

Safe and Reliable Drinking Water by the Biological Filter of Slow Sand Filtration Ecological Purification System

New Concept of Slow Sand Filtration System

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For Cetesb and Cebesb,

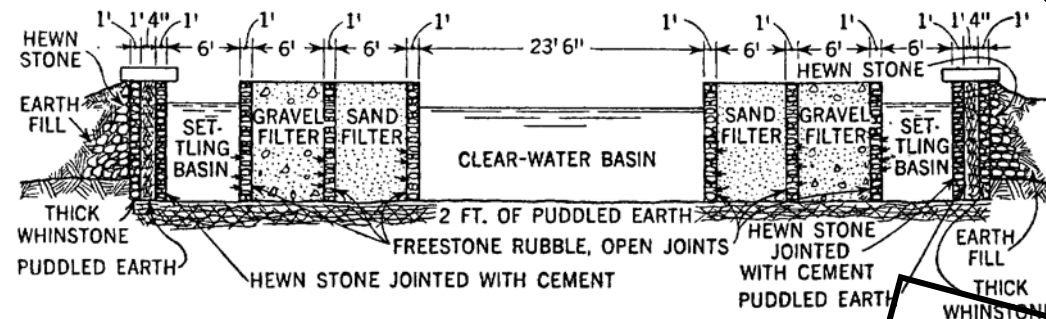
Feb. and Mar. 2008,
Sao Paulo, Brazil



Seepage water in flood plain : clear water: Mechanical separation by fine sand layer

Origin of Public Water

Supply : at Paisley, Scotland, in
1804, by John Gibb.

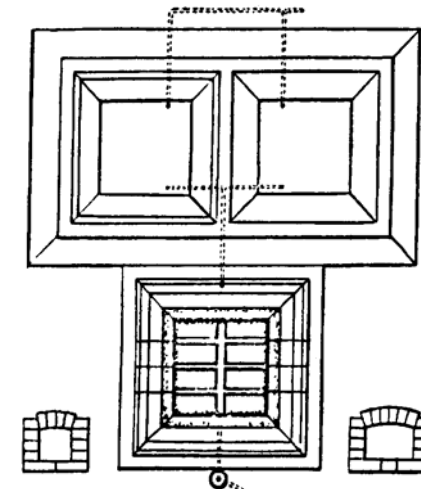


James Simpson's Filter of
1827-28. at London, UK

Decanting
Basins.

Sand-Filter.

Gross
9 ins. 9 ins.



Area at top
water-level,
840 sq. ft.
Max. depth,
3 ft. 3 ins.
Contents
when full,
12,600 gallons.

Area,
1,000 sq. ft.

Main Drain,
14 ins. x 9 ins.

Depth of water
on filter, 15 ins.
Sand, 2 ft.
Gravel, 2 ft.

They believed that clear bacteria free
water was produced by mechanical
filtration using fine sand and slow process.

Slow Sand Filtration : Not Mechanical Filter Biological Filter

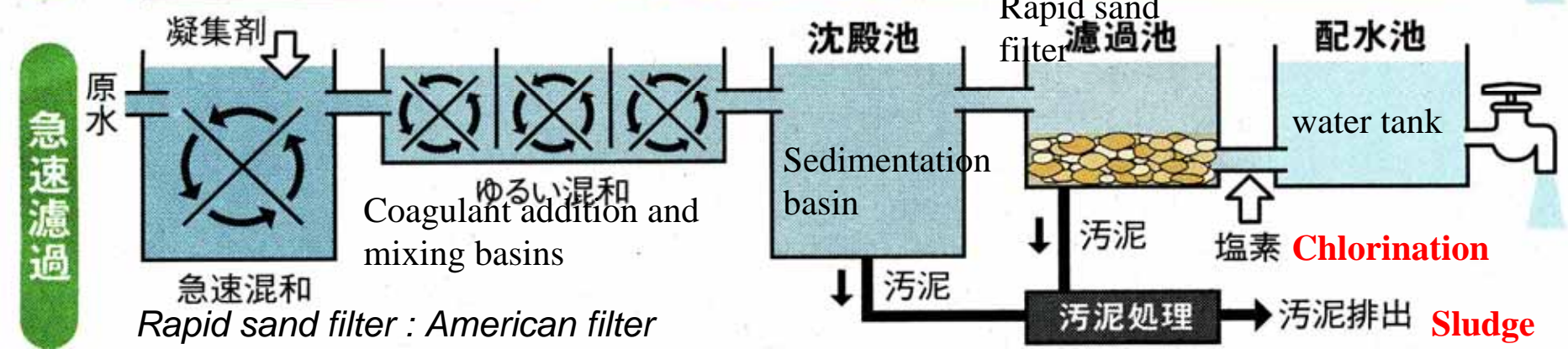
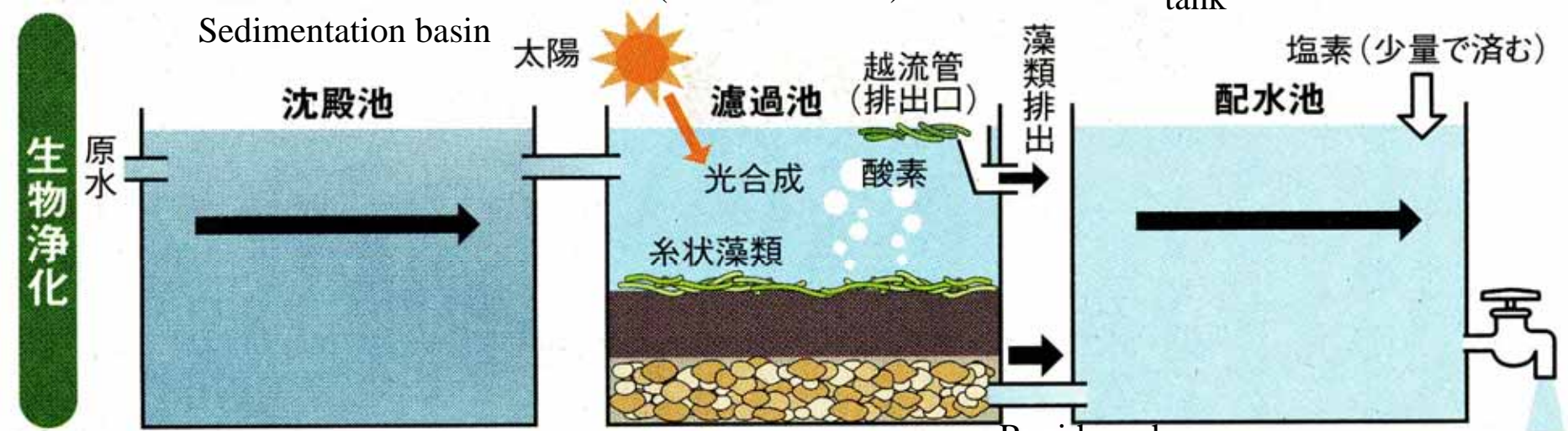
Ecological Water Purification System

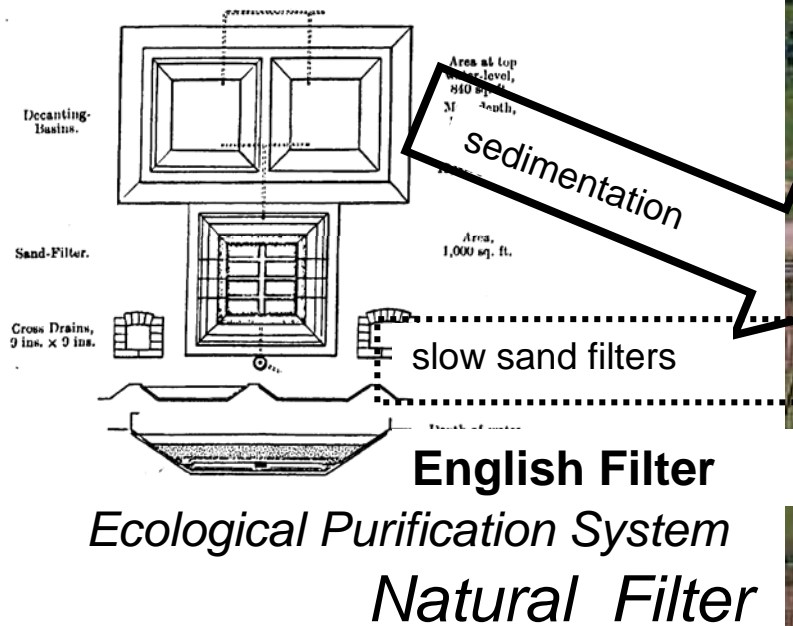
Fine small sand is not important. Faster flow water current is necessary to keep aerobic environment for small animals.

Slow sand filter : English filter

Ecological filter
(slow sand filter)

Filtered water
tank





American Filter

*Rapid Sand Filter :
 Mechanical and
 Chemical Treatment*

*Commercial
 Filter*



Continuous culture system of filamentous algae

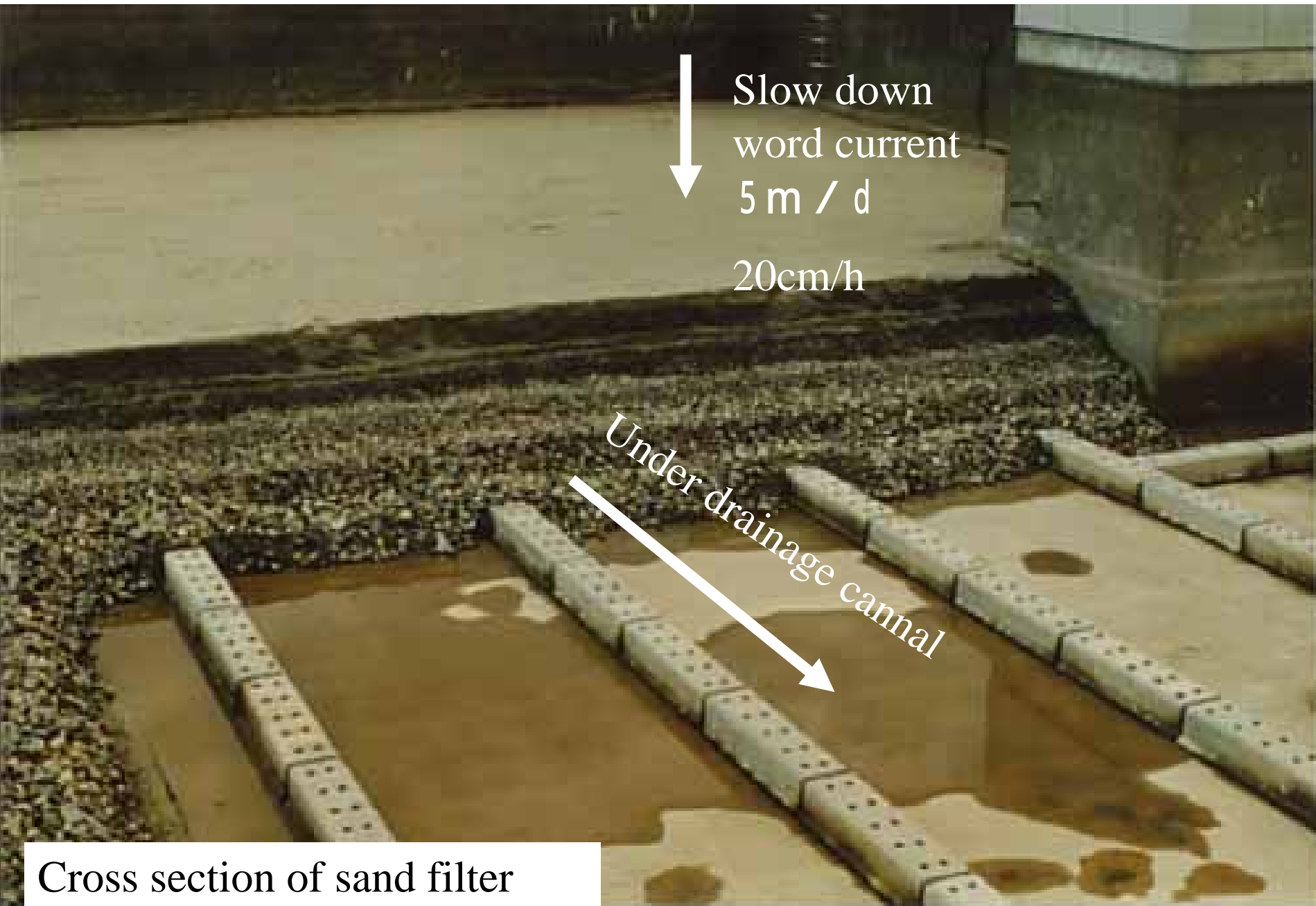


Float by bubbles produced by photosynthesis.

