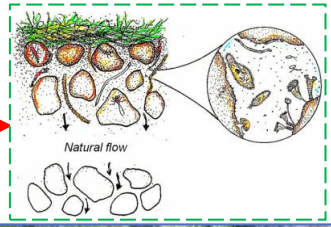
Slow Sand Filtration is Ecological Purification System

Jan.10. to Feb.10., 2024 at Okinawa

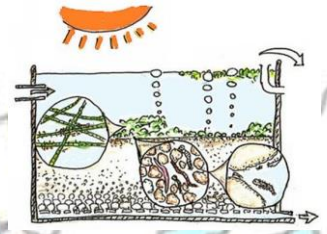
Nakamoto joins the training from Jan.15. to 19. 2024.

Part 3

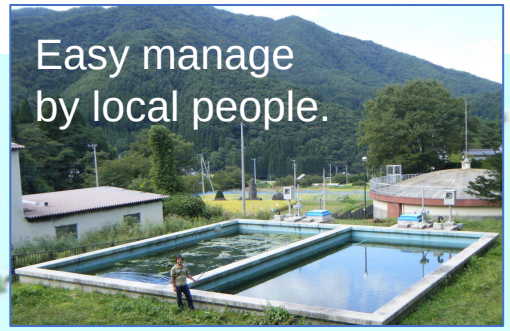
Slow Sand Filtration



Ecological Purification System



Wise Application of Natural Phenomena



Safe Drinking Water for all villagers by EPS in Fiji.

Lebanon

Bhutan

Okinawa

Malaysia

Marshall

Nauru

Tuvalu

East Timor

Fiji

Small simple system is suitable than high tech system in rural area.

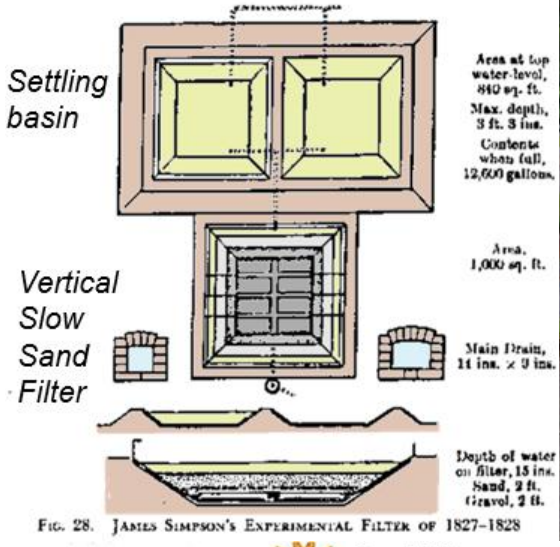
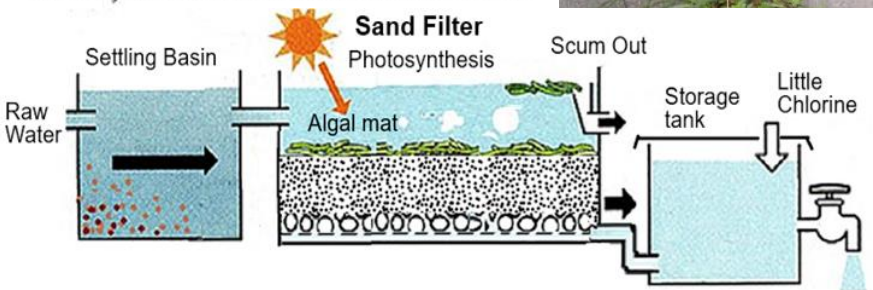


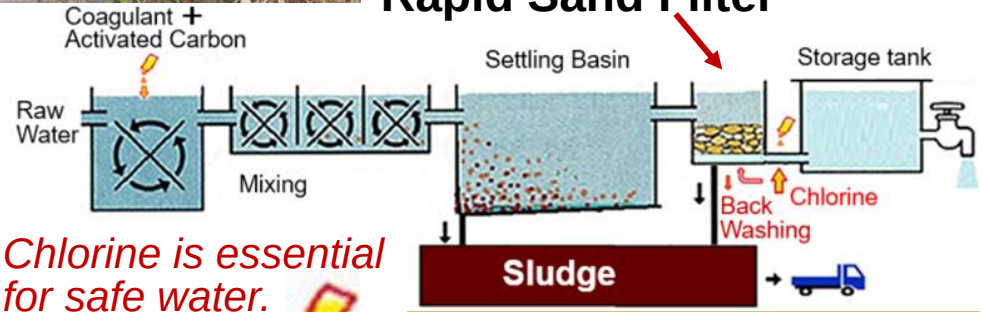
FIG. 28. JAMES SIMPSON'S EXPERIMENTAL FILTER OF 1827–1828

Wise Application of Natural Phenomena

Rural people can manage this system.



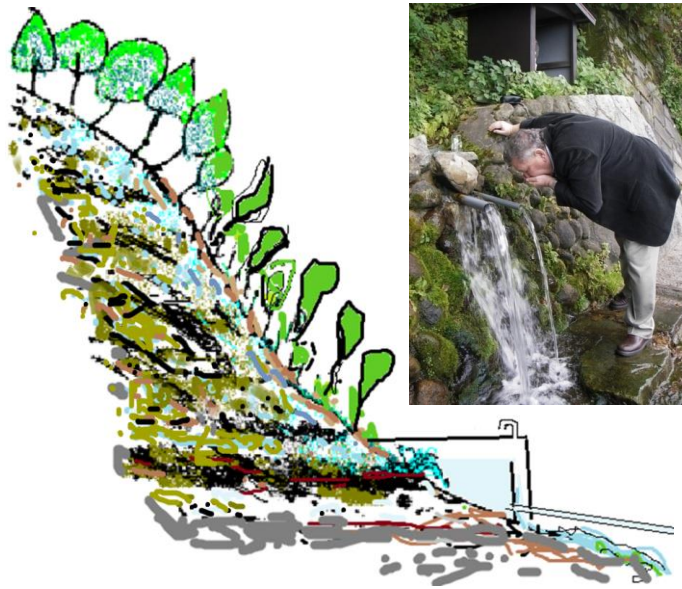
Rapid Sand Filter

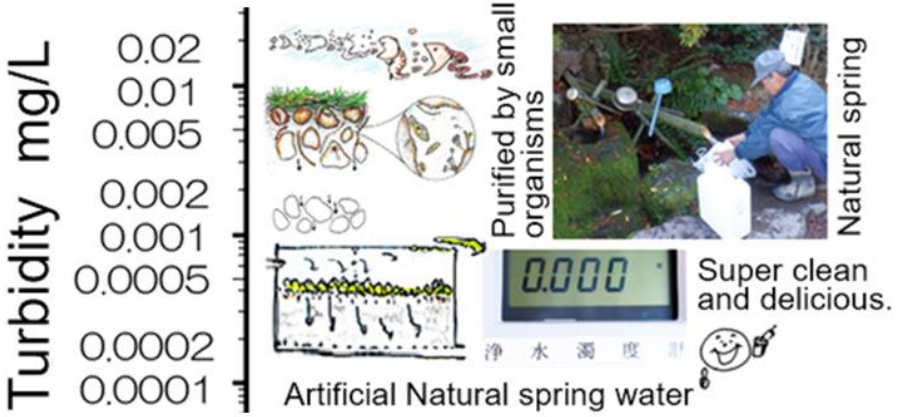


Chlorine is essential for safe water.

American RSF is a commercial filter.
SSF of EPS is a natural filter.

Think about where the money is going.

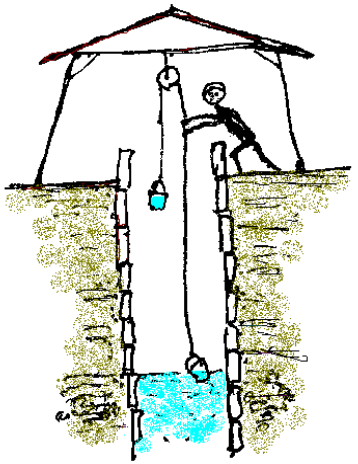


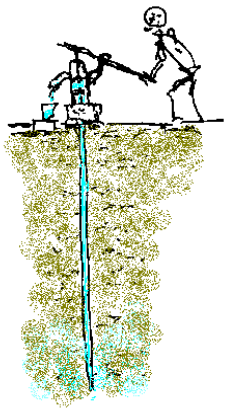


There are many **natural spring waters** in Japan. These are **usually safe to drink**.

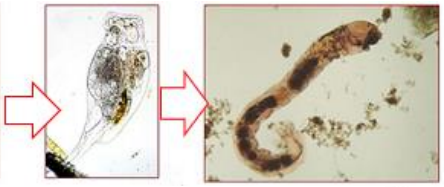
The quality of these spring water is good. It will *not become cloudy even in heavy rain or long rain*. Even in years with strong sunshine, the amount of spring water does not change and is **constantly flowing**.

Long residence time of groundwater : Long contact time. When dissolved oxygen disappears, heavy metal ions that remain undissolved in their oxide state begin to dissolve into the water.

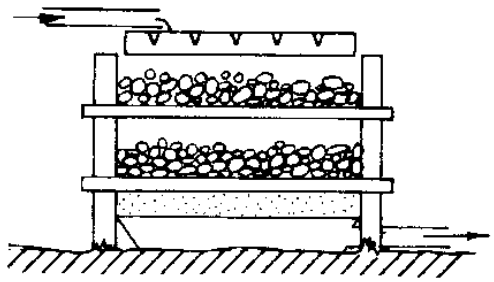




Groundwater in flat plains hardly moves. Over a long period of time, dissolved oxygen is consumed, and iron, manganese, etc. are leached into the groundwater.



Aerobic condition is essential.

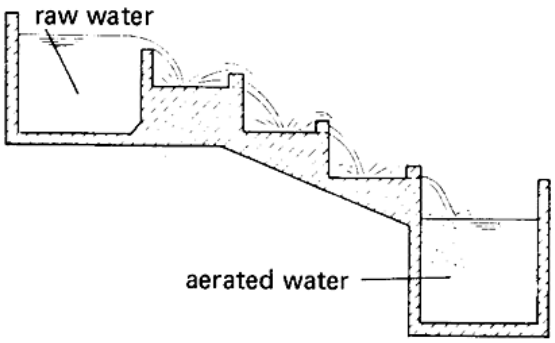


Aeration to provide oxygen: Aeration is commonly used to treat groundwater. Aeration removes odor, color, iron, and manganese, making it more delicious.

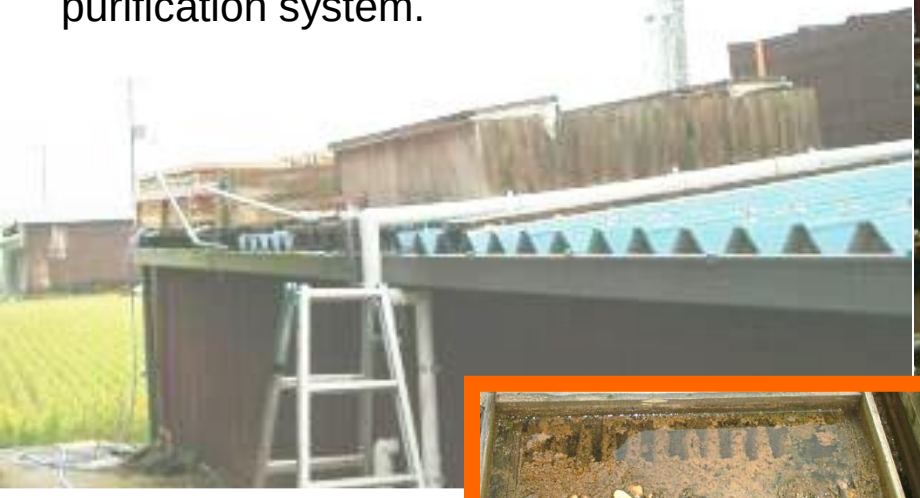
Underground water contains iron and manganese in Jakarta plain. Well water was clear. But the brown colloidal particle was formed soon.

Bekasi, Jakarta, Indonesia

Clean water project team of Yamaha motor company could make clear water using cascade aeration system without any chemical reagent.

