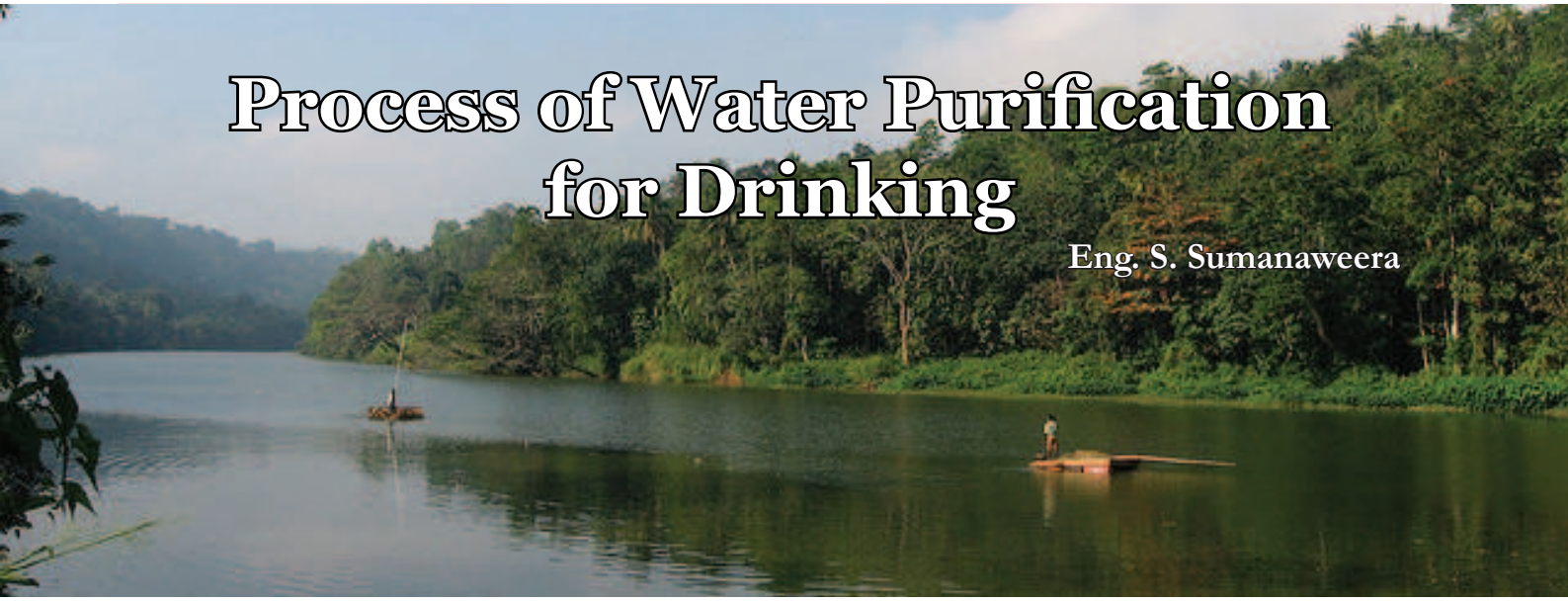

Process of Water Purification for Drinking

Eng. S. Sumanaweera

Fresh Water availability for Drinking

Seven billion people of the world have only 2.5% of world's water for consumption as the balance 97.5% is salt water. This fresh water source will not grow against the expected population of 9.3 billion in 2050. World usable fresh water resources remain at 200,000 km^3.

