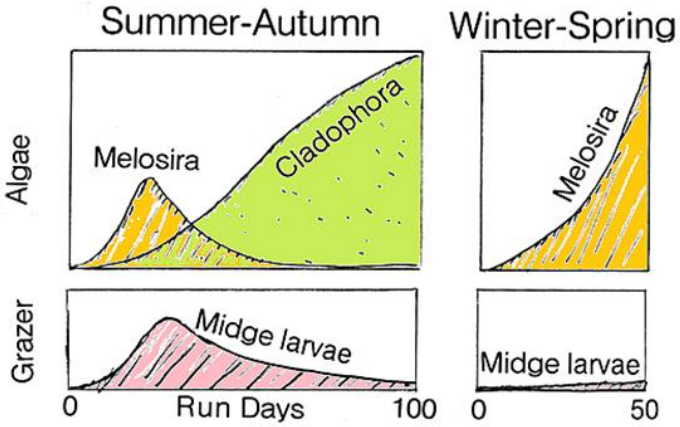
100mx35m
32 Filters

Filamentous green algae bloom in summer

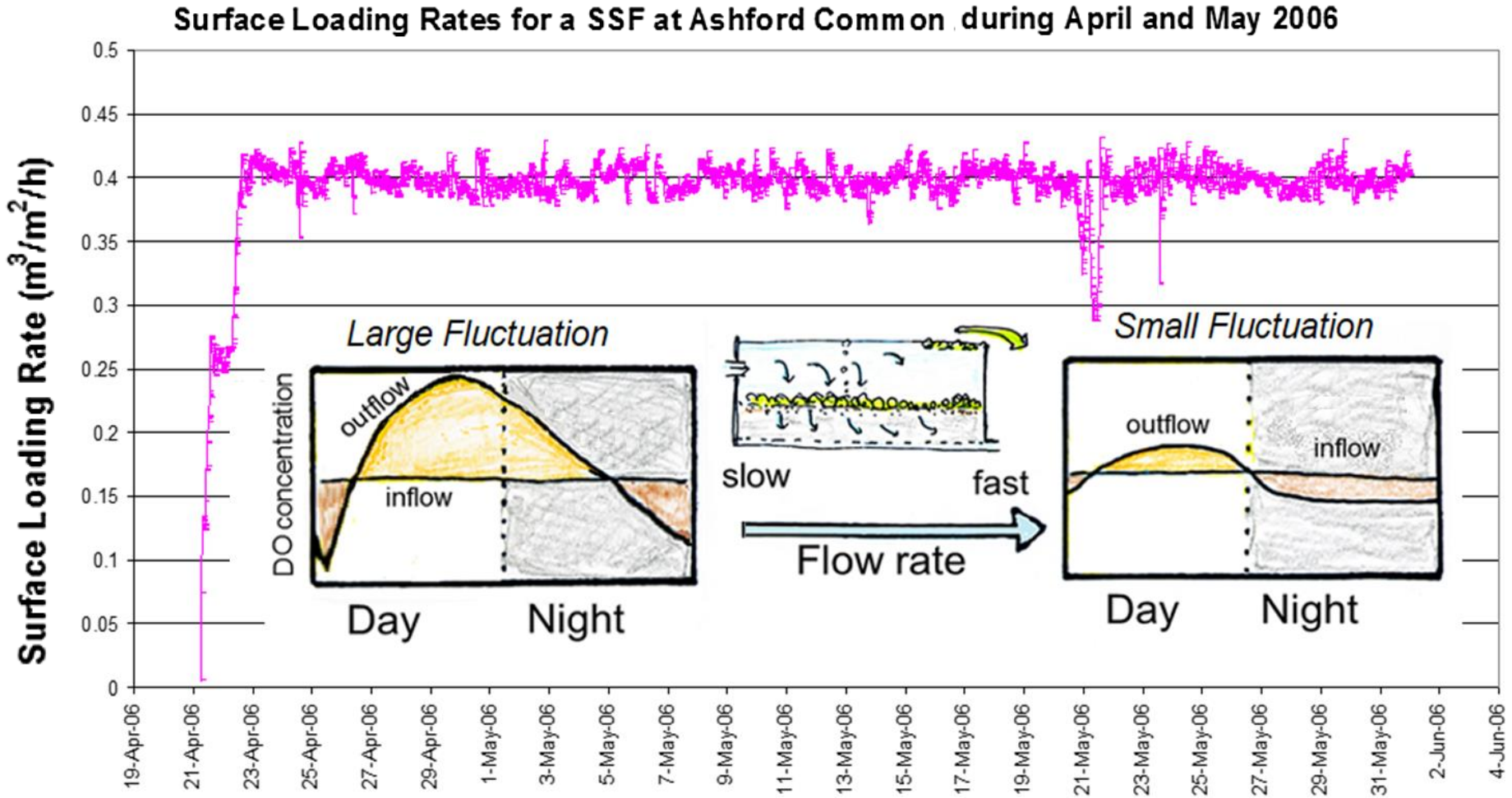
Filamentous diatom in winter



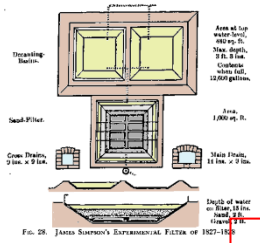
Temperature of surface water of reservoirs. Thames and Lee.



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).

38cm water depth

200yrs ago

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

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

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

W. K. Burton published "**The Water Supply of Towns and the Construction of Waterworks**" in **1894** in London.

https://wellcomecollection.org/works/da2p35kj/items

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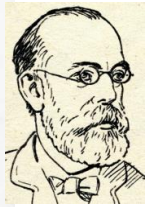
practice. Dr. Koch, the eminent bacteriologist, has (the writer understands) come to the conclusion that a filtering speed should never exceed $7\frac{3}{4}$ feet in twenty-four hours. It seems unlikely that any such hard-and-fast rule can hold good for all cases,* for there can be no doubt that the efficiency of filtration varies with many circumstances—with the purity or the reverse of the water, for example; with the nature of the sand; and with the temperature.

* A series of experiments, both biological and chemical, carried on in connection with the Osaka (Japan) waterworks, gave very different results from this.