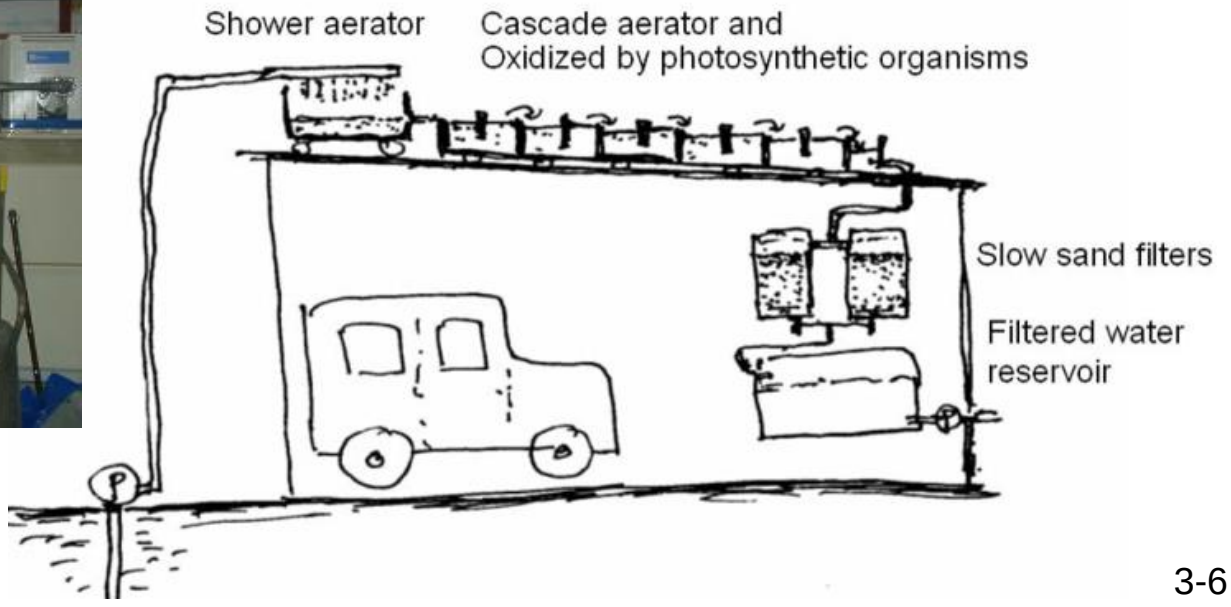


High concentration of iron and manganese in a tube-well water was treated by a cascade aeration with an ecological purification system.



Pre-treatment of cascade aerator using biological activity of bacteria, algae and animals.

Final treatment of slow sand filter.



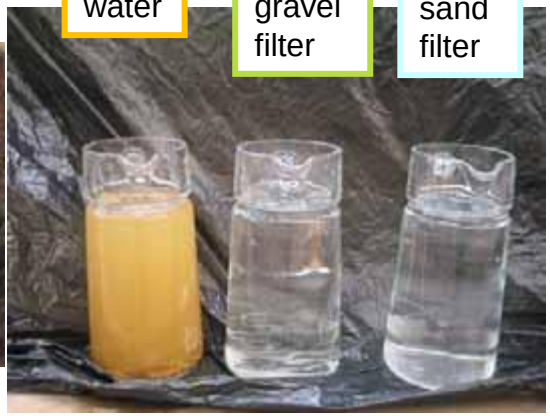
Use of natural slope, drinking water could be made by EPS, Bolivia, 2008

Pump for groundwater and source water tank

3 steps of gravel filters

Use of natural slope, pour in sand filter

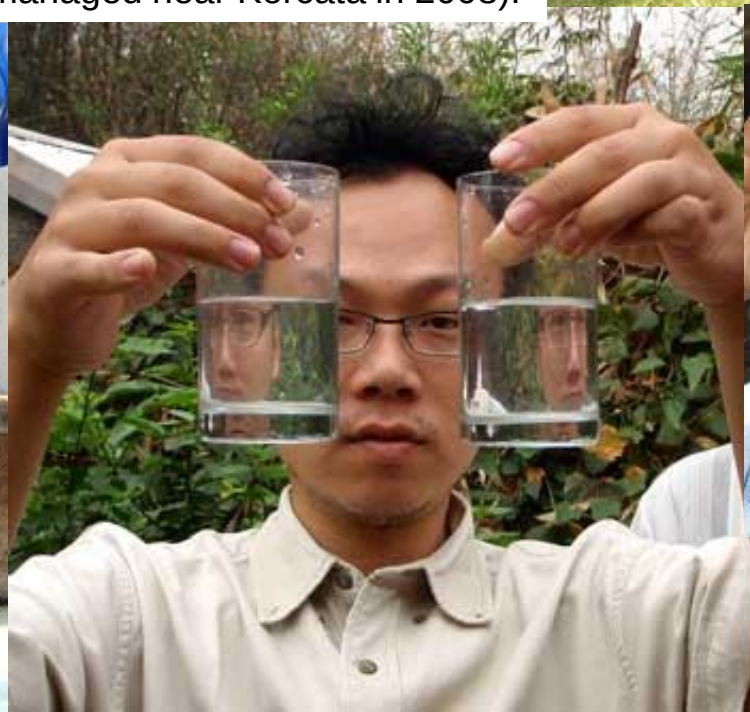
Filtered water tank



After 4 days, filtered water became clear. After one month, the water became drinkable water, in which coli-form bacteria form was not detected.

Volunteer JICA's report, Horie, T. 2009

ApamNapat Art Project (Mr. Sohei Iwata managed near Korcata in 2008).



At the foot of mountain, there is a reed plant where underground water leaks out. Porous pipes were set to take the subsurface water which is suspension free water.

Raw water: Suspended Solid free of subsurface water.
Over two years, there is **no scrapping**.
This is almost **no work to maintenance**.
One filter area: 6.8mx13.5m=91.8m^2 One filter capacity : 91.8m^2 x 5m/d = 459m^3/d. One filter can supply for 1500 persons demand (459m^3/d ÷ 0.3m^3/d /person).
Two filters can supply for 3,000 persons(1,200m^3/d).

Super clean delicious water without any chemicals.

Karasawa WTP (for 9,400 villagers from 1977, Altitude 990 m), Yamagata village, Nagano, Japan

JICA EPS training in Miyako-Island from 2006 to 2008.

Intake Bar Screen filter

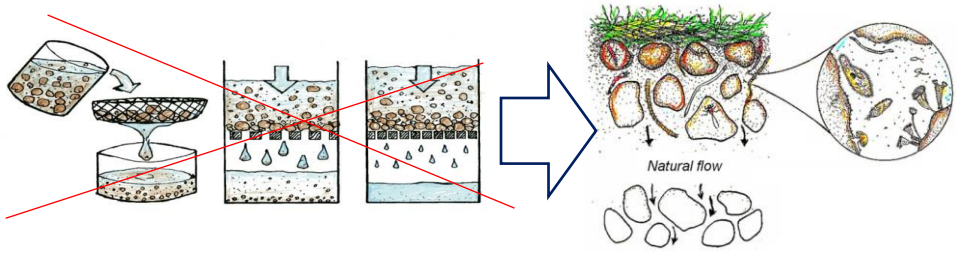
Alaoa WTP, August 2009

In order to check the training effect, we visited to Samoa with Mr. Akita Uechi from Miyako Water Wks and me in 2009.

Agreement to Samoa Water Authority.
Then, Miyako-Jima‘s Water Supply Model Project in Samoa from 2010 to 2012 was done.

During heavy flooding or rainy days, high turbidity blocks sand filters

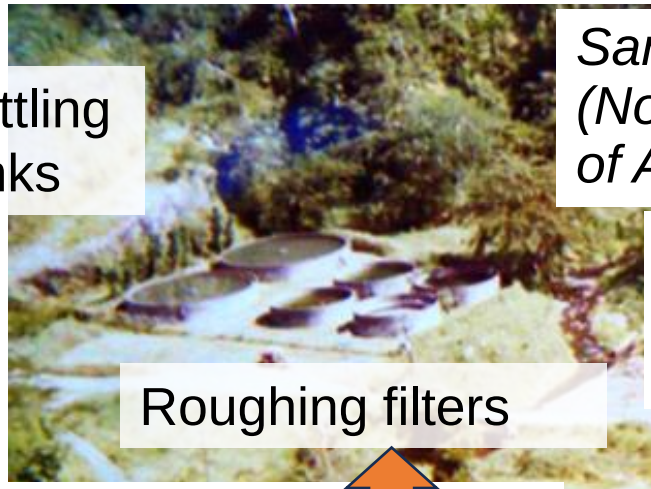
This problem was happened by the misunderstand of the real mechanism. Slow sand filter system is not simple mechanical filter. This is a real Ecological Purification System.



https://www.youtube.com/watch?v=Kkk-wdlHui4

Slow sand filter problem in Samoa was solved by ecological point in 2010.
YouTube / 13:45

Settling tanks



Roughing filters

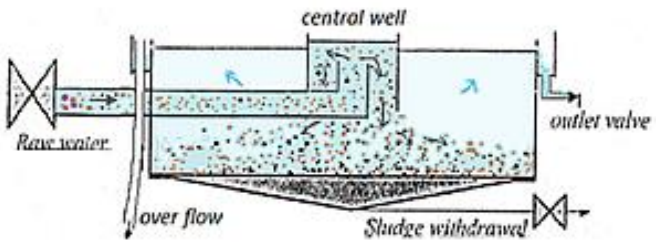
*Samoan people used **non-treated water** (Non-purified water), before construction of Alaoa Purification plant (1984).*

*Joseph River company (Germany) constructed 5 **slow sand filters only** during 1984-87.*

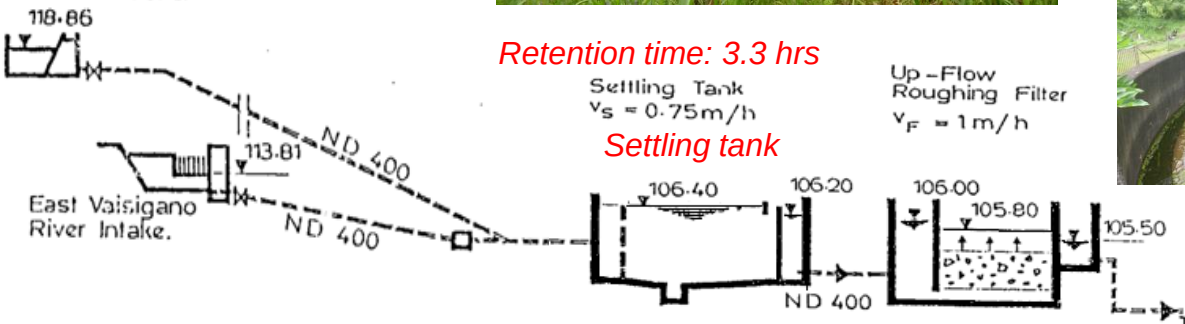
Slow sand filters

*Dorsch consult (Germany) constructed settling tanks and Up-flow **roughing filters** in order to reduce the extraordinary load of surface run off by storm event in 2000.*