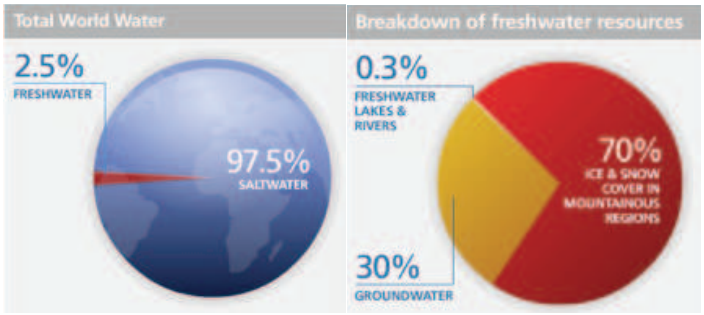

Figure 1 World's fresh water availability

Water cycle is a natural dynamic activity powered by solar energy. It creates rainfall by evaporation of water mainly from the sea. The rainfall feeds the rivers and the ground water flow, thus completing the water cycle back to the sea. Global warming accelerates the water cycle. The outcome will be more rains and stronger runoff. The world population is increasing at the rate of 2 persons per second. So can one imagine the impact of human activity on the "Water Cycle"? The main impact on "Water Cycle" by population growth will be the green house gas emissions and deforestation. Deforestation rate of Sri Lanka stands between 1 to 1.4% per year.

How safe is the water around us for drinking?

People drink water from rivers and wells. With the growing population and the depletion of the forest cover, the catchments allow the rain water to flow faster to the sea through the rivers. This makes the water muddy due to aggravated soil erosion and creates flash floods giving less time for absorption of water into the ground. Garbage dumping and sewage discharging into streams by the communities makes the water more polluted. Pollution discharges from industries make the situation worse.

Figure 2 Global warming makes glaciers melt

How can we make the water safe for drinking?

We can make water safer for drinking by managing the man made pollution. People need to be determined not to discharge waste matter into streams, and to grow more trees. Forests make the water to flow slower, and also help to reduce carbon dioxide in the air thus helping to mitigate global warming by acting as a carbon sink. Alternatively if we do not pollute water it will remain pure. Microbial pathogens present in drinking water are more hazardous than the chemical pollution effects with respect to consumer health.

How natural water can be unsafe for drinking?

Even natural water sources can contain dissolved ionic contents originating from underground soil and rocks. Although we claim that these are pollutants, some ionic contents in low concentrations are of nutritional value to the consumer. Considering all these aspects, health based quality standards have been developed for drinking water. We follow the Sri Lanka Standard 614 for drinking water quality. In case this standard is not detailed enough the drinking water quality guidelines published by the World Health Organization are followed.

The common parameters that are checked in drinking water are Electrical Conductivity, Turbidity, Color, pH (a measure of acid base condition), Iron, Manganese, Chloride, Sulphate, Nitrate, Nitrite, Fluoride, Hardness and Alkalinity. The first four parameters mentioned are physical parameters and the rest are chemical parameters. Additionally there are parameters termed bacteriological quality parameters. These parameters are indicators of the spread of water borne diseases. Water treatment processes are needed to treat water to bring the quality of water to acceptable levels meeting the quality standards mentioned above.

According to one definition, "Water Treatment" shall produce water that is palatable with no unpleasant taste, safe with no pathogens or harmful chemicals, clear with no suspended solids, aesthetic to drink being colourless and odourless, reasonably soft with easy to use soap, non corrosive to the pipes and fittings and low in organic content with no support to biological growth within pipes and fittings.

Water Treatment processes

There are different types of water treatment processes to suit different raw water qualities. For example river water is often muddy while well water may be relatively clear but can be of hard taste ("Kivula") and may