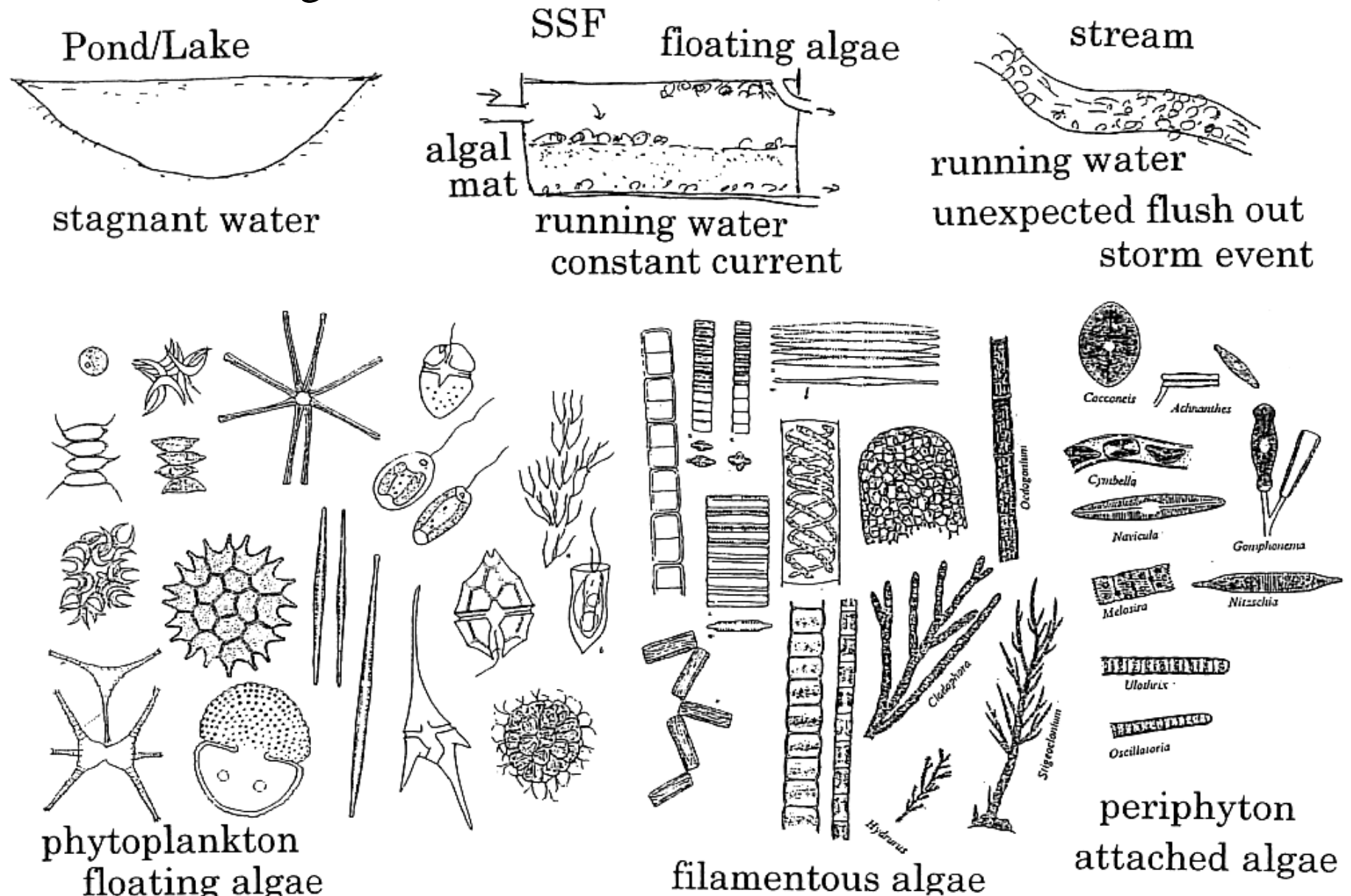


Trap SS on filamentous algae

Slow sand filter = make a sub-surface (ground) water in flood plain



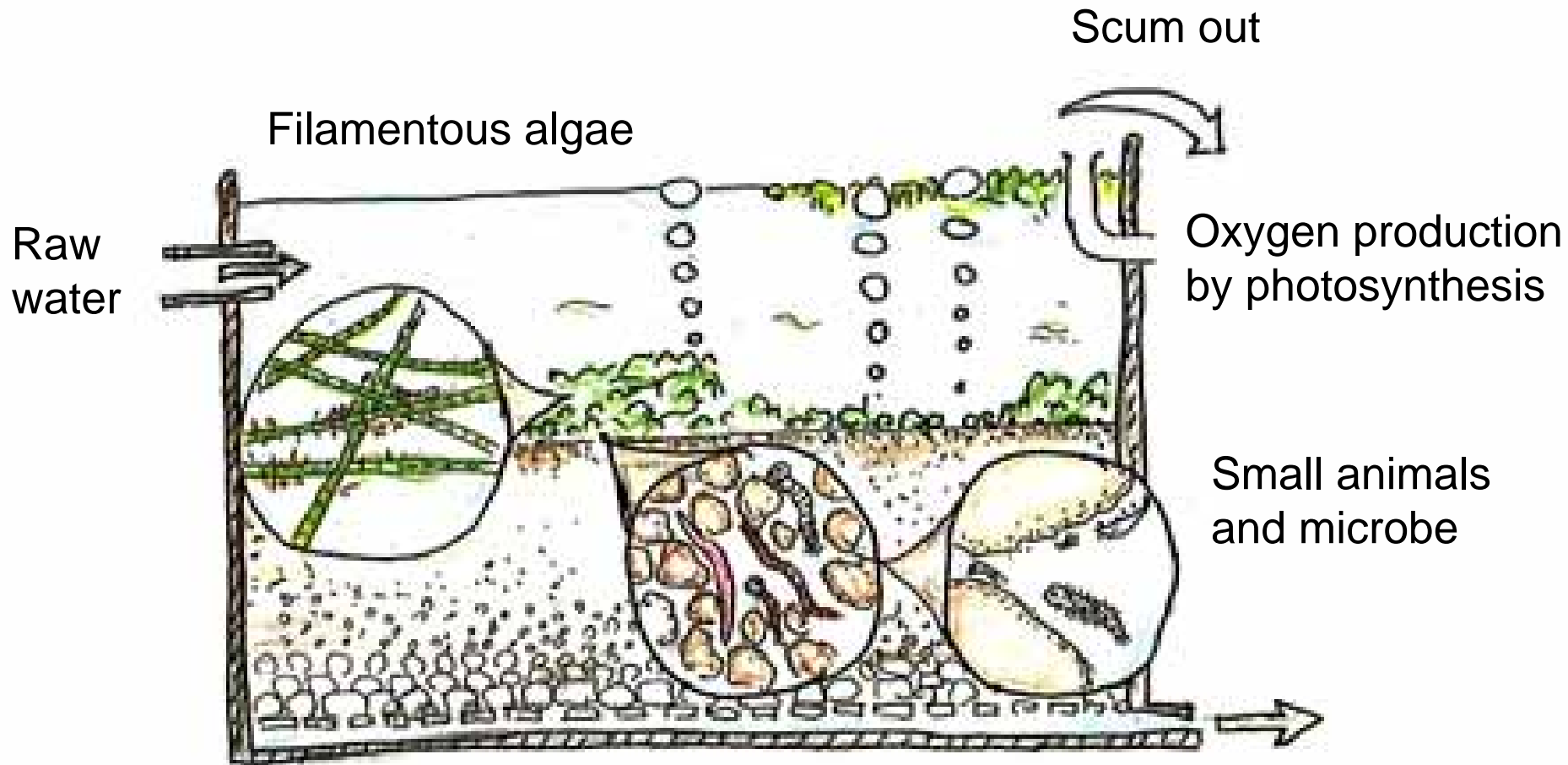
SSF(Ecological Purification System) is the suitable environment for filamentous algae.





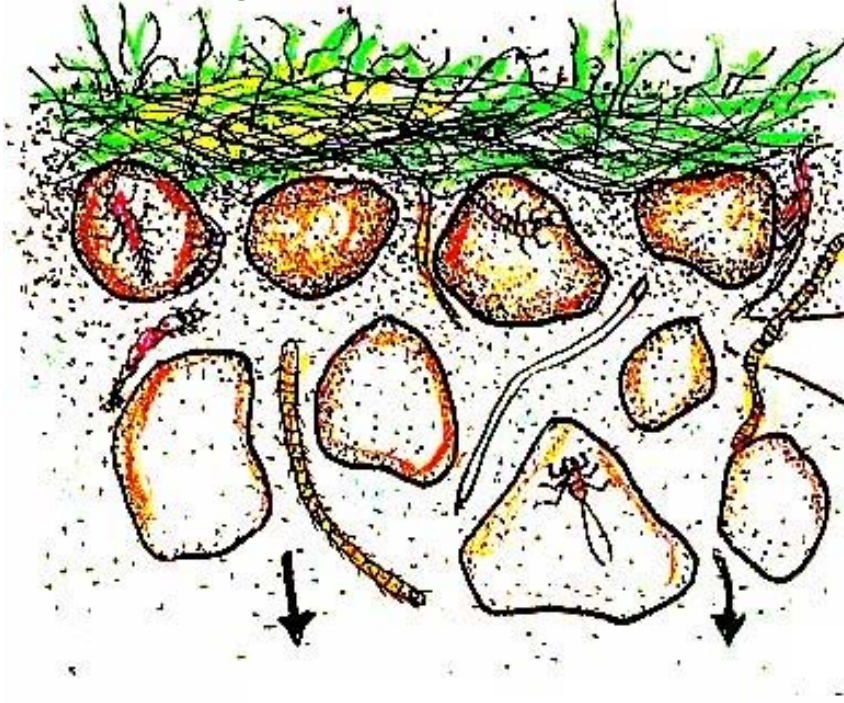
Slow Sand Filtration (*Mechanical Filter*)