http://www.cwsc.or.jp/cwscpanel/wp-content/uploads/2022/10/AlaoaDurch-Manual.pdf

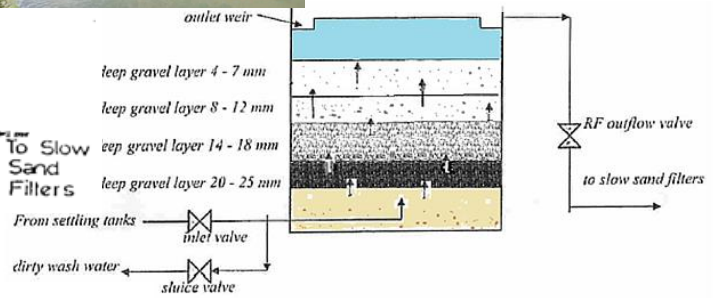


Diameter 17.8 m Area 248.8 m2
2 tanks Retention time: 3.3 hrs



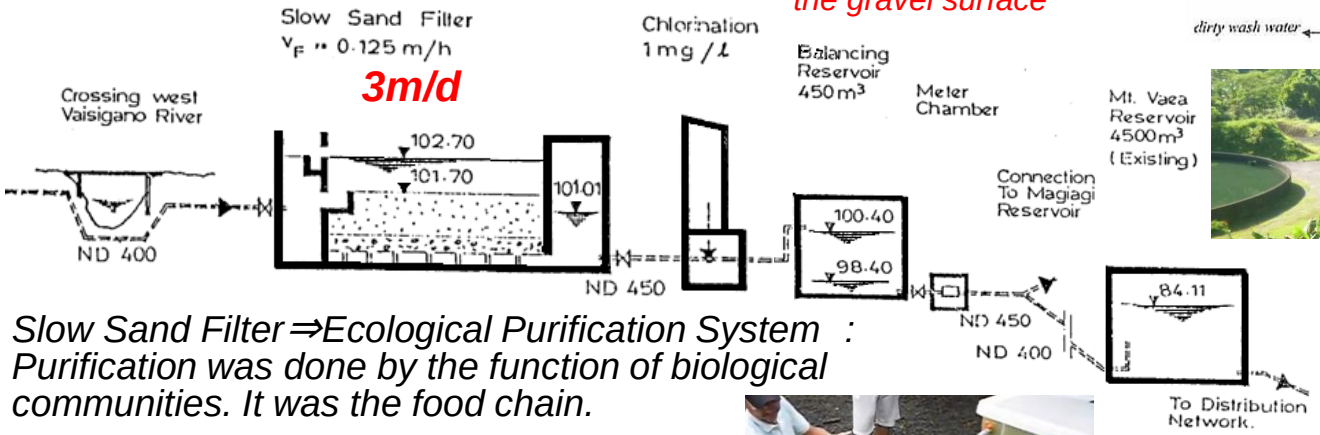
Up-flow Roughing filter:

Diameter 11.2 m
Area 98.5 m2
4 filters
Filter rate: 1m/h



***Up-flow Roughing filter**:*
Fine, light particles cling to the gravel surface

Natural Down flow



Diameter 28 m
Area 616 m2
5 filter ponds
Flow rate: 3m/d

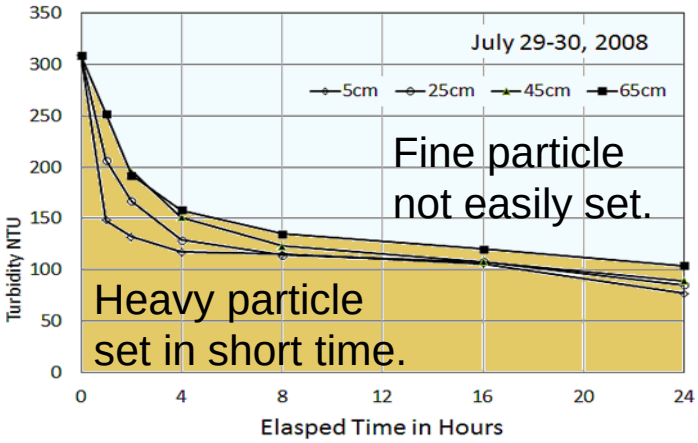
Slow Sand Filter⇒Ecological Purification System : Purification was done by the function of biological communities. It was the food chain.

English standard rate: 5m/d (0.2m/h).
Present Thames rater: 10m/d(0.4m/h)
Our experiment in Samoa：2013: 5m/d, 10m/d, 20m/d = Any rate is good results.

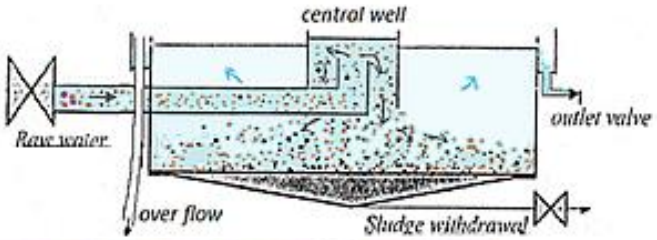
616 m2 x 3m/d = 1,848 m3/d x 5 filters =9,240 m3/d
5m/d; 3,080 m3/d x 5 filters = 15,400 m3/d
10m/d; 6,160 m3/d x 5 filters = 30,800 m3/d

One day demand: 0.1 to 0.3 m3/day person

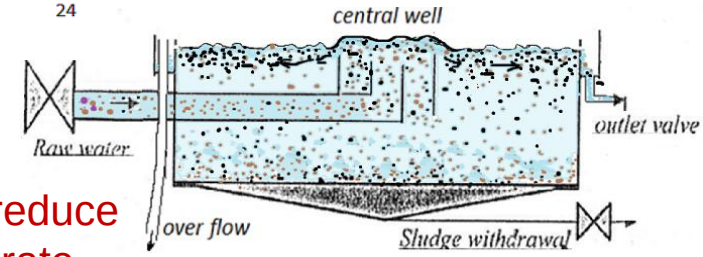
The ideal is a calm surface.

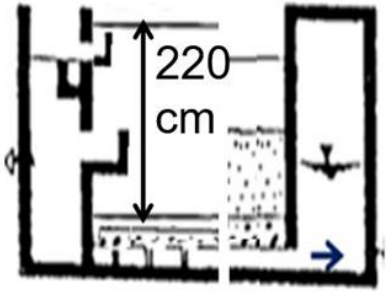


Retention time: 3.3 hrs (design)



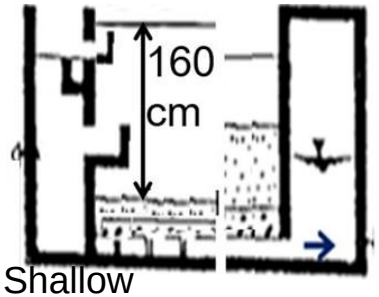
We reduce flow rate





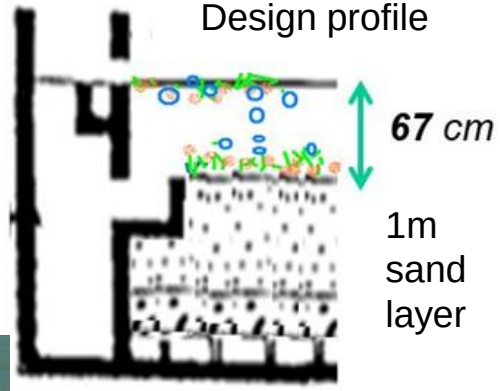
Deep

Almost no sand layer.



Shallow

Design profile



Shallow depth: Active photosynthesis: much oxygen bubble formation.

220 cm Deep

Lifted algal mat with mud.

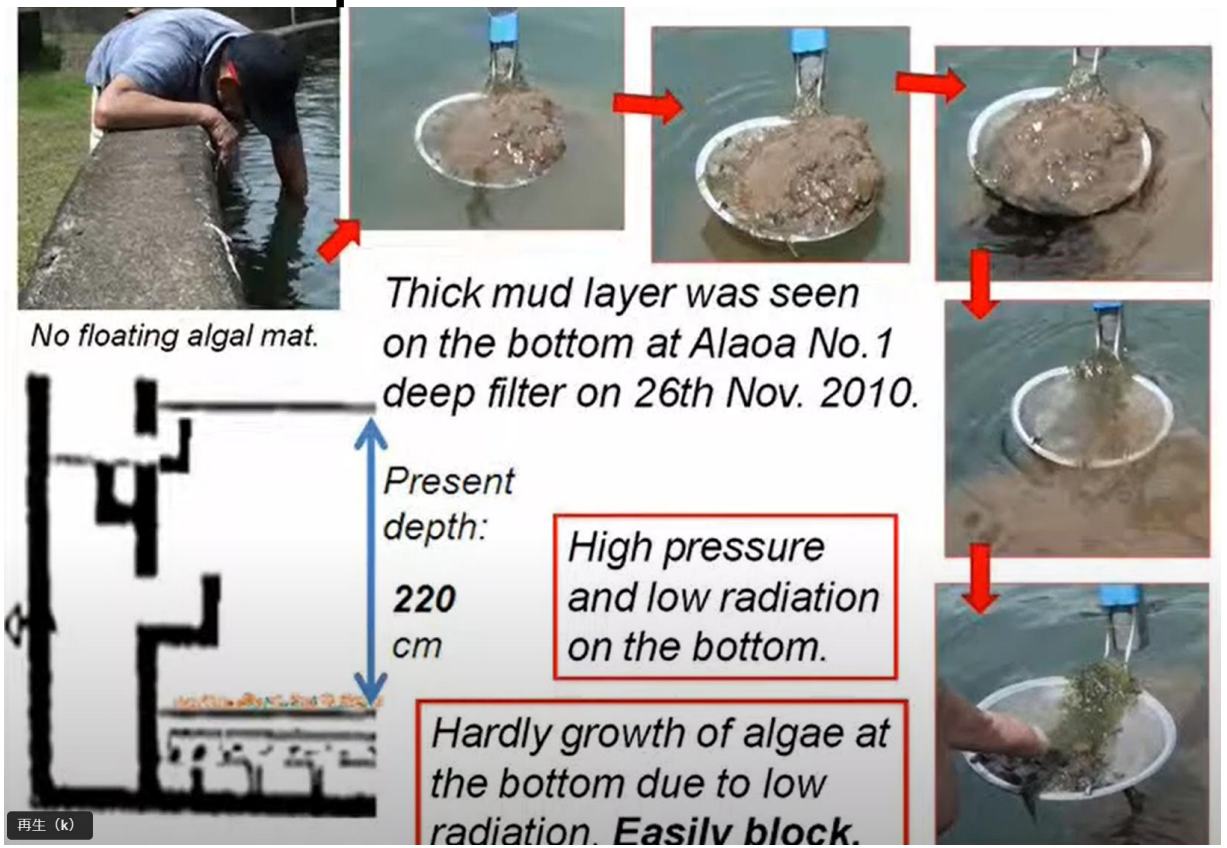
Large mud on the bottom

We recommend: Put sand. Make shallow depth.

Water depth is the key for ecological purification system of slow sand filter pond.

Role of algal mat in slow sand filter, shallow depth is key: experience in Samoa - YouTube/ 5:05

https://www.youtube.com/watch?v=ot-KAm6TuaY

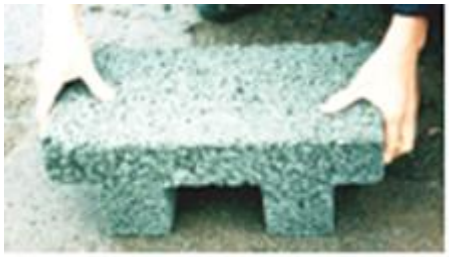


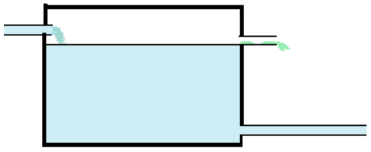
Depth of Fuluasou WTP was also too deep.

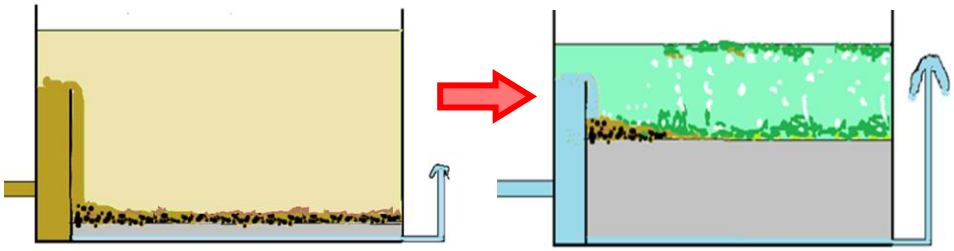
Beach sand near a river mouth was washed to make a shallow depth of slow sand filter pond.

Only the sand was put on the gravel layer using a cloth to separate them.

I knew there was only sand layer on bottom porous brick in slow sand filter pond in UK.