It has recently been discovered, at the Berlin waterworks, that covered filters are much less efficient than open.



Dr. R. Koch neve exceed 7 ¾ feet in 24 hrs. = **2.27 m/d**

Osaka(Japan) wks gave very different results from this.
➪ **faster rate?**

Berlin wks discovered that covered filters are much less efficient than open.
➪ **Open is better.**

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On the other hand, the much higher velocities—16 feet in twenty-four hours or even more—adopted by some English engineers, are undoubtedly too high.

It is with some diffidence that the writer states the conclusion he has come to—namely, that a *maximum filtering speed of* 10 *feet in twenty-four hours is quite permissible* in the case of water already fairly good. That is to say, with arrangements properly

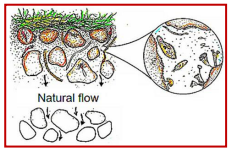
English engineers adopted more 16 feet in 24 hrs. = **over 4.88 m/d**

Burton : max 10 feet in 24 hrs. = **max 3 m/d**

At that time in 1894, he believed that purification was done by slow speed with fine sand.

This means **mechanical filtration**.

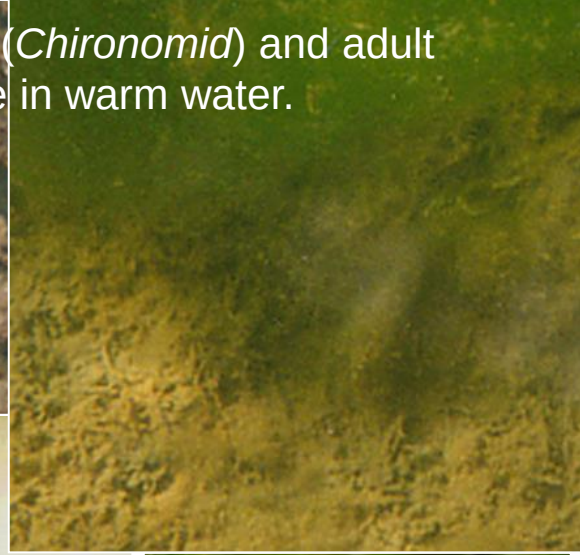
Present Thames wks adopts **9.6 m/d.**



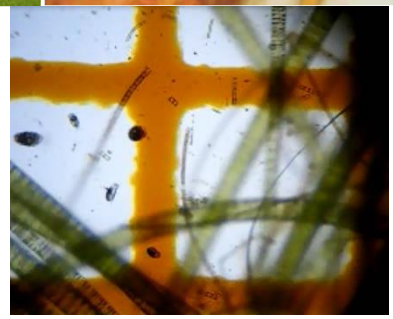
This means **Ecological Purification System**.

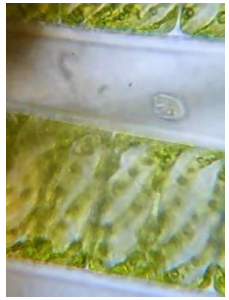
Filamentous diatom of *Melosira* in cold water.