⇒ Ecological Purification System



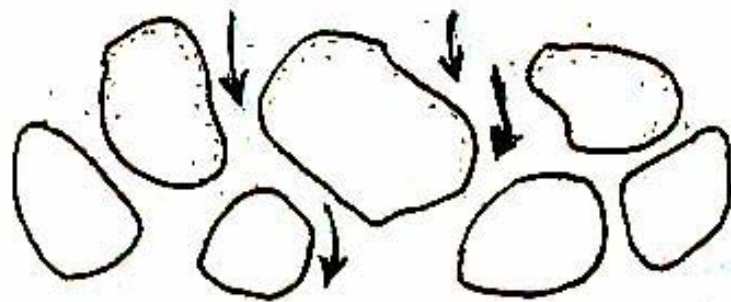
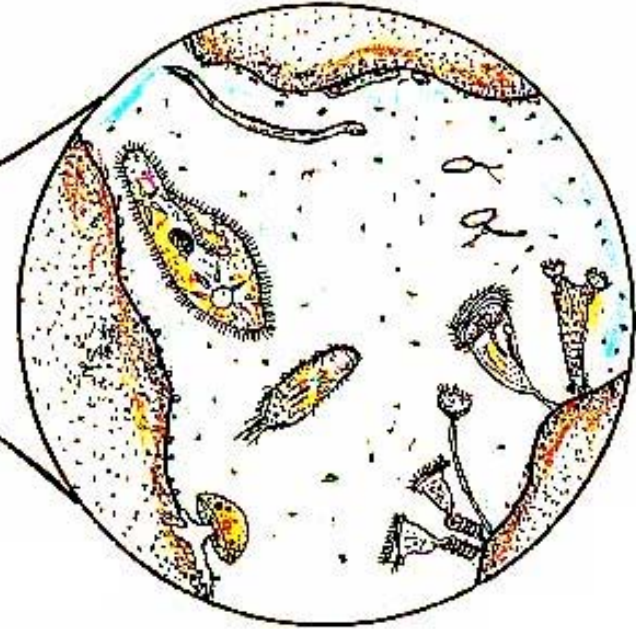
Safe and delicious drinking water by biological activity

Algae: food for animals



Natural flow

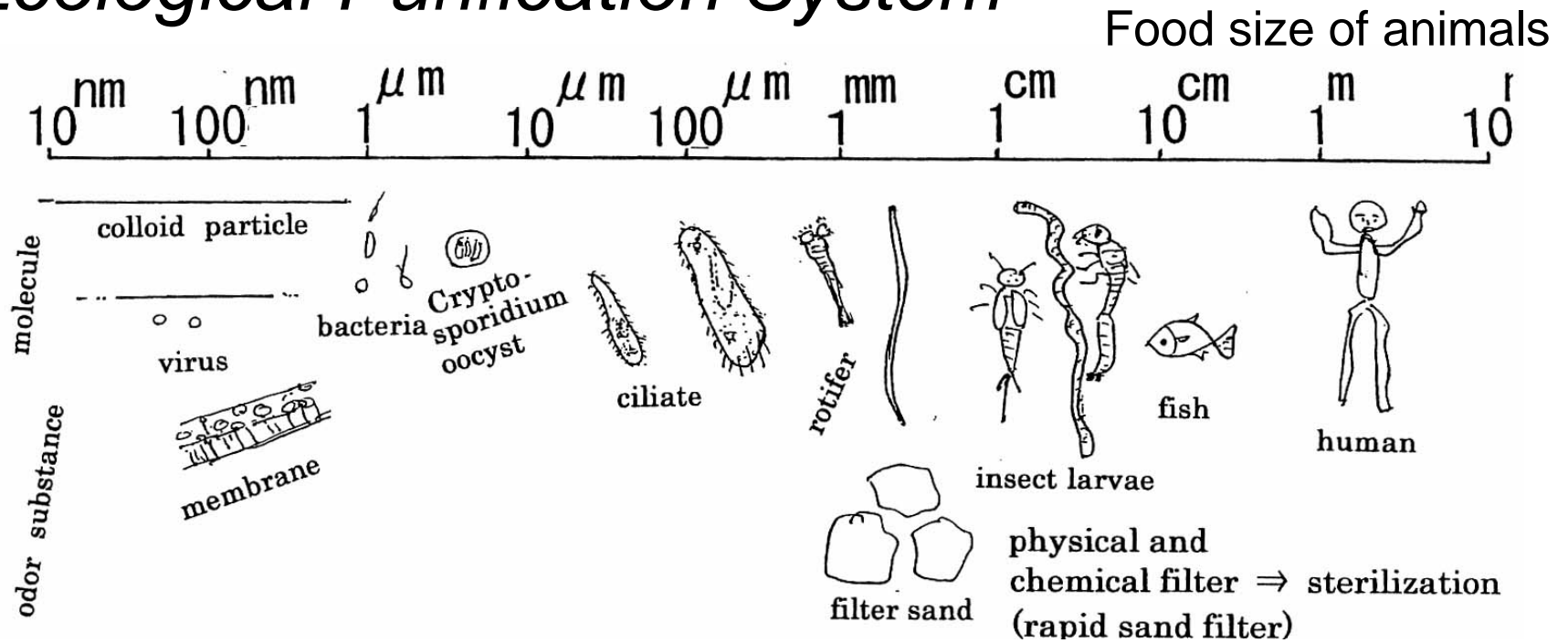
Remove particulate and dissolved matters.



Particle free water: ready to drink as safe water

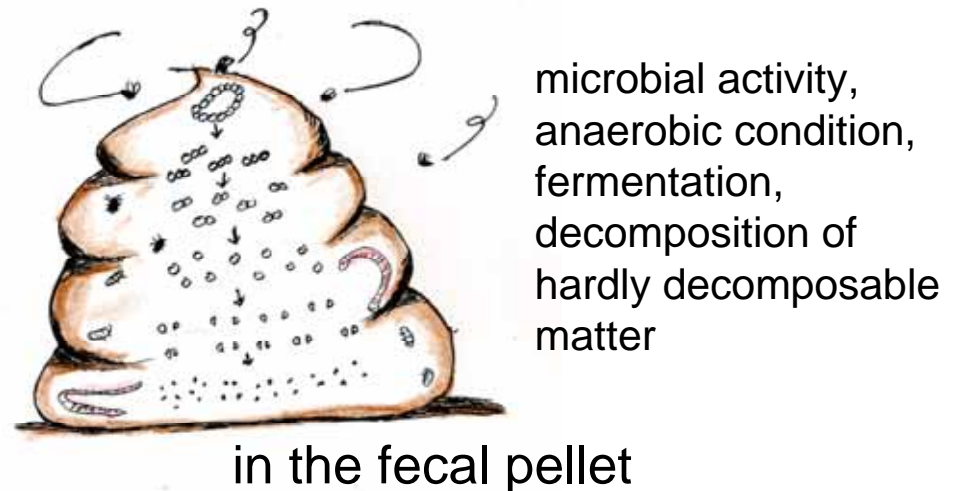
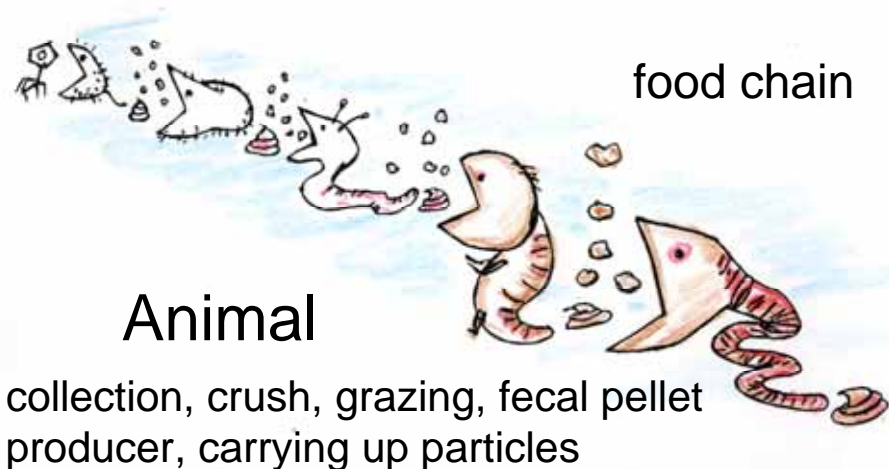
It is essential that presence of oxygen for biological community. Small animals are catcher of particulate matter. Food chain is important. Dissolved oxygen in the fecal pellet is almost consumed up. It becomes anaerobic condition.