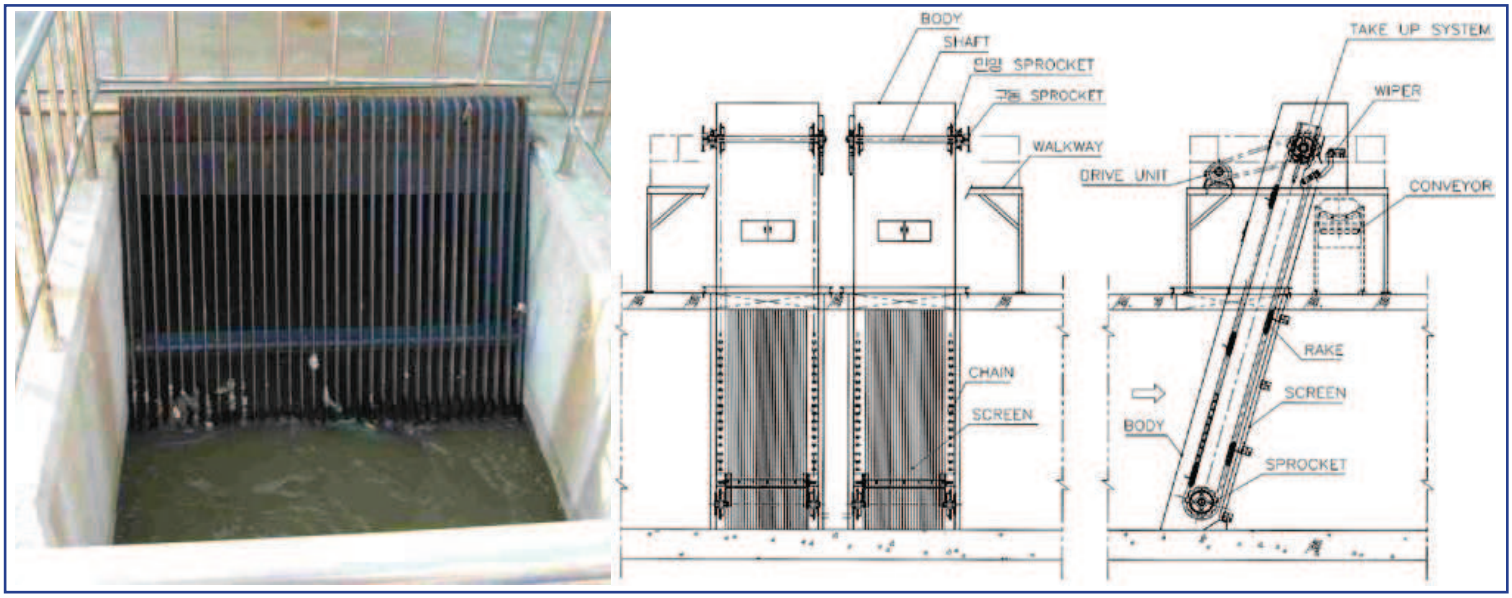

Figure 3 Intake screens

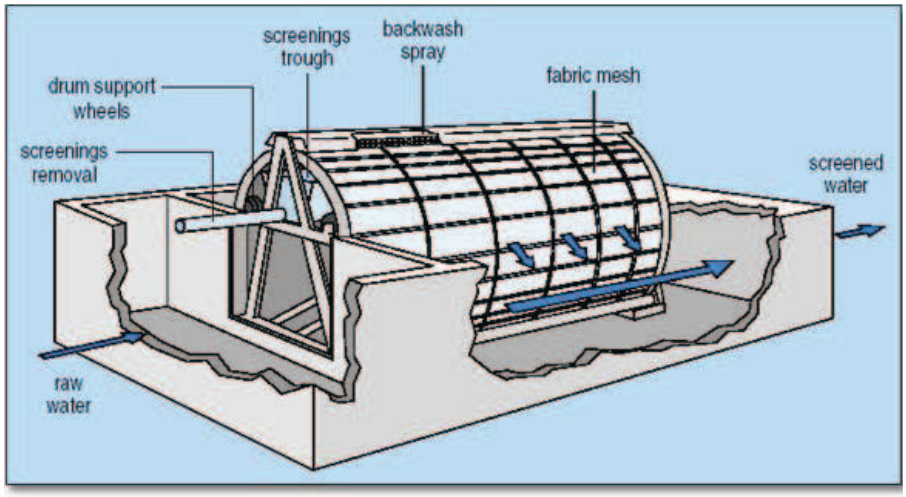

Figure 4 Microstrainer for algae removal

Figure 5 Cascade aerator made by NWSDB

contain ions such as Fluoride, iron and manganese in excess which may not be visible. Therefore complete laboratory testing is essential to select a process for treatment of a particular raw water.