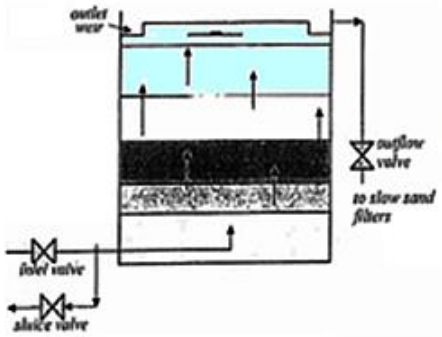


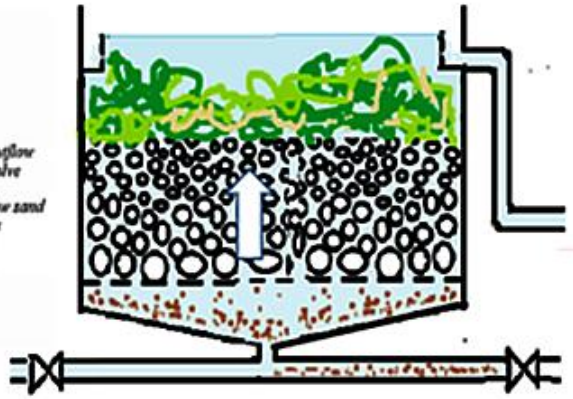
Deep to Shallow

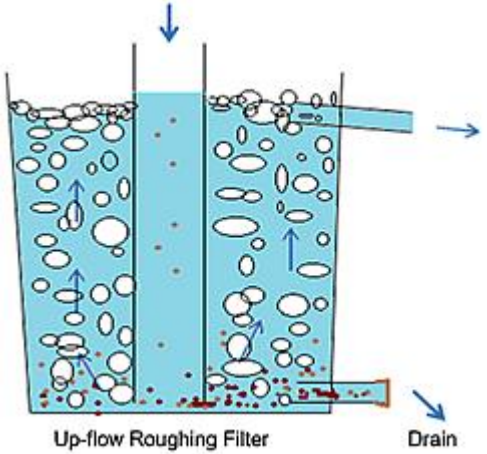
High Biological activity

Over-flow from the balance tank for filtrate water.

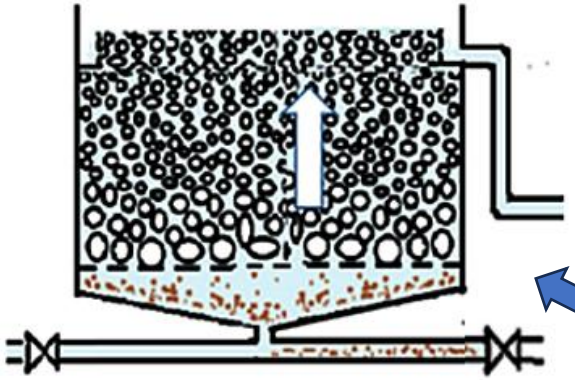
Dorsch 1 m







Active growth in URF



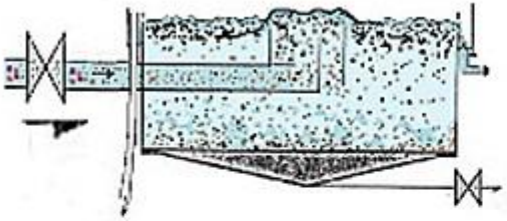
Large area of **gravel surface** is important to adhere suspended matter.

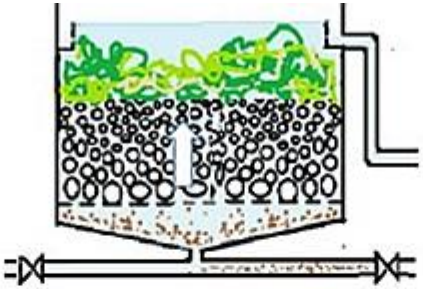
Clear water in river bed.

Full gravel with small crushed stones.

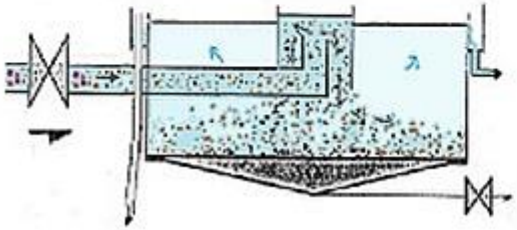
Advise for a better plant system to Samoa

Improvements to the Purification Function.

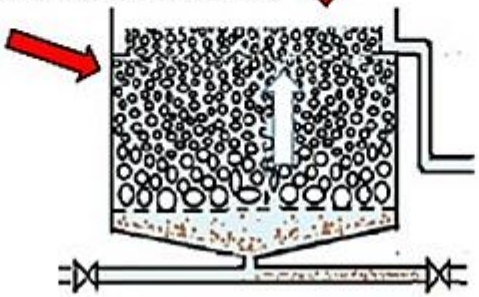




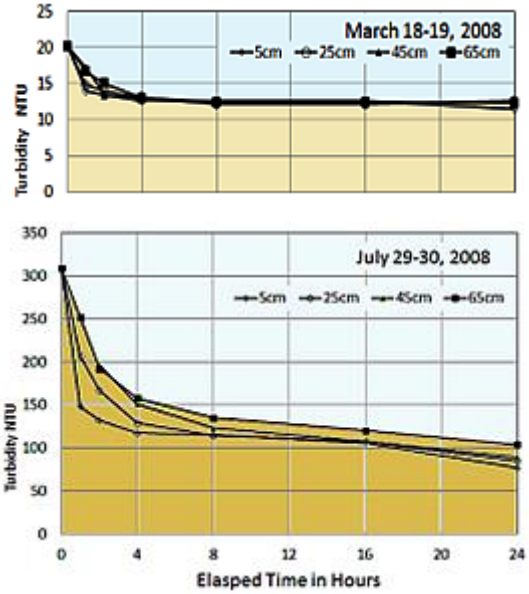
Reduce inflow
⇒Easy to settling



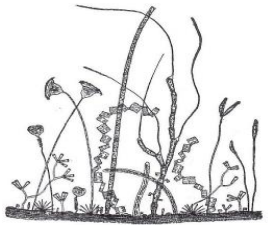
Thicker gravel media
⇒Expand active area



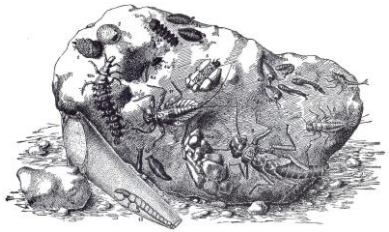
Make shallow depth
⇒ Activate algae



Suitable residence time for settling



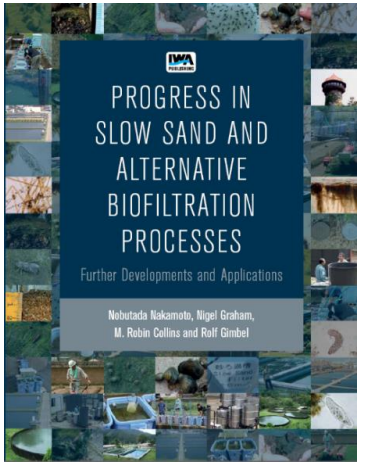
Small organisms active on the stone surface.

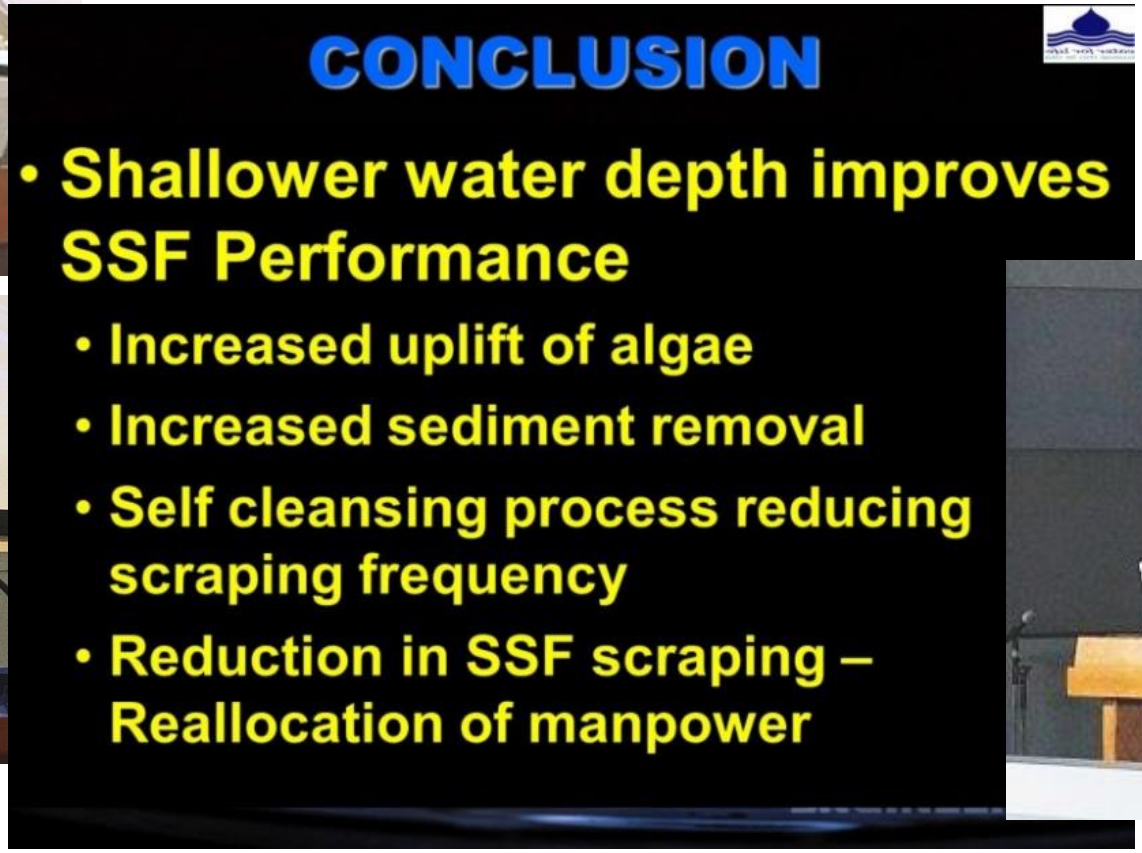


Shallow depth is better for algal activity.

Stuffs of Samoa Water Authority presented their activity at the 5th Conference at Nagoya, Japan in 2014.

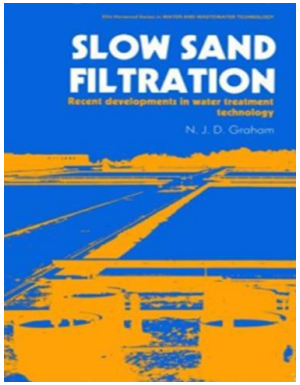
They made shallow water depth of 0.5 - 1m.



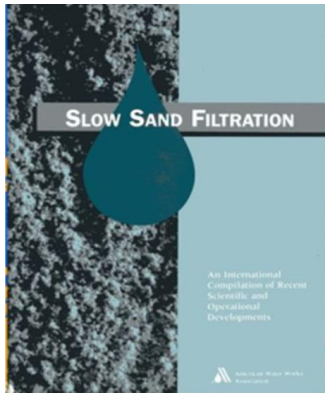


Focus to Slow Sand Filter.

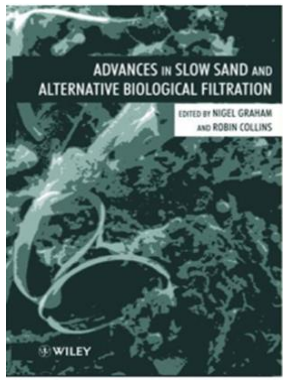
My first visit to Thames Filter was Aug. 1991.