Ecological Purification System

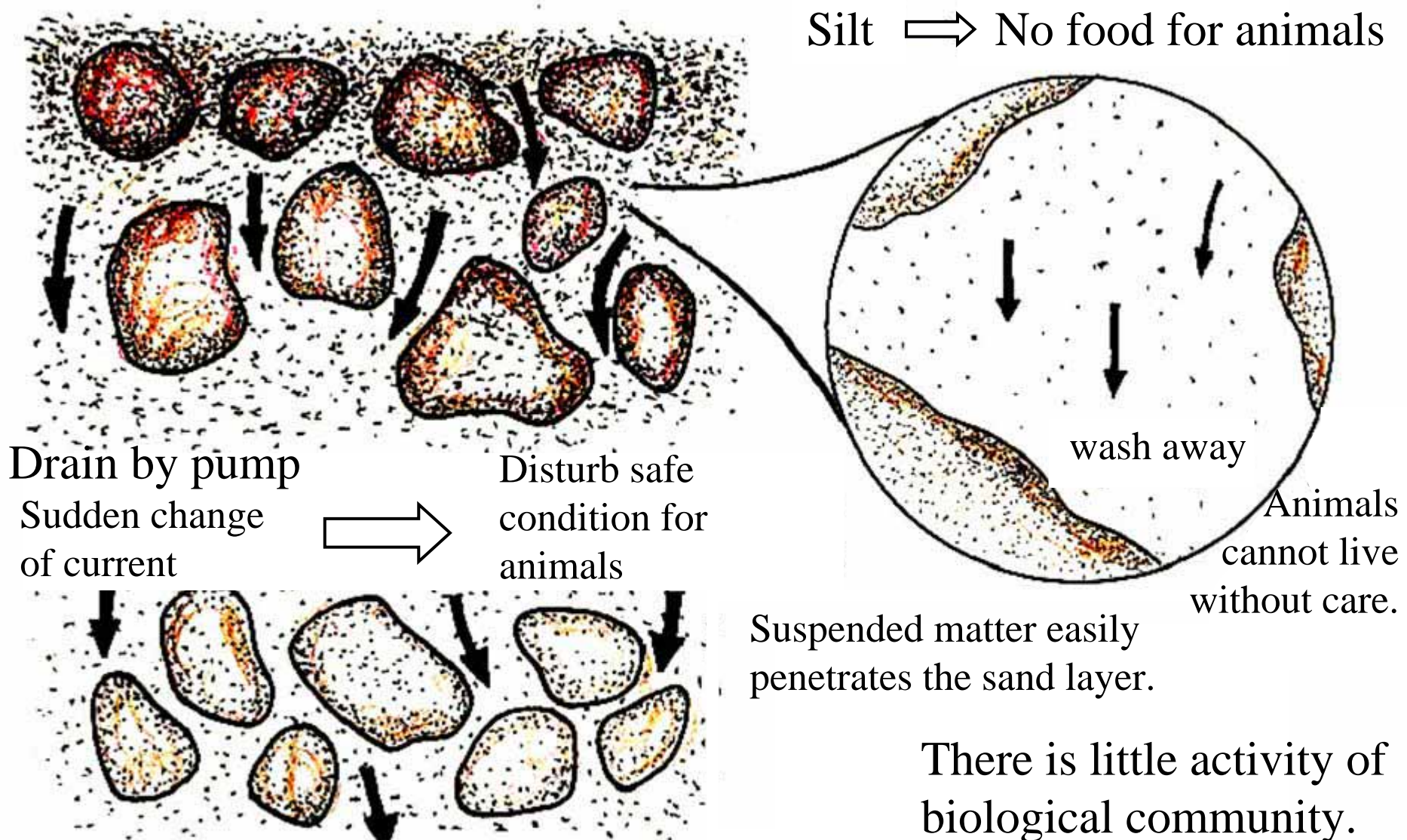


Short term work

Long term action

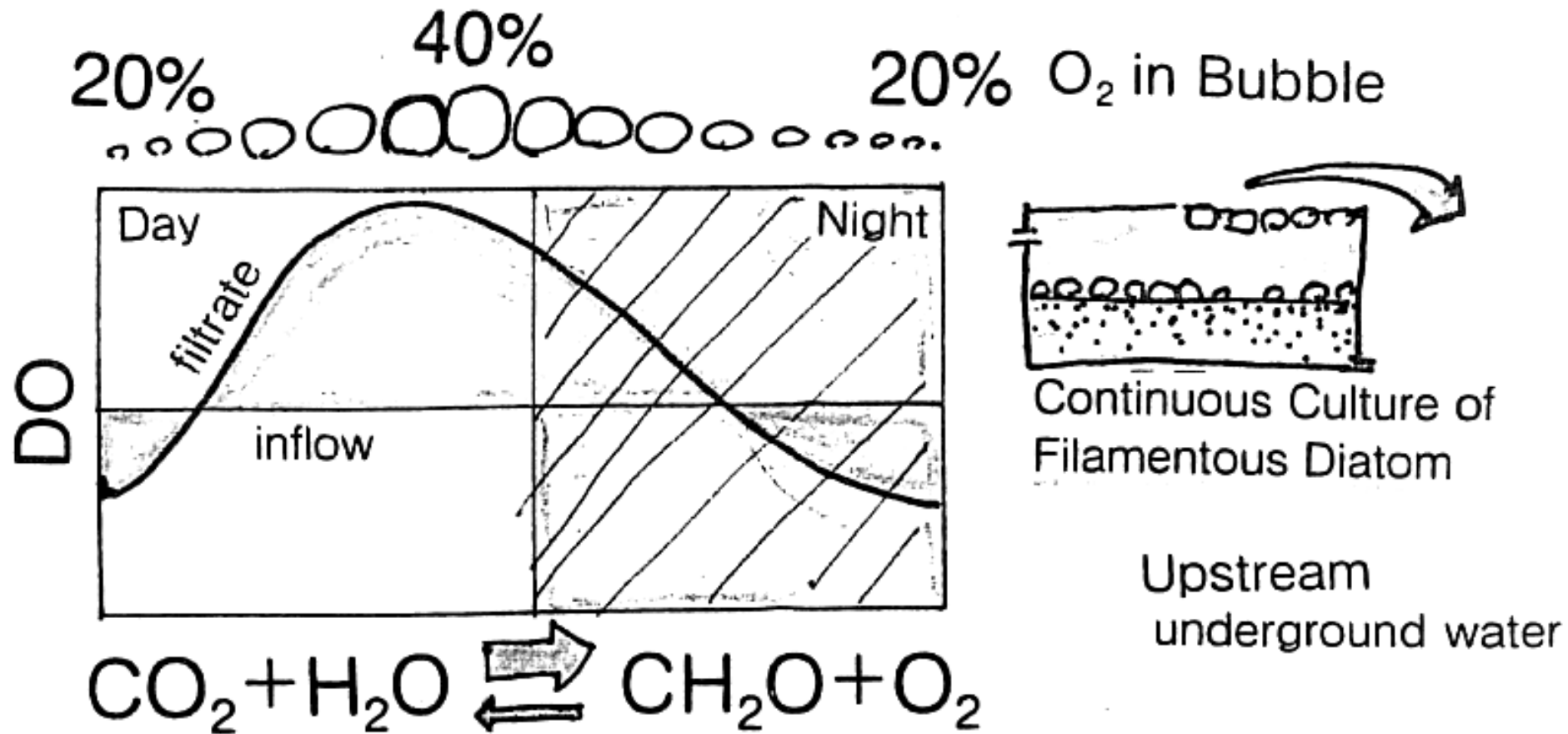


Silt \Rightarrow No food for animals



Bacteria and turbid matter
leak out the sand filter.

Only the large particles are trapped by sand layer.

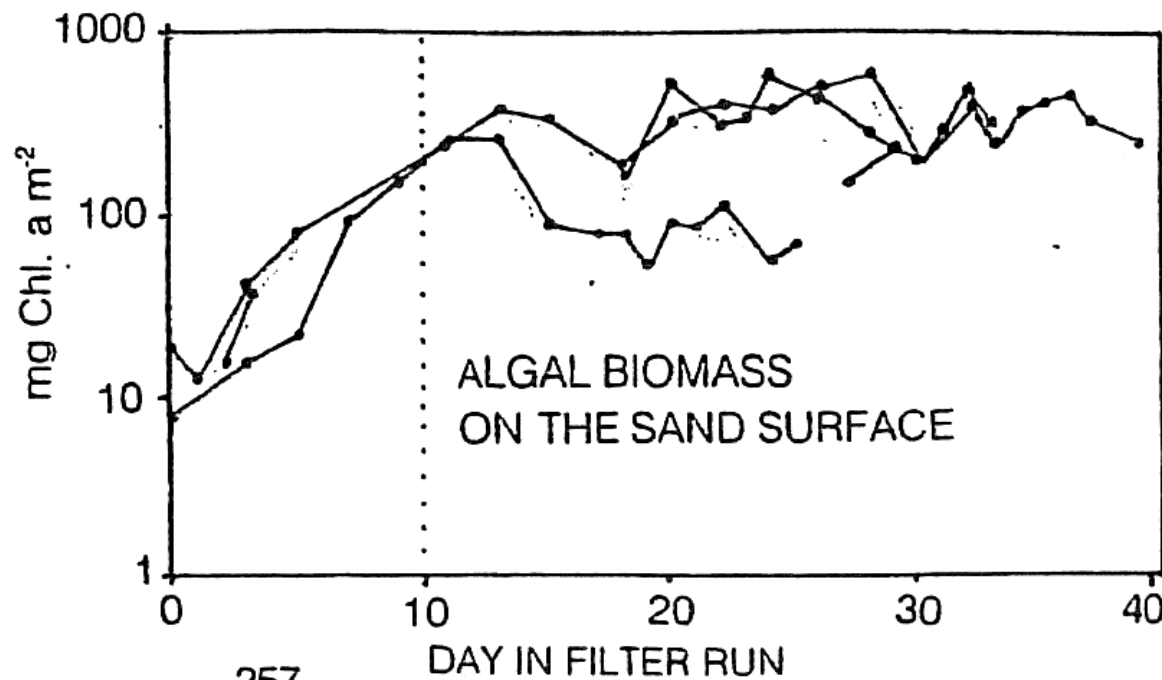


Active growth of algae makes better condition of effluent.

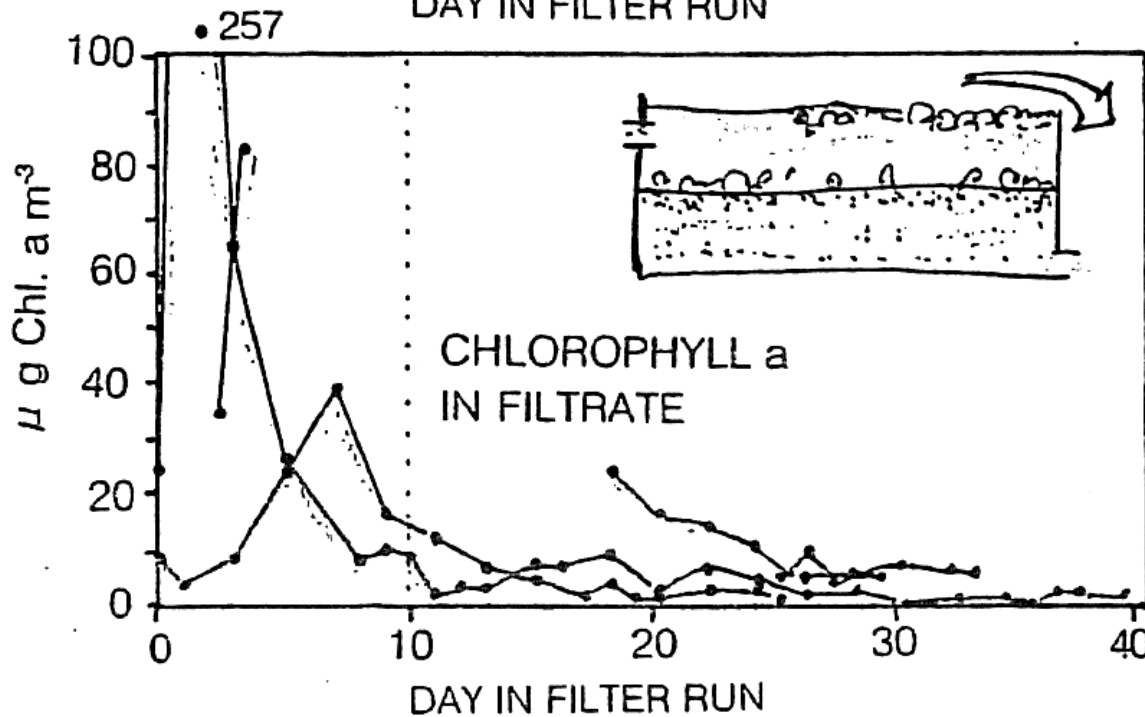
Continuous culture system of algae is important to keep better condition.

Partial pressure of oxygen in bubbles reaches about 40 % under sunshine due to photosynthesis. And it decreases during the night. Oxygen in the bubble released into the water.

Therefore, the daily harvest of floating algae acts is a better treatment.