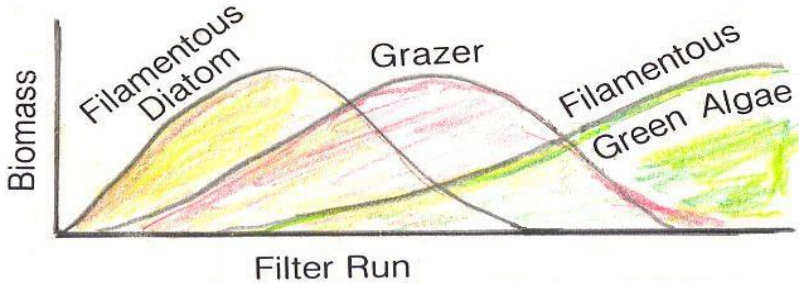
Casting skin of midge(*Chironomid*) and adult midge are remarkable in warm water.



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

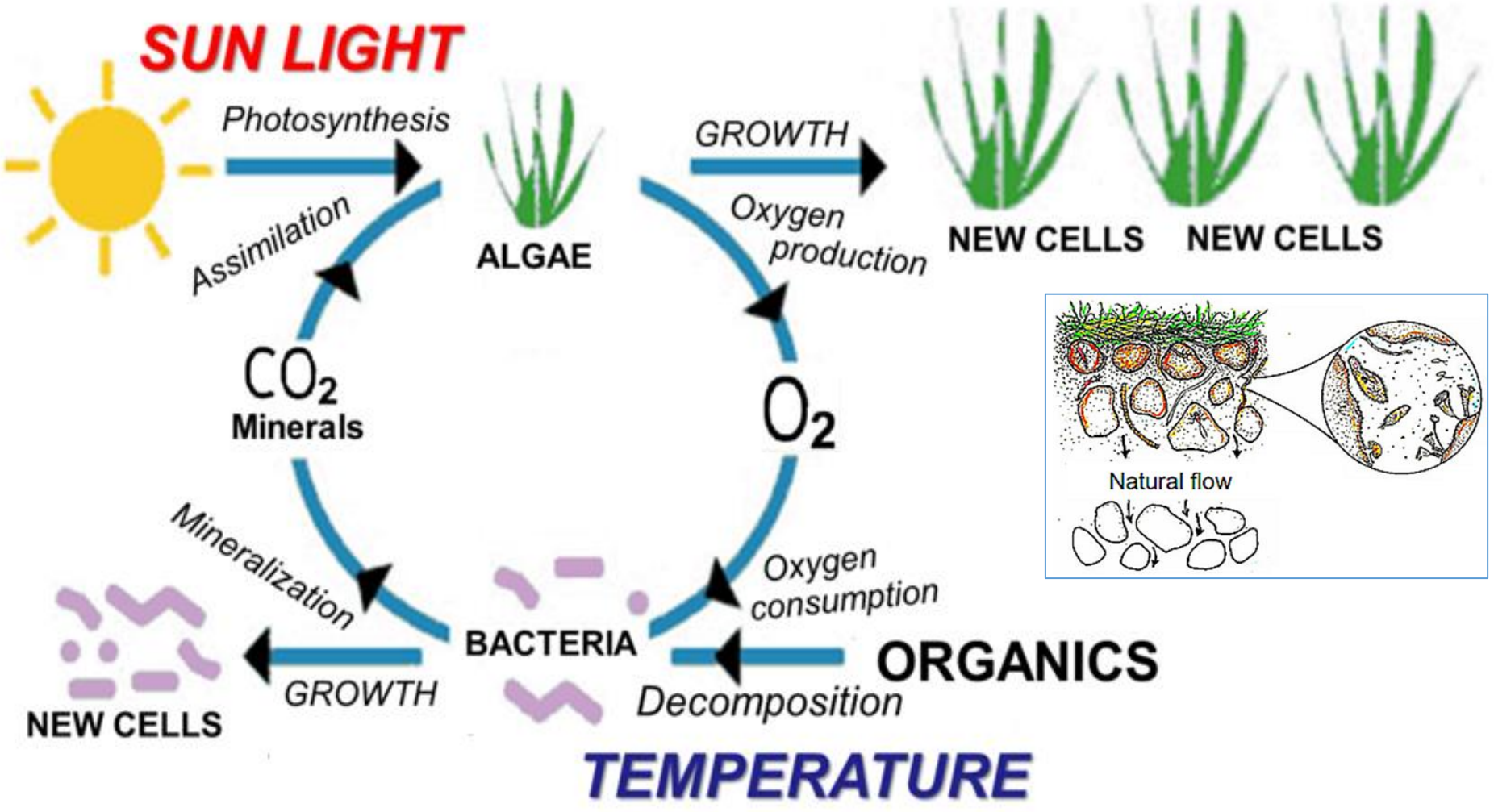






At the beginning, filamentous diatom dominates. However, filamentous green algae becomes dominant during the long filter run.