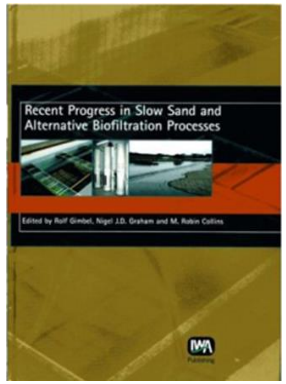
1988, Nov. 1st. SSF Conf. in London, UK



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



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

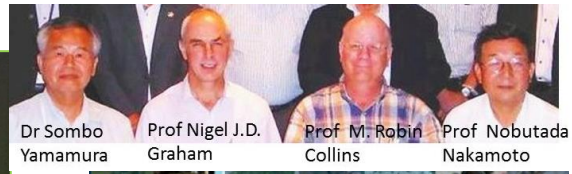


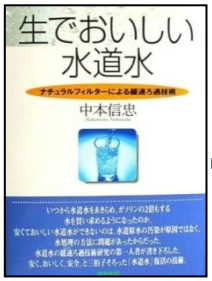
2006 May, 4th SSF Conf. in Mulheim, Germany

I could study on Thames Filters during 1994 to 1996.

Focus to Ecological Purification System.

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

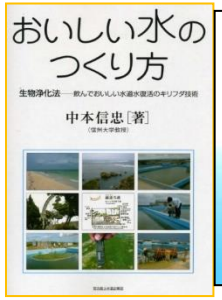




May, 2002.

Aug. 2005.

For Miyako wks.

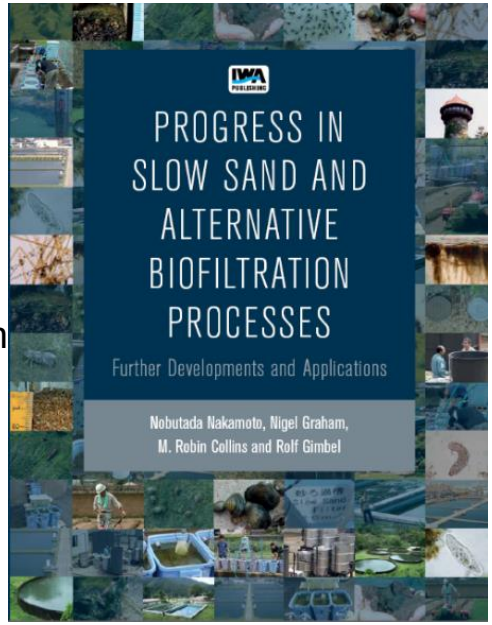


Aug. 2005.

May, 2009.

Chinese, China

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

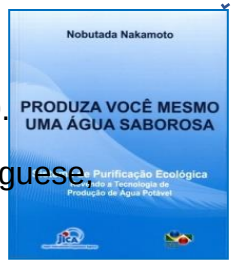


***Natural** filter of slow sand filter*

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.

https://www.youtube.com/watch?v=Wv1FxTkDfsM&t=2s

5SSABC - YouTube / 14:15

Right to adequate food and water

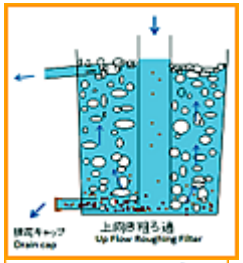
CONSTITUTION OF THE REPUBLIC OF FIJI

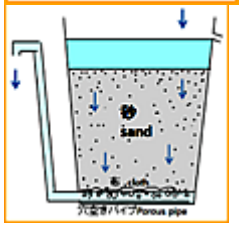
36.-(1) The State take reasonable measures within its available resources to achieve the progressive realisation of the right of every person to be free from hunger, to have adequate food of acceptable quality and to **clean and safe water in adequate quantities**.

https://www.fiji.gov.fj/getattachment/a3cddc01-dc73-4823-83b8-f290672ddae0/2013-Constitution-of-The-Republic-of-Fiji.aspx

Mr. Vishwa Jeet from Fiji gave many questions to me.

He returned back to Fiji, he made a model to make safe drinking water by EPS technology at the yard of Department of Sewage and Water. Water source was rain harvest tank.





The PM had attention for EPS display during the World Marine Time Day on **Sept. 28, 2012**.
Mr. Vishwa Jeet informed the PM on the functions of the EPS and reference to JICA was made.

New plans for cleaner water

Kick off Workshop on Jan. 16. 2013. at Holiday Inn. Commander Francis B. Kean, Permanent Secretary, Ministry of Works, Transport, Public Utilities.

The Fiji Times ONLINE
Quality water for all

Ecological Purification System in Fiji, 2013 for Safe Drinking Water - YouTube/ 3:05

https://www.youtube.com/watch?v=kbCaSAACQZ0

He explained using rain harvest tanks for the EPS system in Fiji.

Beginning of Ecological Purification System (EPS) to make safe drinking water in Fiji / 1:45

https://www.youtube.com/watch?v=wxAGhjx7e40

THE FIJIAN GOVERNMENT

EPS technology is our technology for ours. We can make it by ourselves.

Commander Kean said the pilot project was aim

KALOKOLEVU VILLAGERS WELCOME ACCESS TO CLEAN DRINKING WATER

7/17/2013

NAVATUVULA VILLAGERS GET ACCESS TO CLEAN DRINKING WATER

9/12/2013

Opening ceremony of public tap on September 11, 2013. at 2nd Eps.

EPS technology is our technology for ours. We can make it by ourselves.

Quality Water for All : Safe and Clean Water Project in Fiji, 2013 - YouTube/ 7:43

https://www.youtube.com/watch?v=Vrr2EOS1PMA

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

What is safe water to drink?

Germ free !

Reduce Risk !

We have to think about acceptable risk to drink.

JICA Training at Okinawa, in **August, 2011**

Mr. Vishwa Jeet learned the principle of EPS.

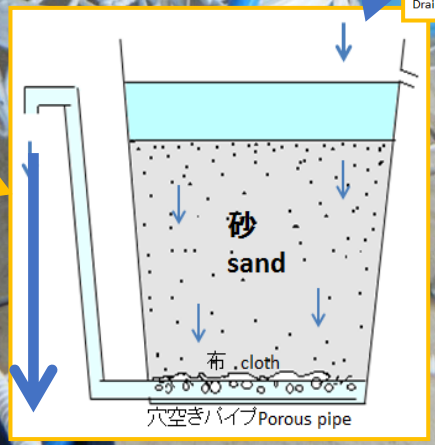
Receiving Tank

Sedimentation function

Up-flow Roughing Filter

He made an EPS model by himself. **He confirmed that filtrate was germ free and safe to drink.**

Ecological Purification System

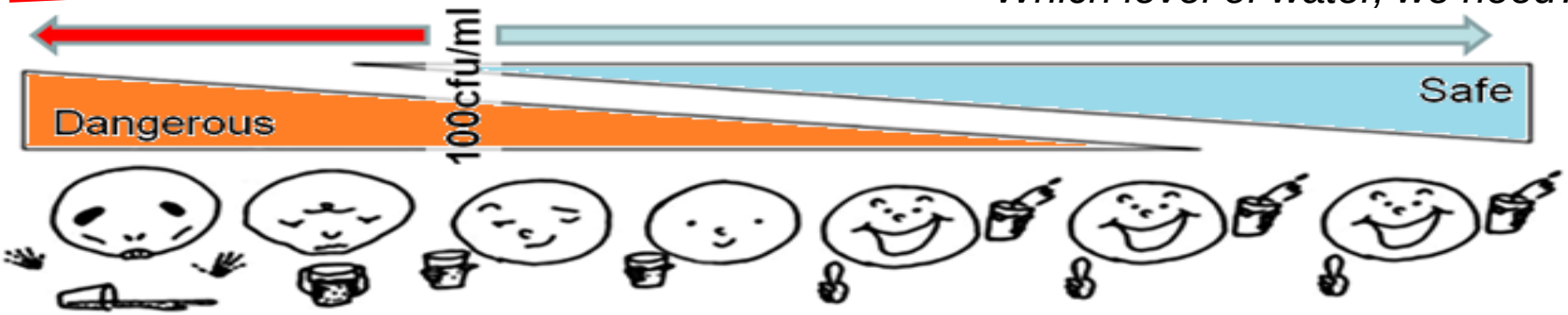


Drain

Filtrate Storage Tank

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

Which level of water, we need?



















Right to adequate food and water
36.-(1) : to **clean and safe water in adequate quantities**.

EPS water is germ free. We can drink it.

CONSTITUTION OF THE REPUBLIC OF FIJI

Aug. 2011 JICA training → in 2012 Model in Fiji → Jan. 2013 Kick off → Pilot Plant in Village

The model and the actual plant are different.

Pilot plant was constructed in Kalokolevu Village by DWS in 2013

There's no need to be afraid of making mistakes.
You fail and realize your mistake.

By improving, you will deepen your understanding and become better.
It's good to make a lot of small mistakes.

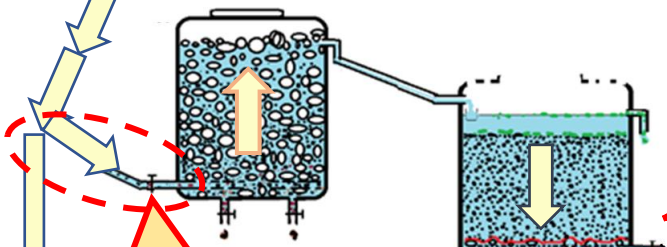
Receiving tank

Sediment heavy muddy matter

Rain harvest tanks of 2.7 tons

Hard to keep water level of EPS and constant natural flow. EPS water happens to drain off, and dry up frequently.

Nakamoto pointed out important weak points to improve as follows in Nov. 2014 .



Hard to control the flow rate and hard to catch filter clog.

By the ball tap, water flow was stopped. Dangerous to EPS function.

URF gravel

EPS sand

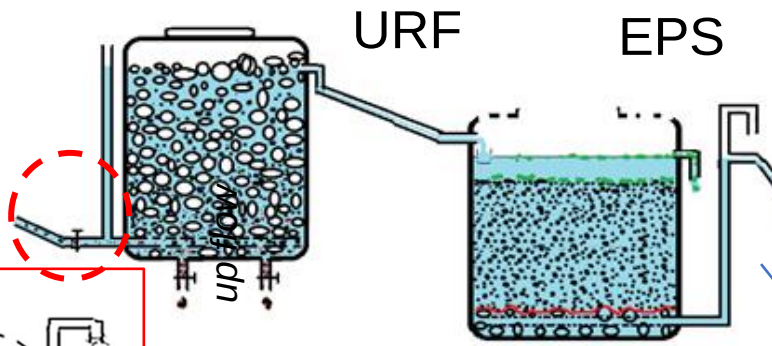
Clean water tank

Non-treated water

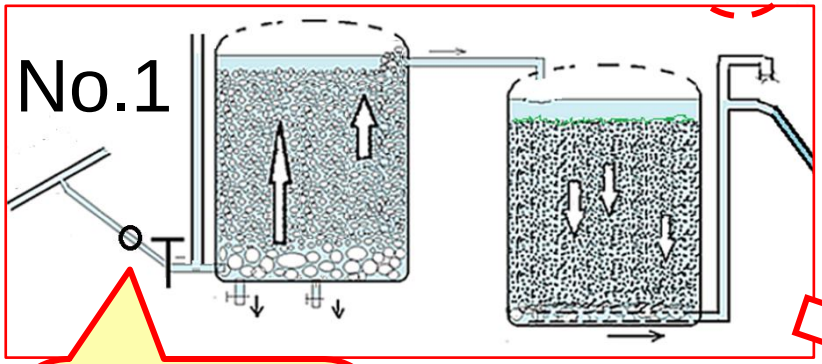
Non-treated water

Public taps

Nakamoto advised the fail safe system for inflow trouble (back draw) in Oct. 2015.