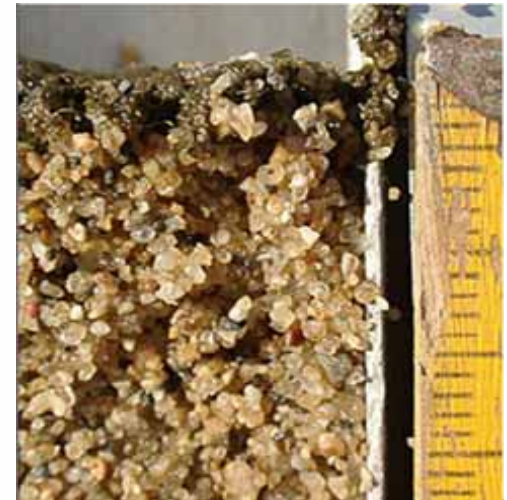
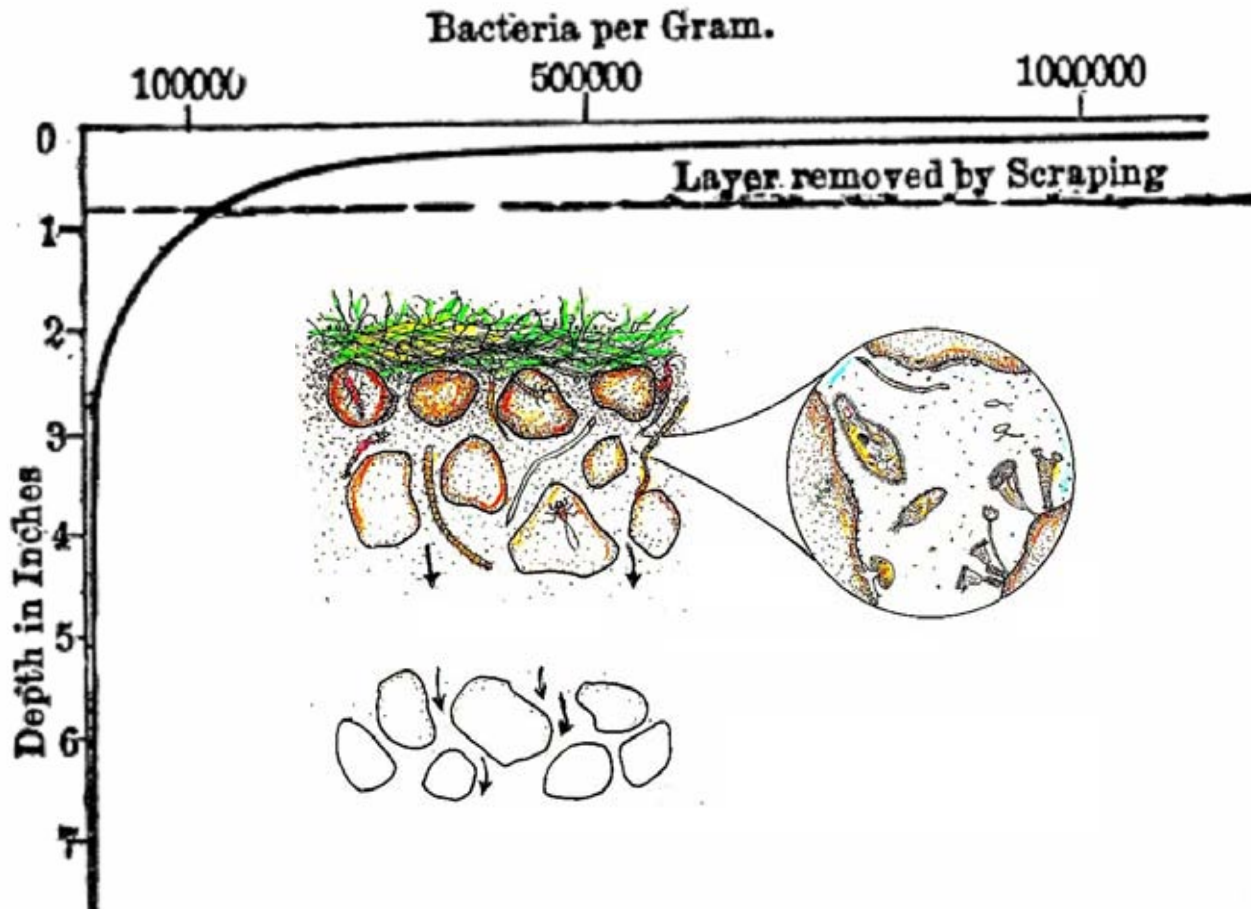
Algae grow well in summer. Continuous culture system of filamentous algae becomes after 10 days.



Filtrate water becomes clear water in 10 days. In summer, scrapping of surface mud is not necessary.

Passing through the active layer where microbe live in the upper sand layer of 1 to 2 cm. It takes only several minutes. It means really instant process.

One meter of sand layer means insurance.





If water source or raw water is sub-surface water (ground water) of suspension free water, the ecological purification system needs only a shallow sand filter. Ecological purification system in a shallow basin under the sun shine makes drinkable sweet water. This system is an artificial method of spring water.



Even cold winter, filamentous diatom can grow well. There is enough sun shine. Suspension free water is essential.





Filamentous diatom of *Melosira*



Ecdysis case of midge larvae are remarkable in warm period. Grazing activity is higher than cold season.



In the short filter run, filamentous diatom dominates. This is the pioneer stage.

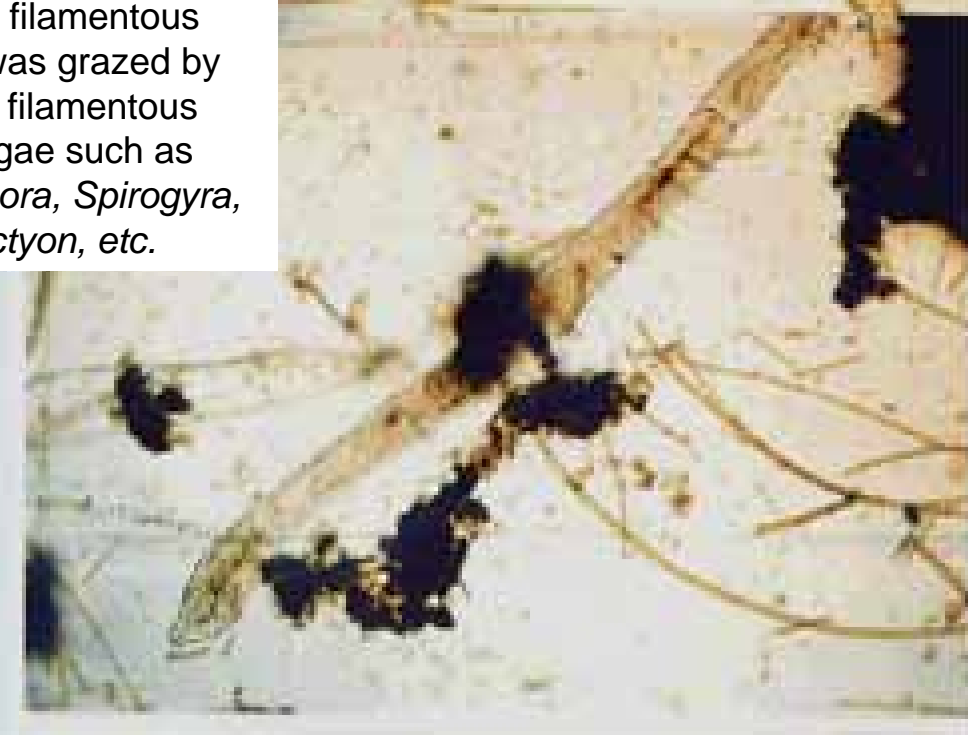


After the filamentous diatom was grazed by animals, filamentous green algae such as *Cladophora*, *Spirogyra*, *Hydrodictyon*, etc.



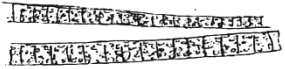


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Algal succession caused by grazing animals.

Photosynthetic
Organisms



Filamentous diatom

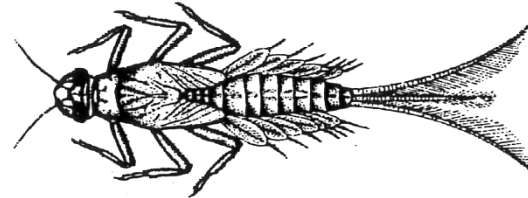
Melosira, Flagiralia

Grazing animals

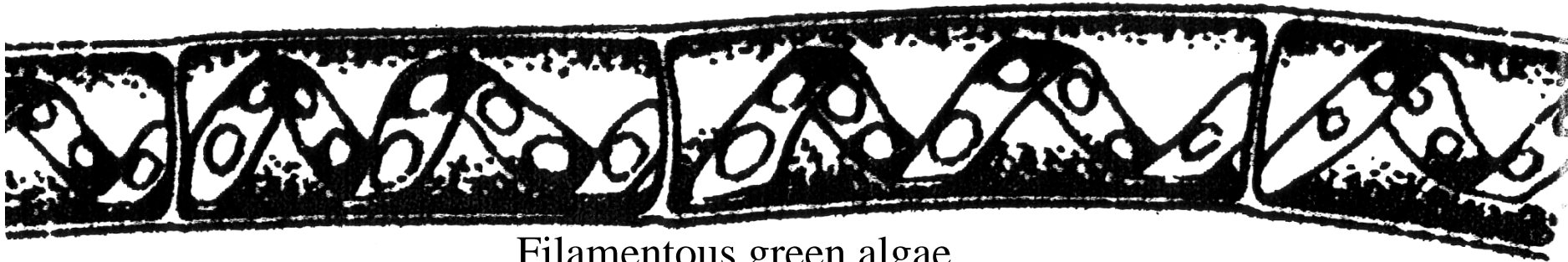
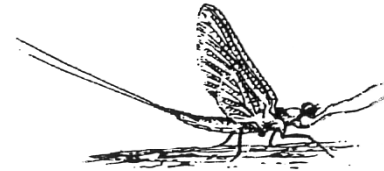
Poikirothermal animal