Impurities in raw water can be in forms such as suspended matter, colloidal matter and dissolved matter. Suspended matter could be removed by settling. But removal of colloidal and dissolved matter is not so easy. Colloidal matter is in continuous movement within the water body which is referred to as "Brownian Movement". The dissolved matter consists of salts and other ionic and organic compounds. The dissolved matter cannot be seen by the naked eye. They may be toxic for human beings if consumed beyond the recommended values. Further there are living organisms in natural water such as microbial pathogens and algae.

Water Treatment processes can vary from simple boiling or sand filtration to advanced treatment such as ozonation, membrane filtration or adsorption by activated carbon. The objective of water treatment is the removal of impurities from water, thus making it acceptable and safe for drinking.

Screening

Screening is the first step in water treatment process. Raw water is screened through a set of coarse screens of around 100 mm size to remove suspended solids such as litter, branches etc. Then a fine screen will be used to remove fine floating solids. Further there could be a micro strainer to remove any algae present is raw water.

Aeration

Ground water extracted through borehole wells could be lacking dissolved oxygen. Dissolved oxygen in water is very important to make the content oxidized, thus reducing the corrosiveness. Aeration helps to remove dissolved gases in water such as Carbon Dioxide, Hydrogen Sulphide and dissolved Volatile Organic Compounds (VOC). Aeration also helps to remove dissolved iron from water by an oxidation process. There are different types of aerators used in practice such as Spray aerator and Cascade aerator.

Coagulation

After the screening step many suspended particles could be removed by a sedimentation step. However colloidal matter is difficult to remove by sedimentation alone. Therefore a coagulation and flocculation step is necessary. Colloidal particles are very small, less than 10 micrometers in size with very low settling velocities. Most of these particles are negatively charged. So they never aggregate due to the repelling action caused by these negative charges. Coagulation is the removal of the electrical charge

on these colloidal particles, thus destabilizing them and making them capable of aggregation or flocculation. Coagulation is done by using a coagulant aid such as Aluminium Sulphate which is generally termed "Alum".

Coagulation facilitates flocculation of the particles. Destabilized or neutralized particles attach each other due to lack of an electrical charge forming micro flocs, and then such attached particles form more dense groups named flocs. These flocs are easy to settle. Coagulation takes place in a water treatment process within a unit termed flash mixer or rapid mixer. Flash mixers can be mechanical or hydraulic.

Flocculation

Flocculation is the process of neutralized particles getting together to form flocs. The first barrier to flocculation is the repulsion among particles, which is eliminated by the coagulation step. If coagulation is successful, flocculation can easily happen by Brownion motion of the particles. But the process can be accelerated by creating velocity gradients in water. This could be achieved by providing slow mixing. This happens usually in three compartments fitted with slow mixers as shown in Figure 6. The mixers operate at different speeds from high to low to minimize floc breakage. Flocculation could also be done in a hydraulic baffle flocculator.