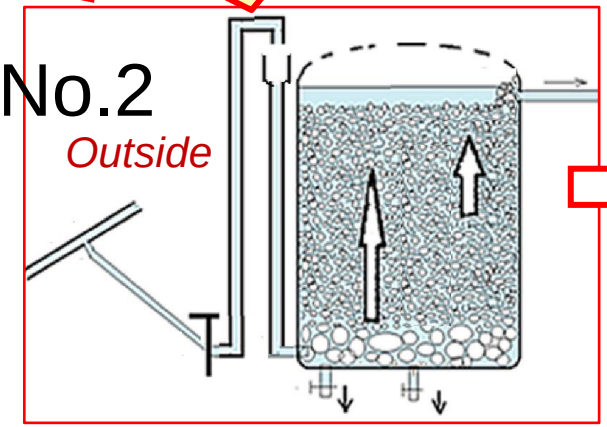
Storage tank with over flow function



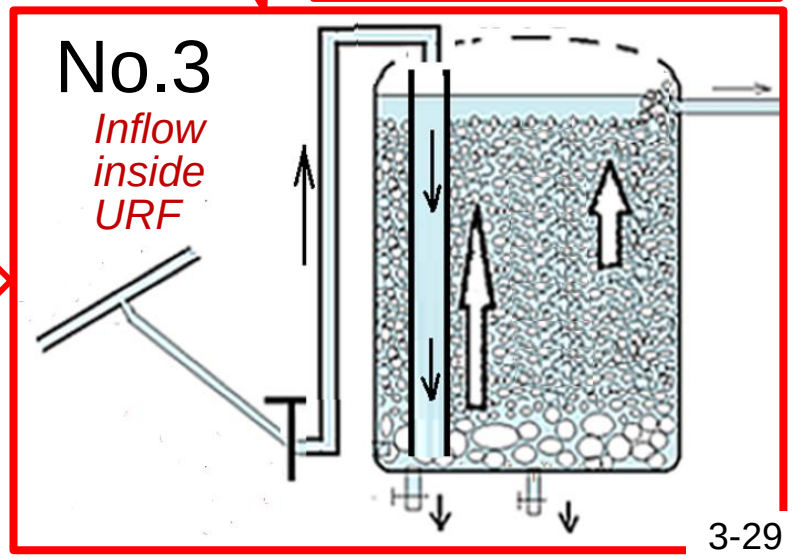
Fail safe system against back draw in case of low water pressure.

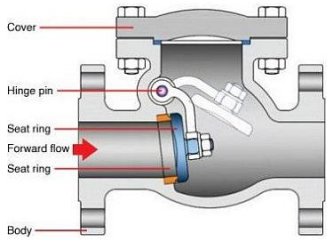
One way valve is necessary to protect draw back of mud, when water pressure is low in the existing pipe. This is the Japanese standard.

Fail Safe system against back draw in case of low water pressure.



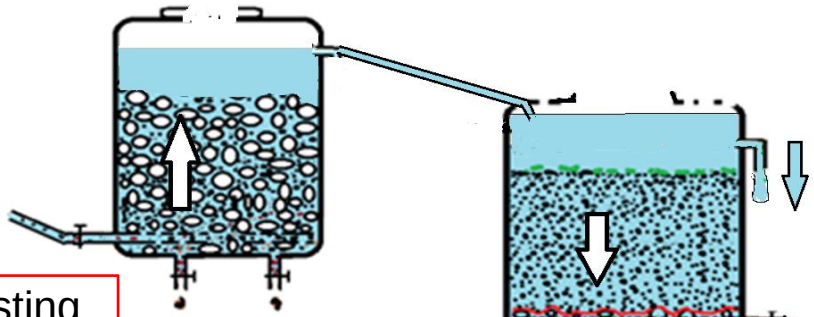
Ideal inflow system which was taught at JICA training in Japan.





Swing check valve

Present Kalokolevu EPS is hard to regulate, check the flow and difficult to catch filter clog.

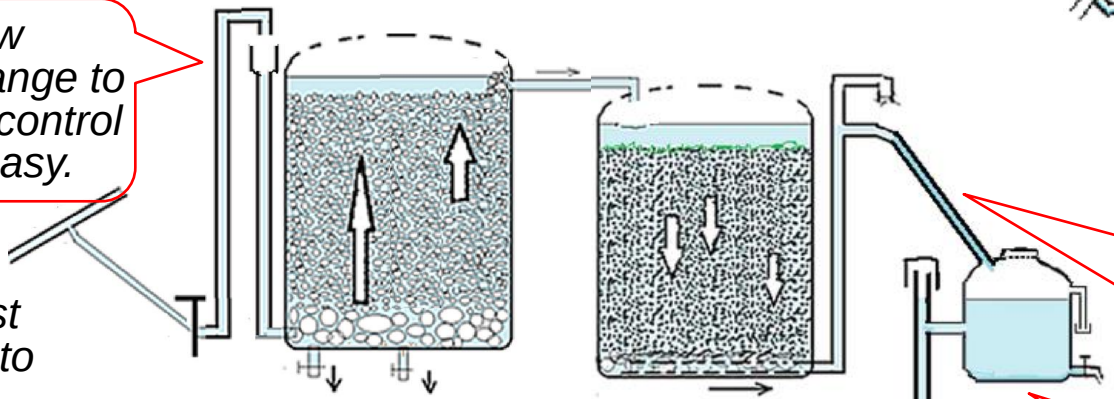


Massive over flow from EPS to keep water level over sand layer. If the inflow is small, the water is easily drain off through the sand layer. Sand surface is easily dried up. This is dangerous to small aquatic organisms.

There is a risk of leakage of coliform bacteria in the filtrate.

Repair idea of the existing Kalokolevu EPS.

When inflow system change to this. Flow control becomes easy.

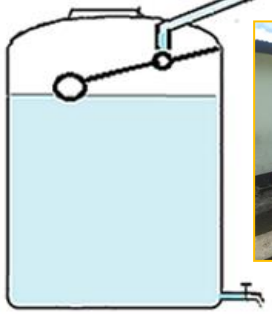


This flow system is also against back draw to existing main pipe.

Filter clog is easy to catch. Accumulated mud can be easy drained off.

The water level over the EPS can be kept by the siphon system for filtrate. This is natural over flow system from the bottom.

We propose to insert a small balance tank with over flow function between EPS and Storage tank at village center.



This balance tank is to keep natural flow for EPS. Excessive over flow is not necessary. The small over flow from this balance tank is enough when the storage tank with ball tap is full of filtrate.

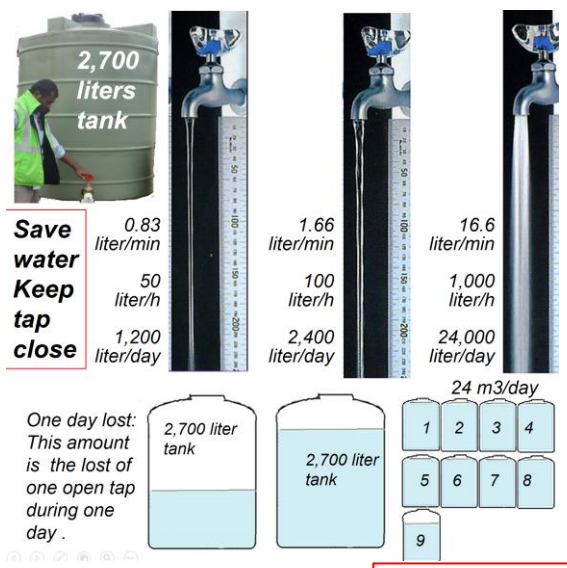
EPS capacity of 2,700 liters tank									
radius（r）=0.7m、（π x r x r）=1.54m2									
flow rate			filtrate			Available persons			remarks
m/d	cm/h	m3/d	liter/d	liter/h	liter/min	2 liter/d	6 liter/d	100 liter/d	
2	8	3.1	3,080	128	2.1	1,540	513	31	Original flow rate in UK, 1829
5	20	7.4	7,392	308	5.1	3,696	1,232	74	English standard rate
10	42	15.4	15,400	642	10.7	7,700	2,567	154	Present Thames Water rate
15	63	23.1	23,100	963	16.0	11,550	3,850	231	Possible rate in warm region
20	83	30.8	30.800	1.283	21.4	15.400	5.133	308	Possible rate in warm region

Comment on more use of EPS water in a village

Drink

Drink
Cook

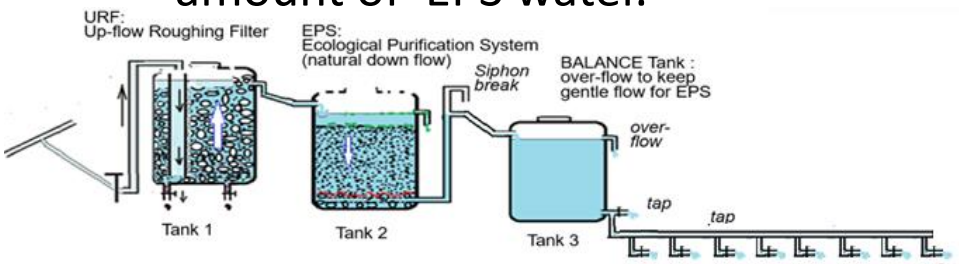
Drink
Cook
Shower



1. Block distribution system for EPS water is recommended.

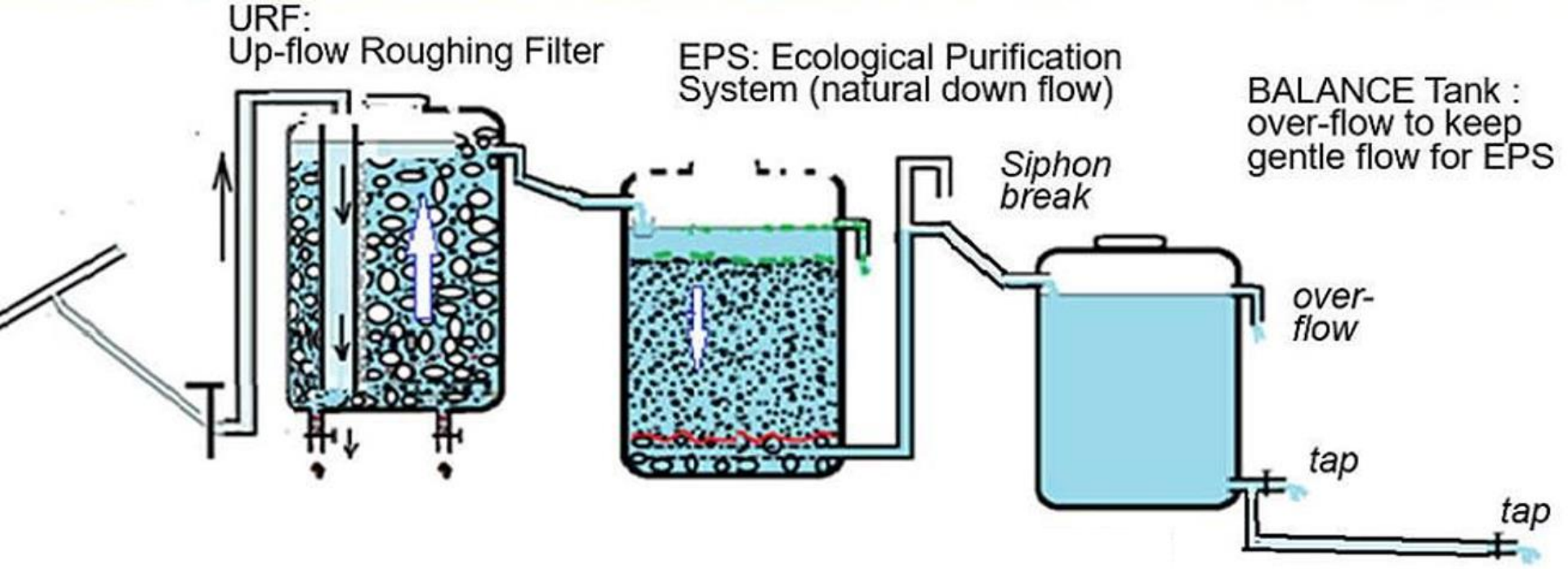
2. Install more public taps for villagers.

3. Training for the save the limited amount of EPS water.

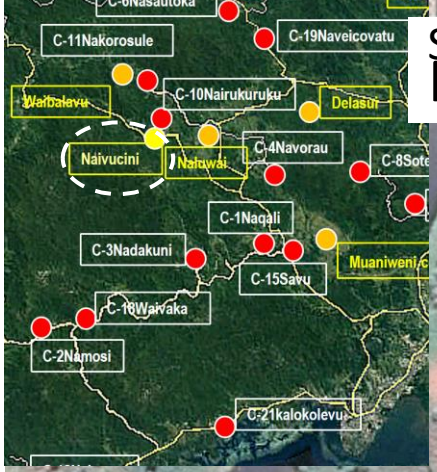


There is non-detected leak, therefore we have to install EPS pipe with may public taps in a small village (even up to 200 persons).