Midge :
Chironomus

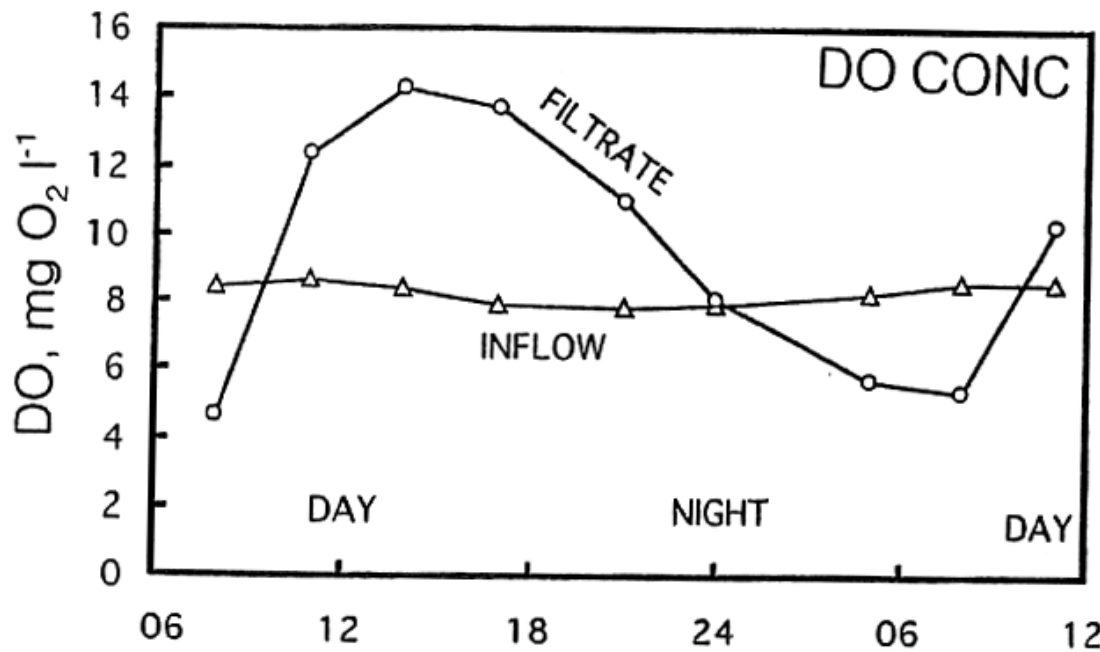


Insect larvae : Mayfly nymph



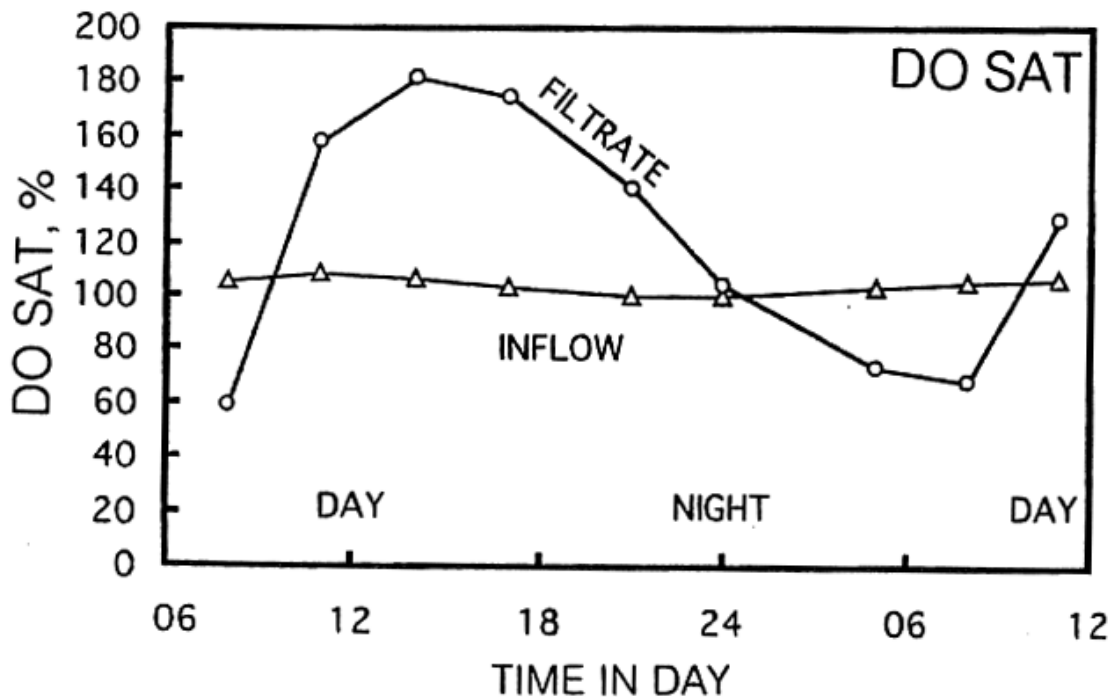
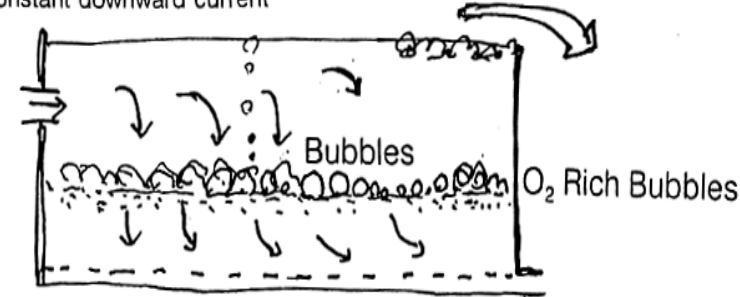
Filamentous green algae
Spirogyra, Cladophora

In case of long filter run, green algae dominates.



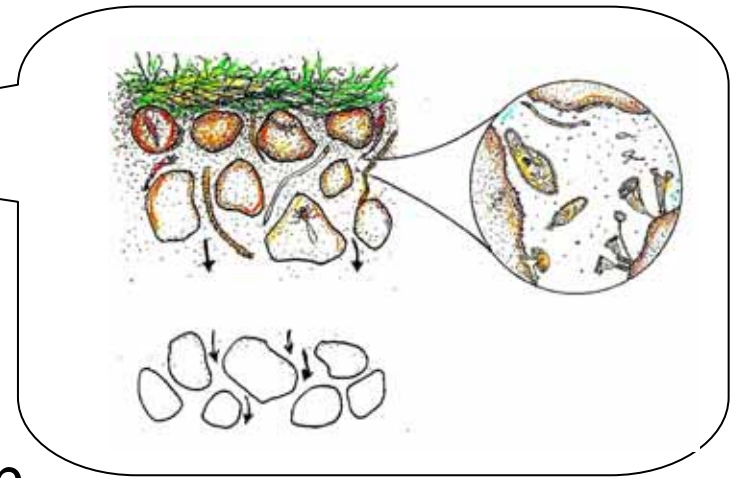
Diurnal DO changes in inflow water and in outflow water.

constant downward current



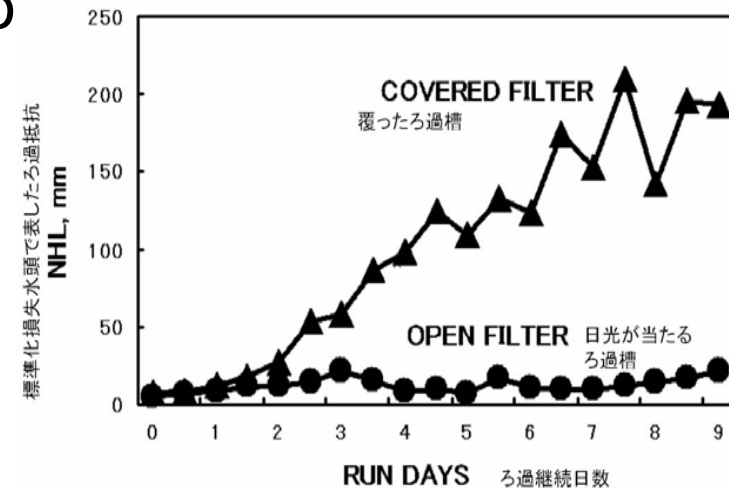
Inflow DO is almost constant. Outflow DO shows a large diurnal fluctuation. Passing time is about 2 or 3 hrs. DO concentration rapidly increases after the sunrise. High concentration of DO in outflow water remains after the sunset. Oxygen in bubbles keeps high concentration after the sunset.

Beneficial effect of algal growth on filter clog using bucket model experiment



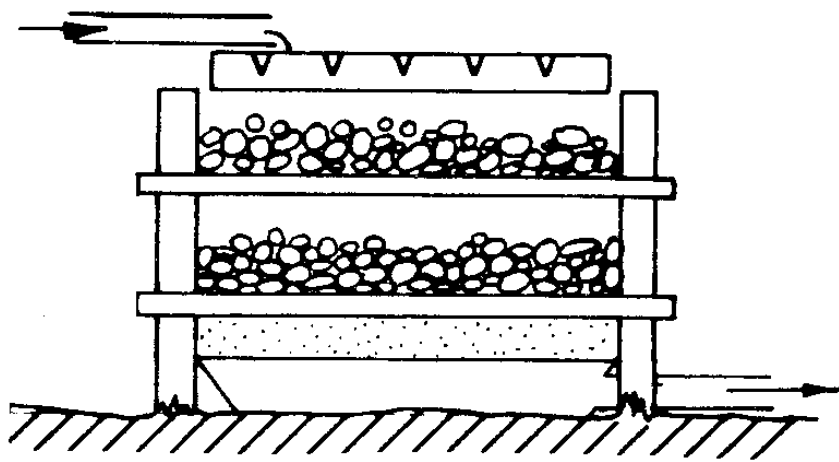
Open bucket: Algal growth under sun shine Algal and animal can grow. no clog: long filter run

Covered bucket: Increase the filter resistance: easily clog the filter No growth of algae no food for animals Animal as a collector of suspended matter does not grow.

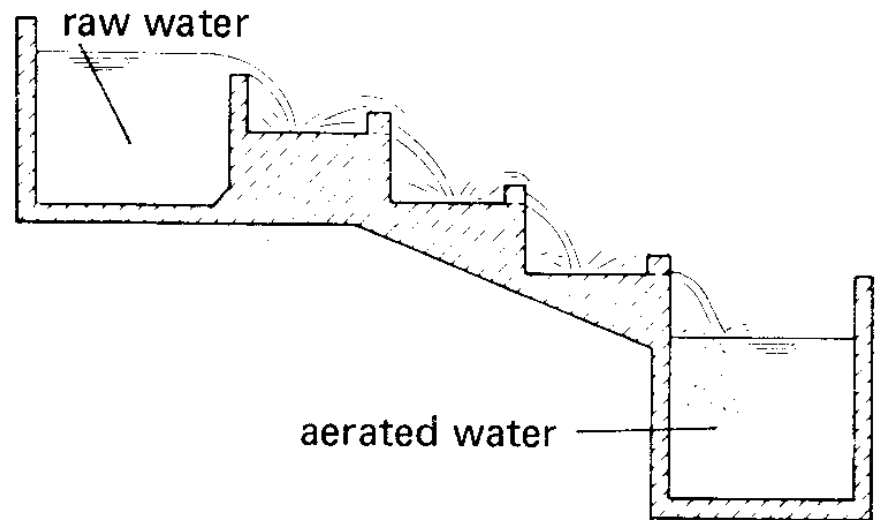


Addition of oxygen: Aeration is frequently used for treatment of groundwater (reduction of unpleasant tastes and odors, discoloration, precipitation of iron and manganese).

Aeration filter

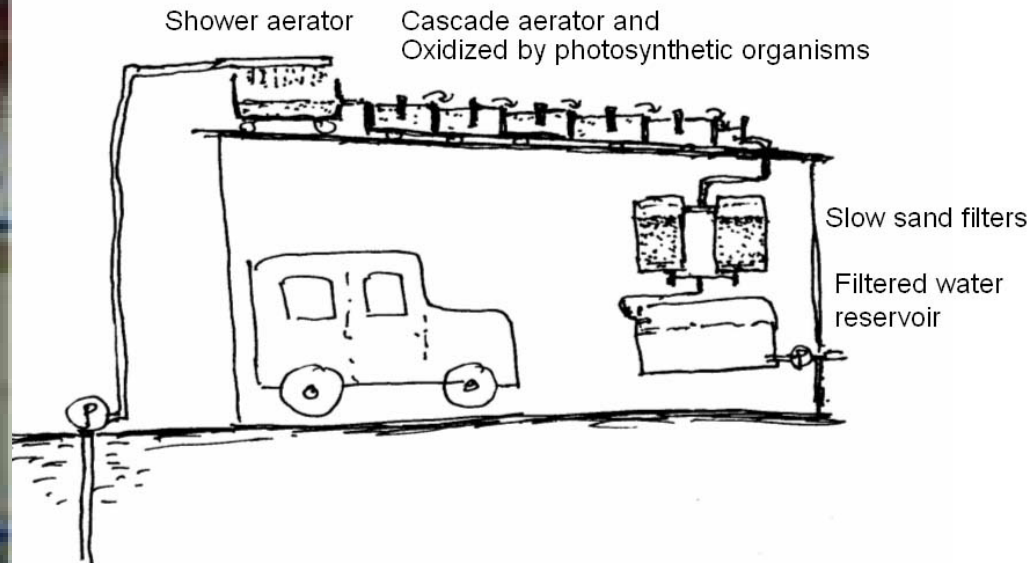


Cascade aeration



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

Family use of an ecological purification plant.