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.*

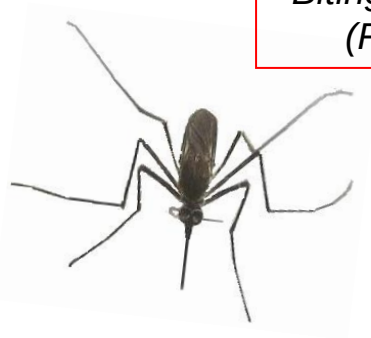
Chironomid

Non-biting Mosquito

Troublesome Nuisance Insects

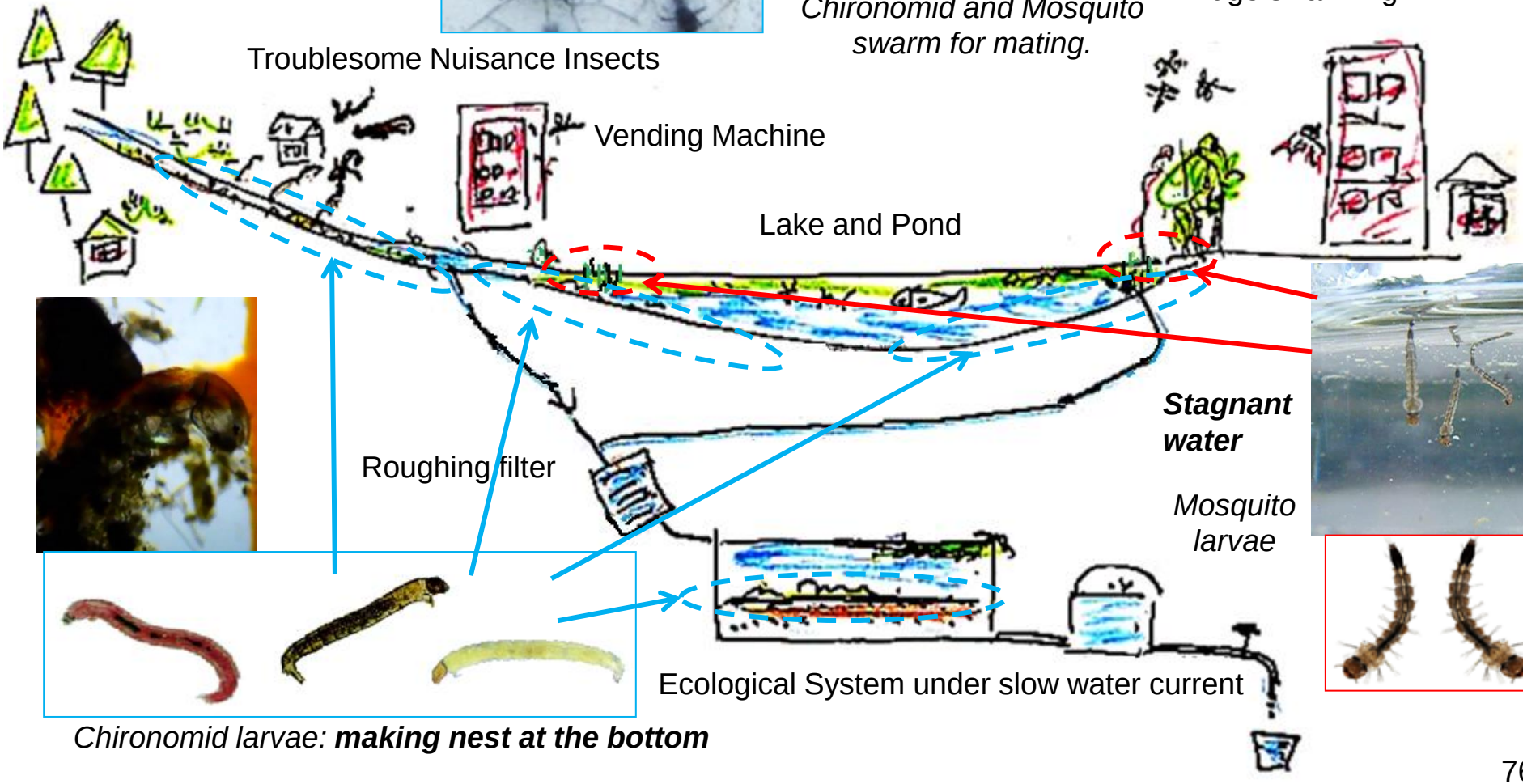
Mosquito

Biting Mosquito (Female)



Both Midges of Chironomid and Mosquito swarm for mating.