If there is absolutely no leak problem, we may connect to present distribution pipe in case of a small village. But this is risky. I cannot recommend this connection.


URF:
Up-flow Roughing Filter
EPS: Ecological Purification System (natural down flow)
BALANCE Tank : over-flow to keep gentle flow for EPS
Siphon break
over-flow
tap
tap

Sites visit on 03/07/17
Naivucini



Present Receiving tank. Water shortage problem.

NEMANI TG 9501657
500 persons 120 houses

Storage 2
EPS
Present Receiving tank
Storage 1
Serea Laselevu Rd
50 m
New pipe line from new water source is now under construction.

More use of EPS water is key to be better quality.

6 liters x 200 persons = 1,200 liters

Strg-2
2,000
Stem pipe with taps

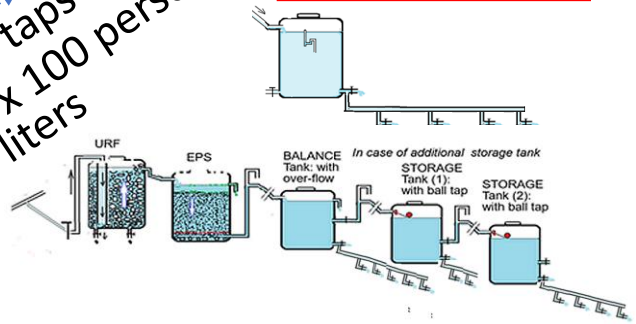
6 liters x 100 persons = 600 liters

Strg-1
Stem pipe with taps
1,000

Blc
1,000

EPS
2,700

URF
2,700
Stem pipe with taps
6 liters x 100 persons = 600 liters

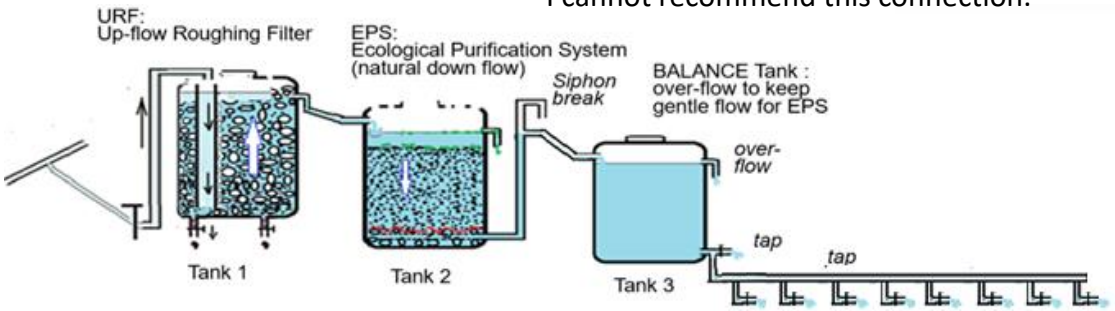


Comment on more use of EPS water in a village

There is non-detected leak, therefore we have to install EPS pipe with may public taps in a small village.

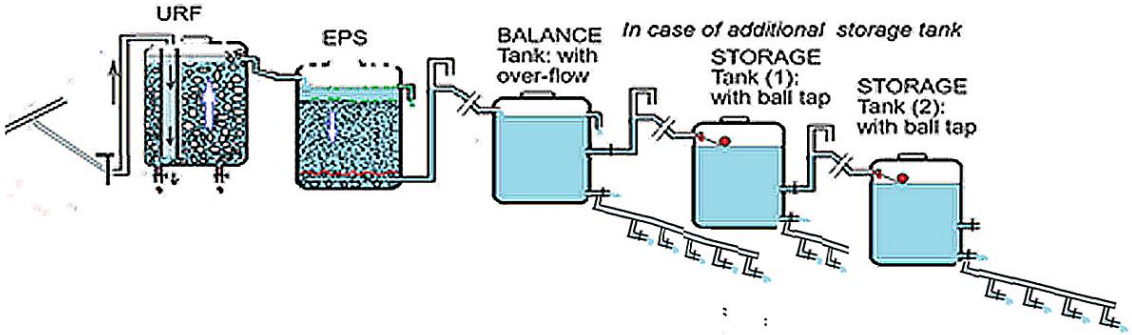
Up to 200 persons in a village

If there is no leak problem, we may connect to present distribution pipe in case of a small village. But this is risky. I cannot recommend this connection.



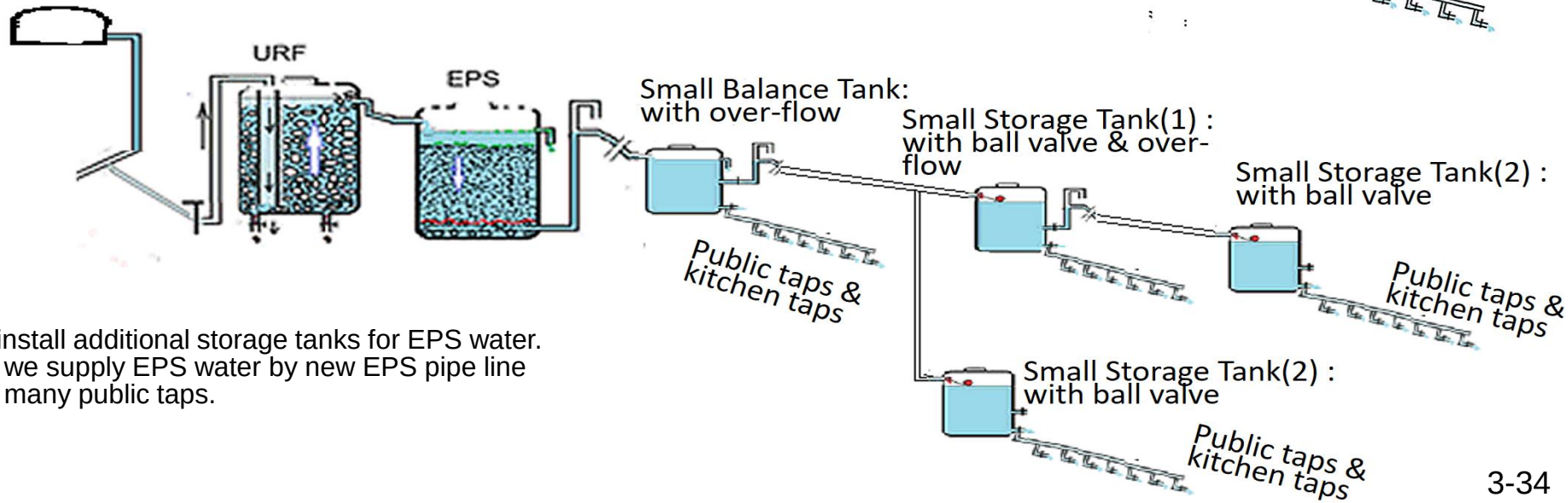
200 to 500 persons in a village

We supply EPS water by new EPS pipe line with many public taps. Or we install additional storage tanks for EPS water. And we supply EPS water by new EPS pipe line with many public taps.



More 500 persons in a village

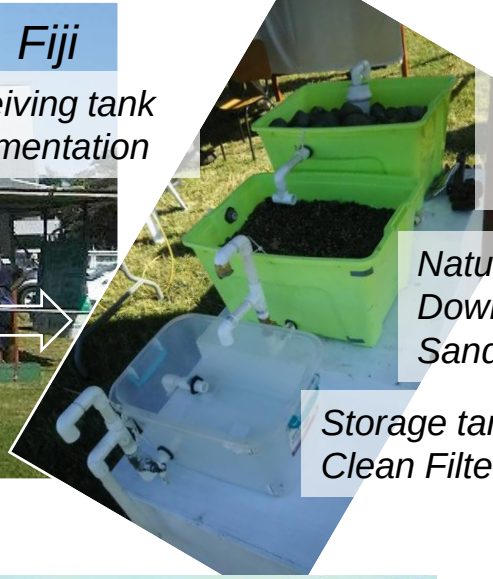
Present receiving tank



We install additional storage tanks for EPS water. And we supply EPS water by new EPS pipe line with many public taps.