Indonesia

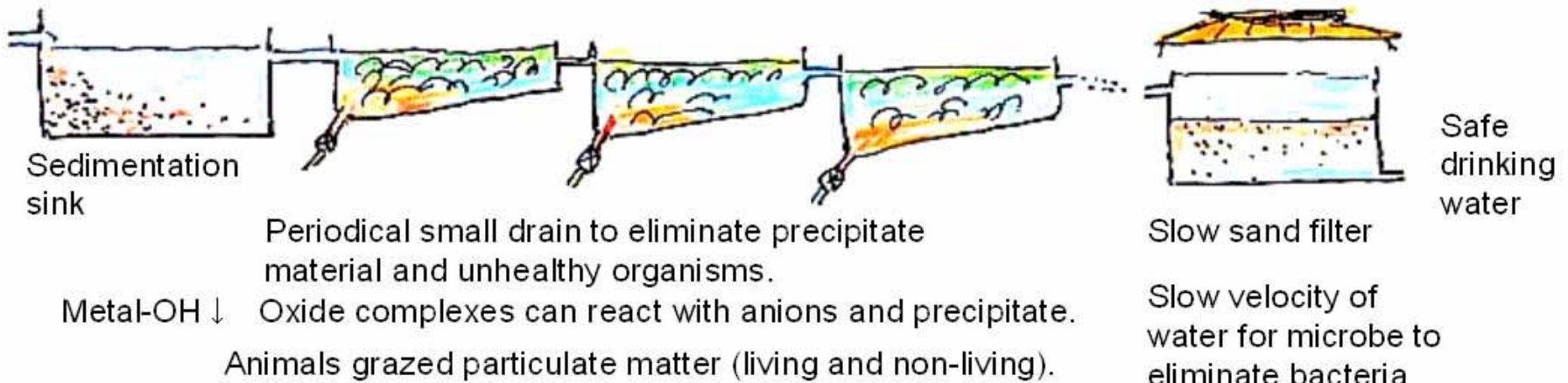


New biological pre-treatment for SSF

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

$O_2 \uparrow \rightarrow$ bubbles \rightarrow keep aerobic condition

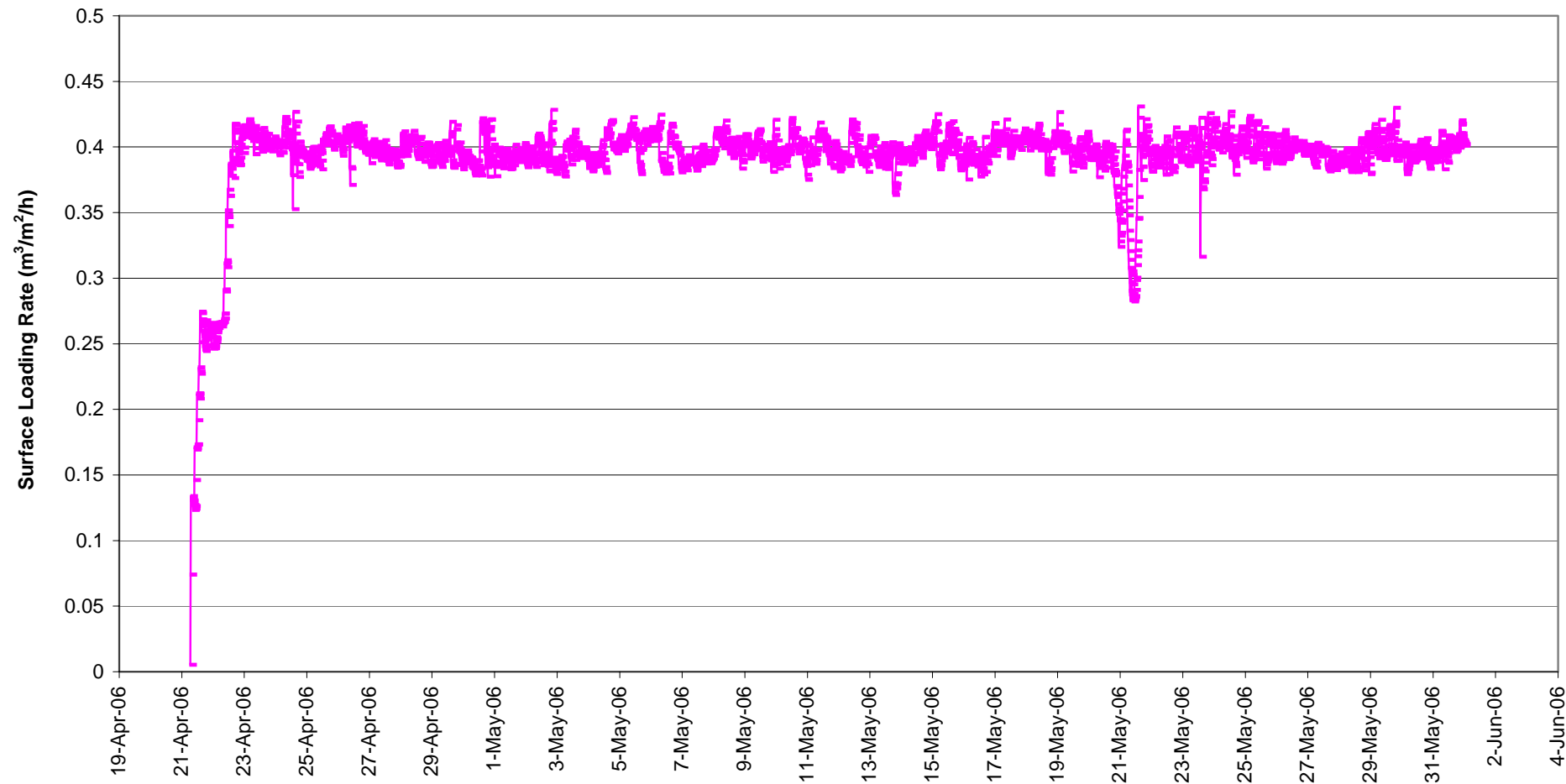
$pH \uparrow \rightarrow$ precipitate oxide and hydroxide complexes.



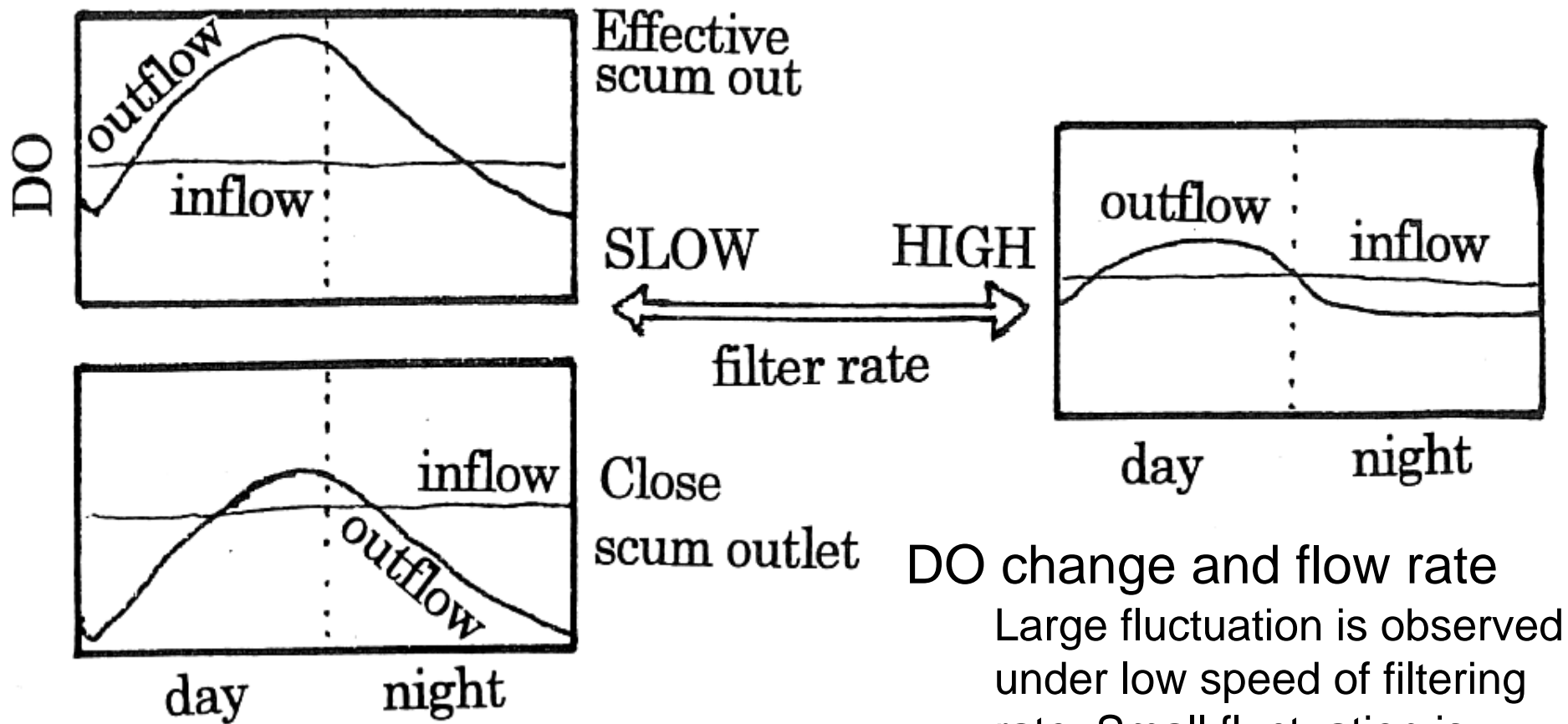


100 % of tap water in London city is supplied by slow sand filter. Thames river water is eutrophic water. At first, river water stock for about one month in a reservoir. Then it is treated by a gravity rapid sand filter without any chemical reagent to eliminate plankton. And ozone treatment, slow sand filtration are done. It flow rate is 9.6 m/d (40cm/hour). This is double rate of traditional standard rate.

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



All the plant of Thames waterworks adopted 9.6m/d (0.4m/h). Higher flow rate makes better quality in the filtered water. Diurnal change of DO in effluent water becomes small. It is better to avoid low oxygen concentration in the morning.



DO change and flow rate

Large fluctuation is observed under low speed of filtering rate. Small fluctuation is observed under high speed.

Effect of scum outlet and DO change

Effective removal of floating scum is necessary to keep favorable DO condition in night. Algae produce oxygen when they grow. When they die, they consume much oxygen. Oxygen releases from the surface to atmosphere. During the night, oxygen consumption becomes high. Sometimes, low oxygen makes unpalatable effluent water under low DO concentration.

Artificial subsurface water.