Midge swarming



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

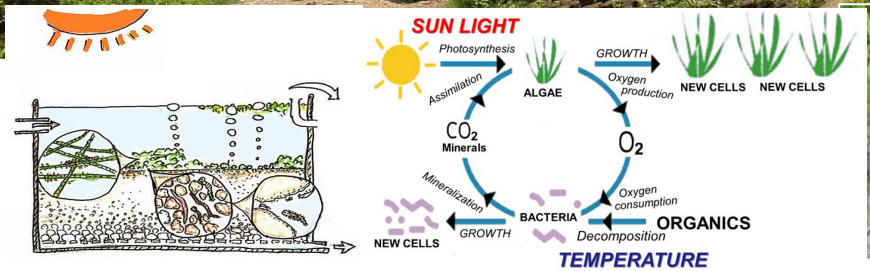
Chironomid (midge) is called non-bite Mosquito.

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.

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

Chironomid : non-bite Mosquito

Mosquito



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**.

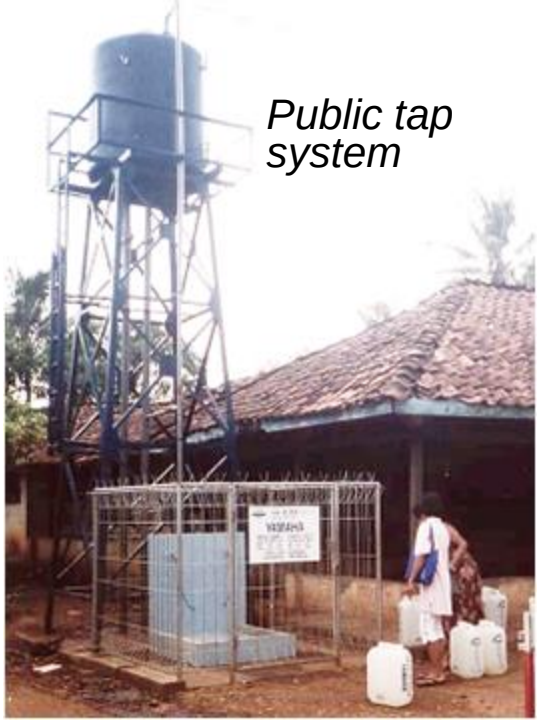
2. Pilot test plant with several public taps was donated from Yamaha Company to Kagawong village near Jakarta, Indonesia.

3. **Villagers discussed how to maintain this plant by villagers**.

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

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

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



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.

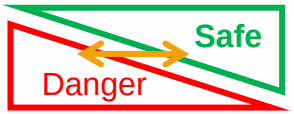
→**Health village** →Sanitary sense and its level are distributed among the villagers.

→This acts to **reduce the risk** against sickness.

Villager maintains over 10 years by themselves.

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

Acceptable Risk

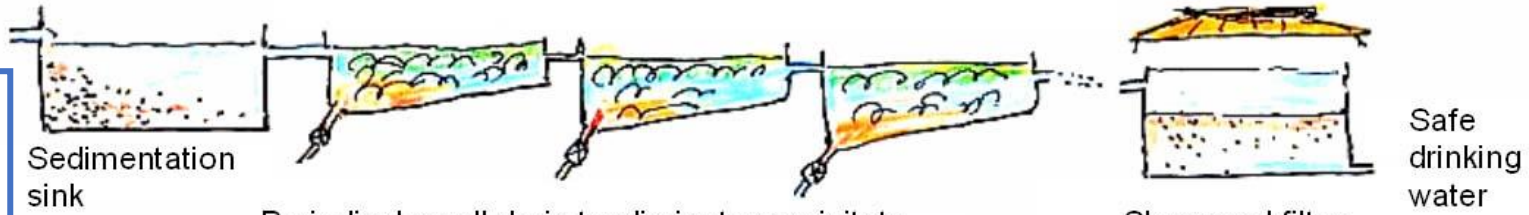


New biological pre-treatment for SSF

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

O2↑ →bubbles →keep aerobic condition

pH↑ → precipitate oxide and hydroxide complexes.



Periodical small drain to eliminate precipitate material and unhealthy organisms.

Slow sand filter

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

Slow velocity of water for microbe to eliminate bacteria.

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

Villagers maintained this plant by themselves.