World Water Day 2018. March 22/23 Lautoka, Fiji

Receiving tank
Sedimentation

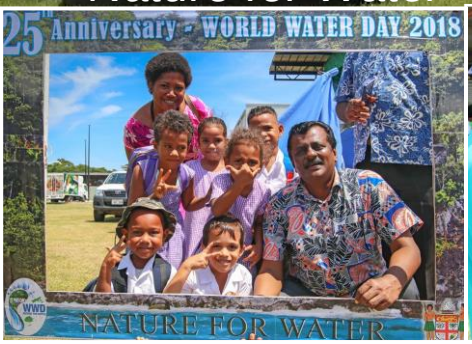


Upflow
Roughing
Filter

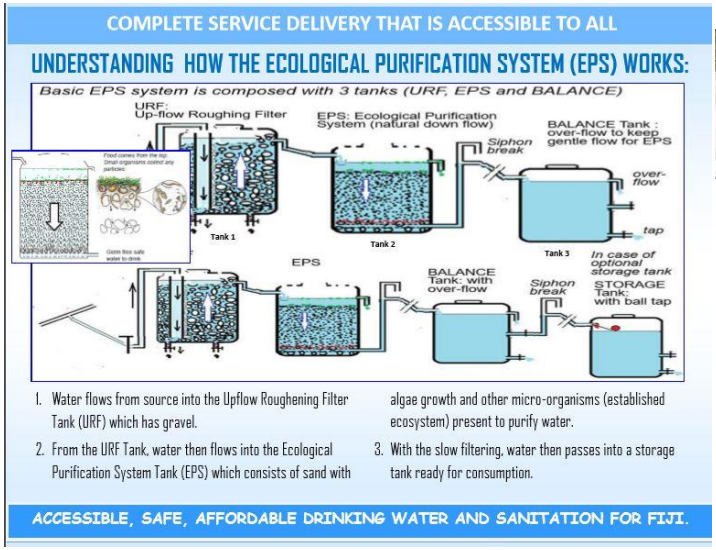
Natural
Down flow
Sand Filter

Storage tank for
Clean Filtered Water

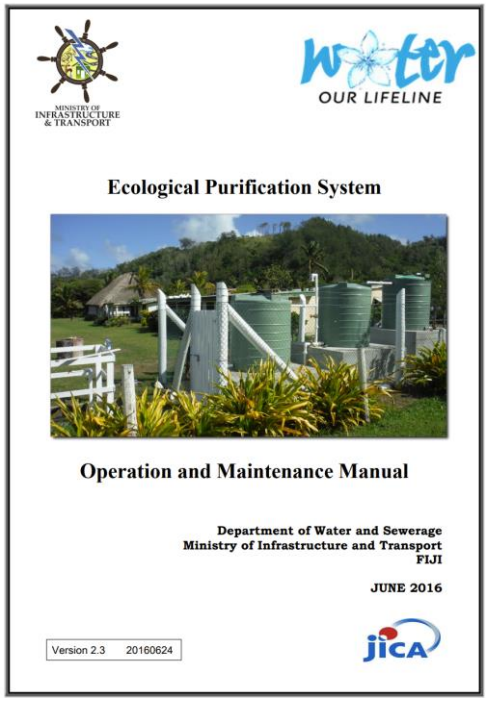
Nature for Water



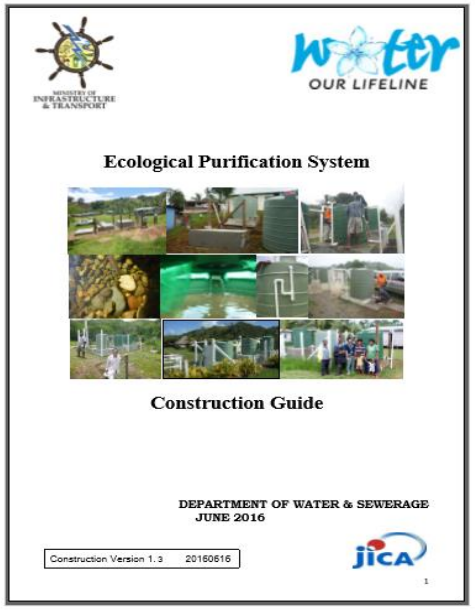
Fiji上下水道局はモデルを使ってEPS事業を積極的に解説をしている。



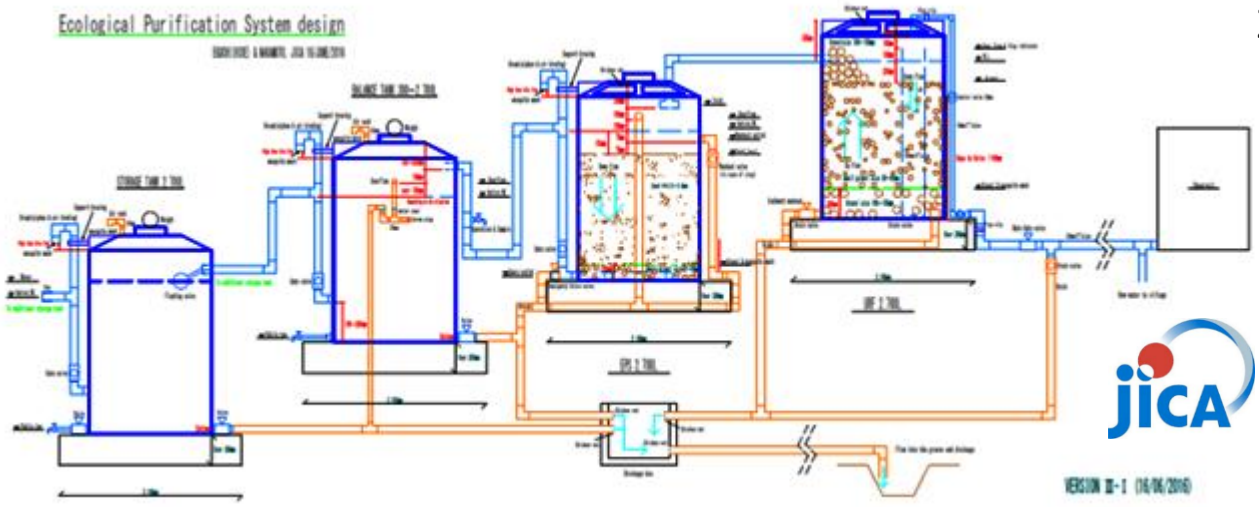
New movement to make more large scale EPS plant arises by own activities of a rural village in March, 2018.

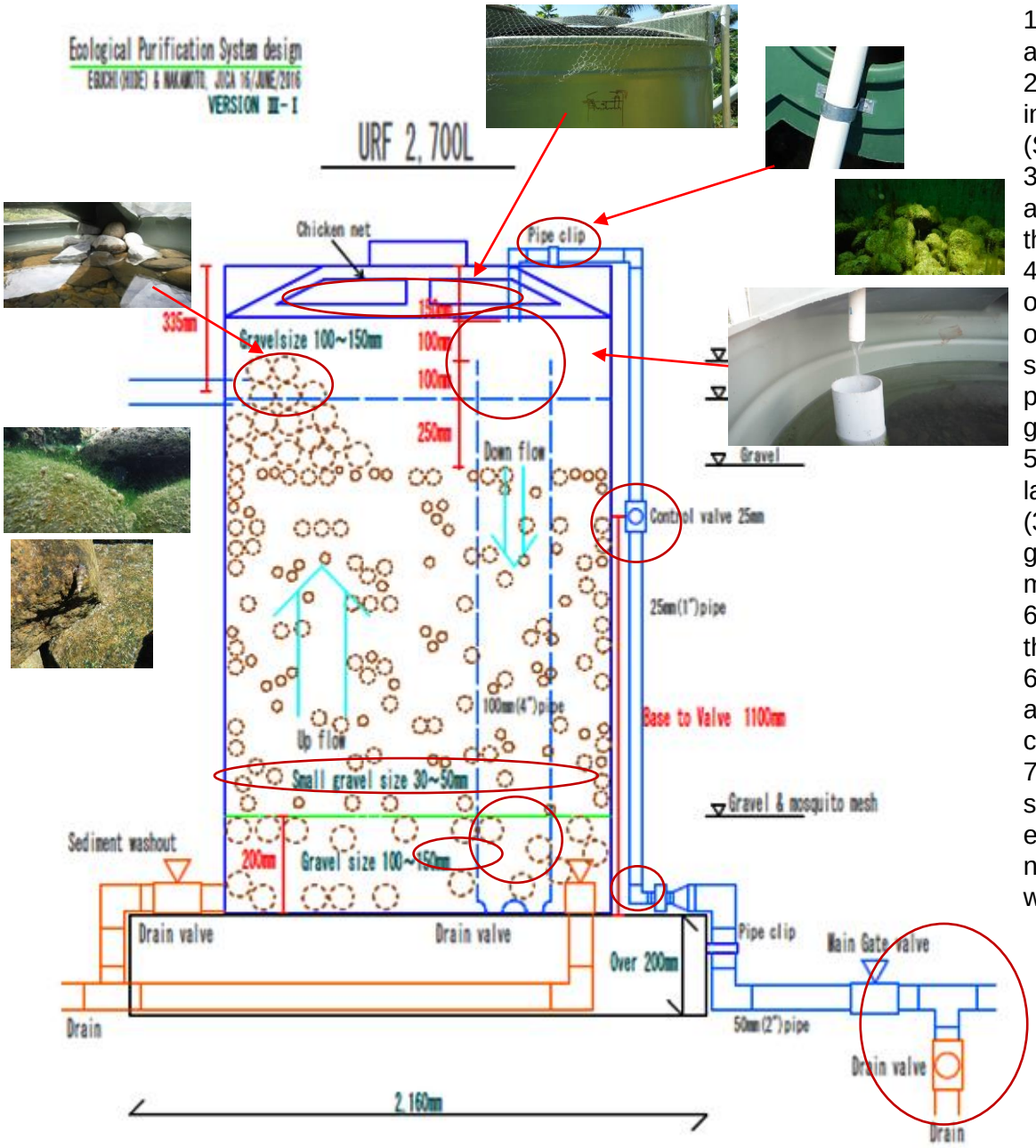


http://www.cwsc.or.jp/files/pdf/Fiji/160614-Eng-Fiji-EPS-Manual.pdf

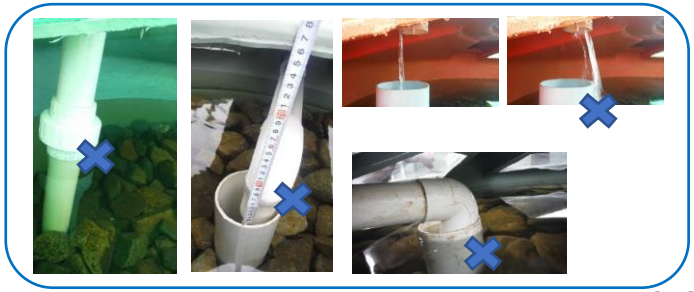


http://www.cwsc.or.jp/files/pdf/Fiji/Fiji%20EPS%202016%20tank300-2700CAD-Design.pdf



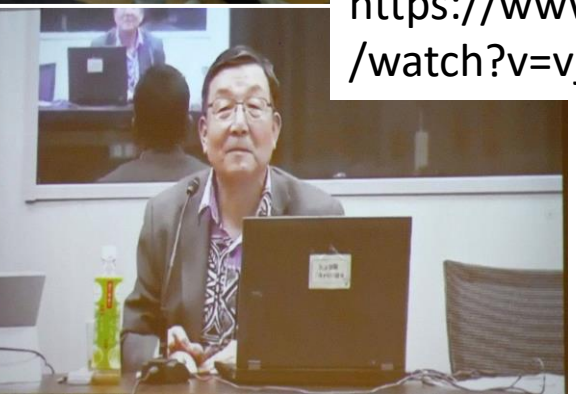


1) Inlet pipe size is 1 inch and is fixed with a clip to avoid any damage of the inlet pipe by shaking.
2) Flow rate can be controlled using a control valve (1 inch size) by watching the pouring of an inflow water. (Suitable valve setting height is 1,100 mm from the base.)
3) A gap of 100 mm between the inlet pipe (1 inch size) and the inner pipe (4 inches size) is necessary to confirm the flow rate and to sampling the raw water.
4) The height difference of 100 mm between the top edge of the inner pipe (4 inches) and the bottom height of the outlet (over-flow) pipe is requested to keep the level of seepage water from gravels. In order to guard the outlet pipe against the excess floating scum, the larger size of gravels are heaped up the outlet pipe
5) Insert a mosquito mesh (plastic) between the bottom a large gravel layer (100-150 mm size) and a gravel layer (30-50 mm size) to avoid dropping small stones from the gravel layer and to easy drain the accumulated muddy matter.
6) One drain pipe and valve are set near the bottom of the inner pipe to easy drain.
6) Open (cut) windows are covered with chicken mesh to avoid fallen leaves. And one cover near the inlet pipe can be lifted for a caretaker maintenance.
7) Each tank connecter must be tightly connect from both sides (inside and outside) by two persons. Then the empty tank is filled with water. After the confirmation of no leakage from the connect point, this tank can be filled with the large gravel, mesh and small gravel.



EPS Fiji Wksp 2019 for safe water/ 7:08

https://www.youtube.com/watch?v=vji0ay-7GA8



EPS Seminar/ Wksp at USP, Suva, Fiji March 2019/ 4:32

https://www.youtube.com/watch?v=fEl5ghBzfMw&t=23s

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

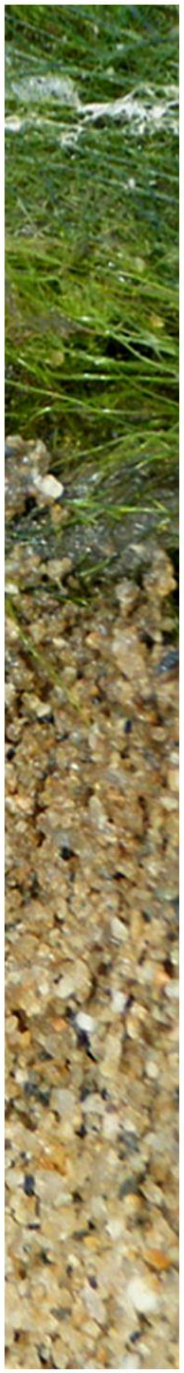
Study Tour - EPS Site Visit to NAKINI Village

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

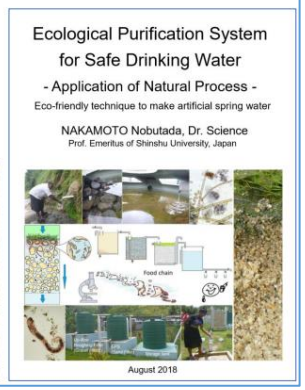
EPS Public Seminar/Workshop 11:30-12:30 Principle of EPS, Q&A

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.cwsc.or.jp/files/pdf/USPLecNk-1.pdf

https://www.cwsc.or.jp/files/pdf/USPLecNk-2.pdf

JICA short term Expert
N. NAKAMOTO
Oct. 2014-Nov.2018
8 times:
Each about one month

JICA Volunteer
Hide EGUCHI
2015-2016

JICA Volunteer
Isamu SHIOIRI
2017-2018

https://www.cwsc.or.jp/files/pdf/USPLecNk-3.pdf

Fijian people made EPS by themselves.
EPS is Our Smart System.
Fijian people realized and certified.

Nakamoto : Short term expert
2014.10.~2018.11.

8 times of a month visit during 4 years.

Hidemitsu Eguchi
Volunteer
2015~2016

Isamu Shioiri
Volunteer
2017~2018

EPS sites completed during 4 years.

Cleaner Water Project by EPS (Ecological Purification System: Wise Use of Natural Phenomena) for Rural People in Fiji

EPS project started from Kalokolevu and Navatuvula in 2013