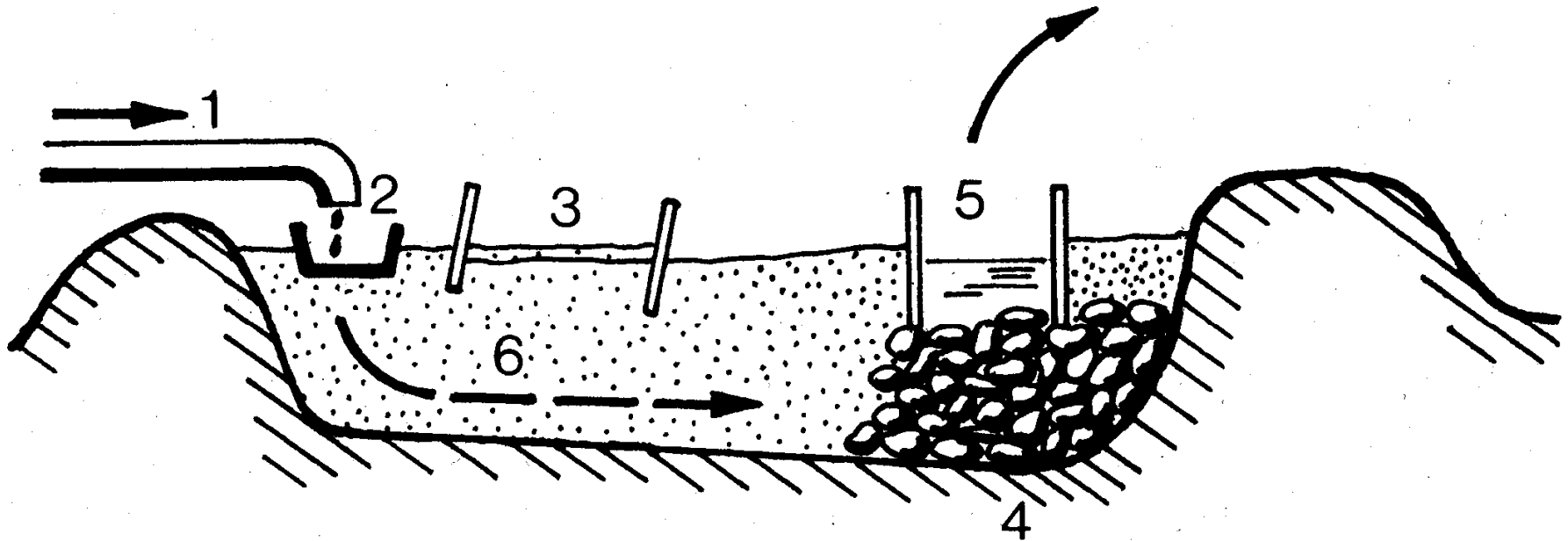
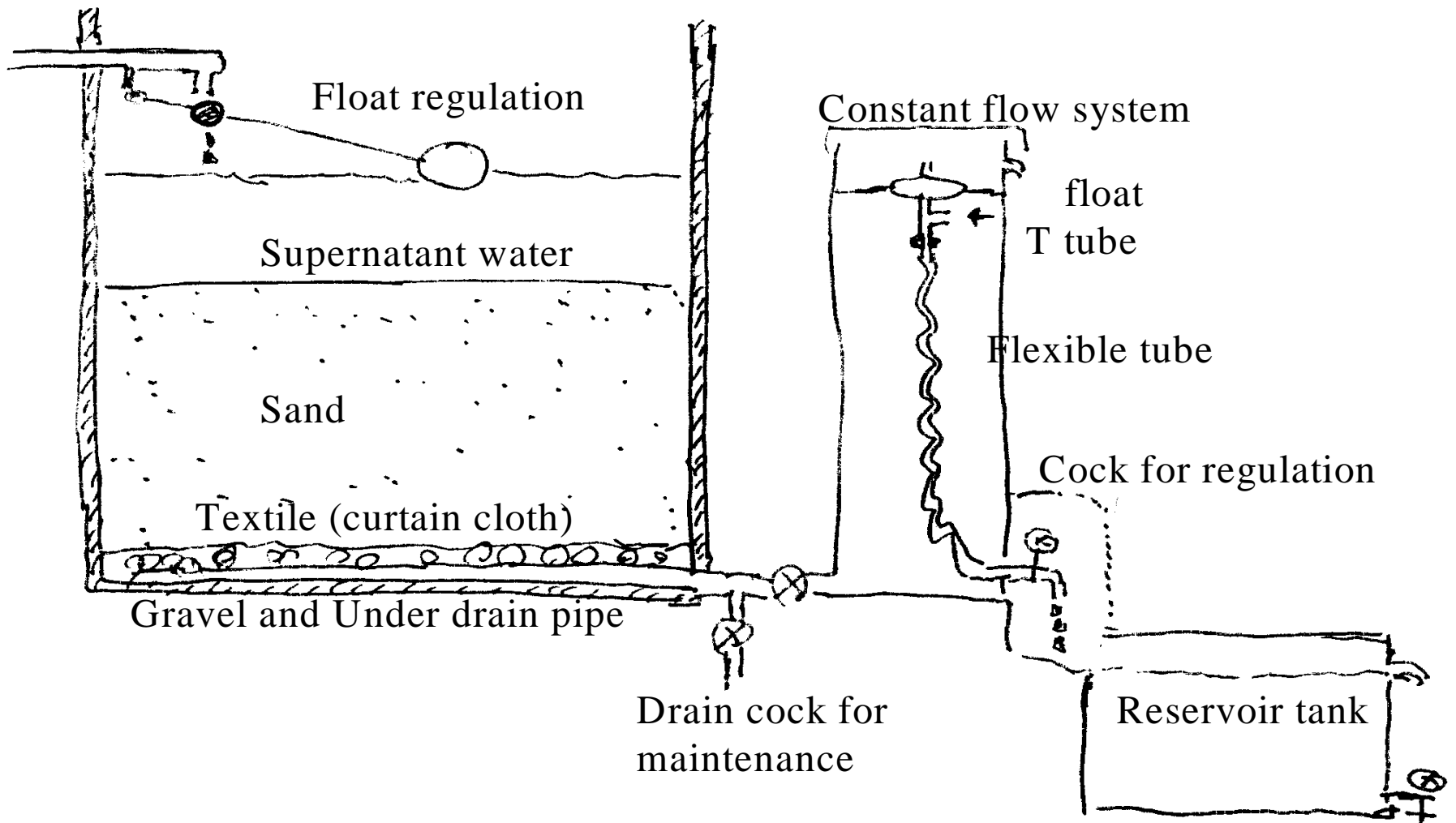


Fig. 27: Horizontal flow sand filter [46, 77, 81]. 1 Inlet pipe, 2 inlet trough to prevent scouring, 3 barriers, 4 gravel 50 mm, 5 outlet trough, 6 flow direction

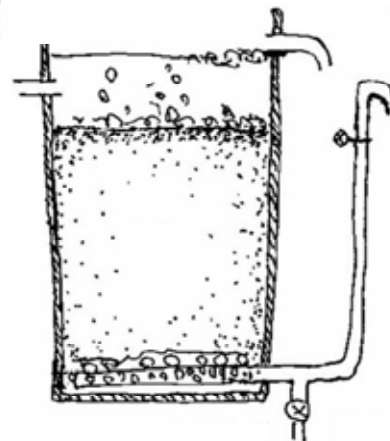
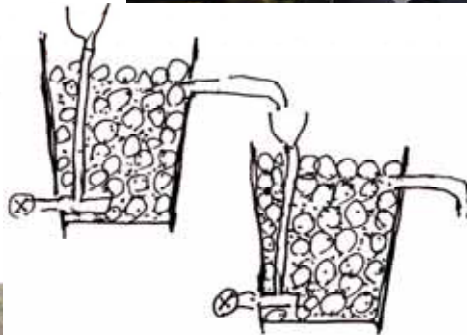
G. Heber 1985 Simple Methods for the Treatment of Drinking Water.



It is necessary to keep some water level of supernatant on the sand filter. This is one of the idea to keep the water level by an float and flexible pipe. Almost constant flow is important in this system.

Pressure control
for constant flow

Up-flow
elimination
system of SS



Sand size
is not
important:
large size
of sand is
better.

Mr. WRIGHT Filipo(Samoa)
Mr. KAPHLE Ram Chandra(Nepal)
Mr. PHIMMASONE Vilaykhone(Laos)

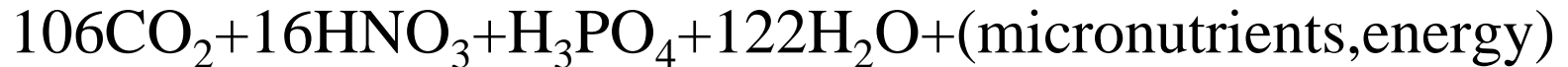
*Ecological Purification
System can be made
by yourself.*



Biological Phenomena of Ecological Purification System(EPS)

Oxygen Production by Photosynthesis $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{CH}_2\text{O} + \text{O}_2$
Gives a better condition for heterotrophs. (Decomposer: bacteria, small animals)

Reduction of Nutrients in Water by Algal Growth



Photosynthesis respiration, decomposition

$(\text{CH}_2\text{O})_{106}(\text{NH}_3)_{16}\text{H}_3\text{PO}_4 + 134\text{O}_2 + \text{micronutrients}$
Oligo-trophication (opposite process of eutrophication: shift to less polluted water)

Production of Food and Energy Source for Heterotrophic Organisms
Algae is one of the best food for animals in EPS.

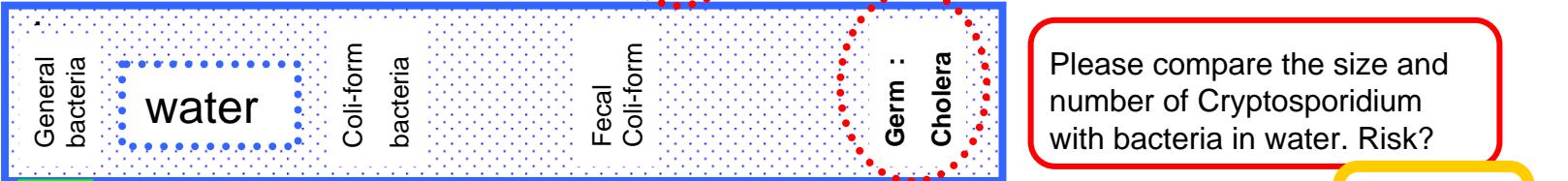
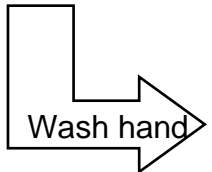
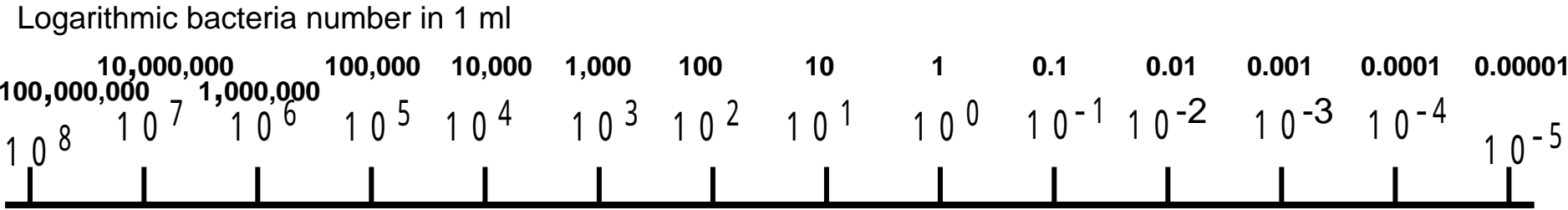
Shift to High pH and High DO Concentration by Photosynthesis
(Low CO_2 concentration shifts to high pH condition)

Metal ions are easily changed to hydro-oxide compounds.

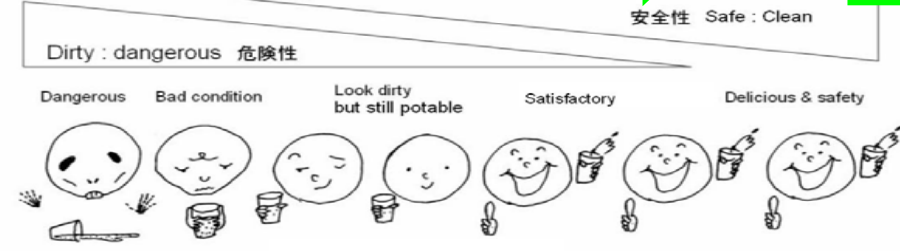
Easily precipitate: ***bio-mineralization***

Reduction of metal ions: Reduction of toxic heavy metals

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



Risk of germ bacteria in water.



We have to think about acceptable risk.