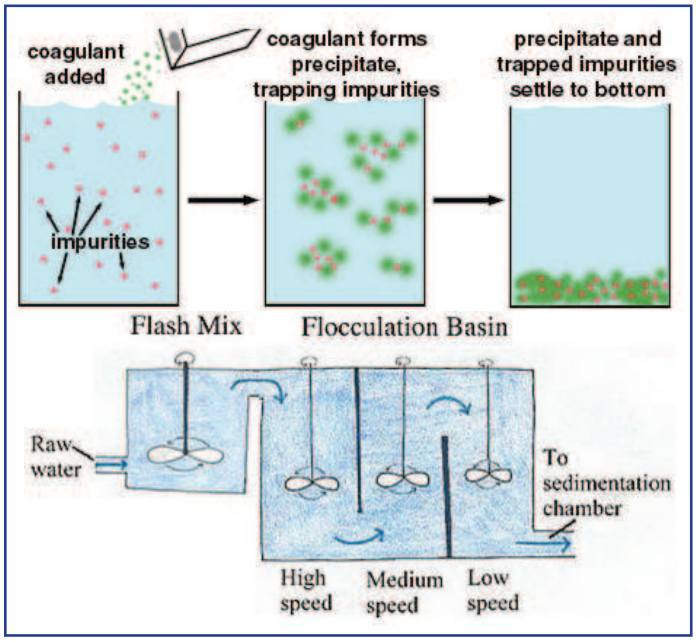

Figure 6 Coagulation & Flocculation

Sedimentation

Sedimentation or settling step is the unit process of water treatment where the flocculated particles are allowed to settle in a tank. Particle settling occurs vertically in the tank while the water slowly moves horizontally. The sediments are collected from the bottom of the tank as shown in Figure 7 below.

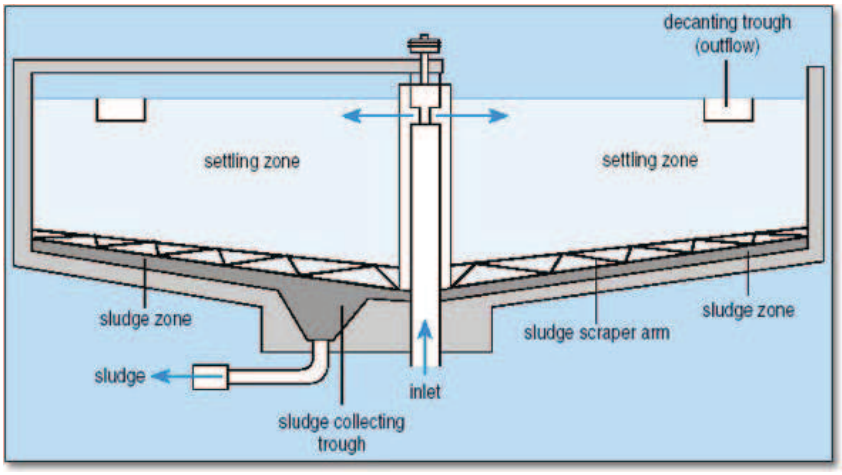

Figure 7 Sedimentation Tank

Tube settler is a much efficient particle settling device. It is about seven times efficient in time and space requirement compared to a plain sedimentation tank. Water is allowed to flow upwards in inclined tube modules. The settled particles fall down along the tube and drop down while clear water flows out from top as shown in the Figure 8.

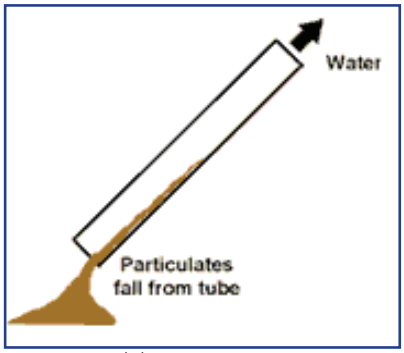

Figure 8 Tube Settler principle

Figure 9 Tube Settlers at Thanthirimaley & Oya Maduwa by NWSDB

Sand filtration

Filtration is a simple technique of water purification with a long history of application. In fact the earth acts as a kind of sand filter in cleaning the surface water stored as ground water, which is extracted by people through the wells. Sand filtration has two categories namely slow sand filtration and rapid sand filtration. Slow sand filter which consists of fine sand in the size range of 0.15 to 0.3 mm, can remove most of the microbial contaminants with about 98% removal efficiency. It suits to cleaning less muddy water. The main mechanism of a slow sand filter is through biological activity which happens in the top layer termed "Schmutzdecke". It traps bacteria, algae, protozoa and rotifers present in natural waters. A cross section of a slow sand filter is given in figure 10.

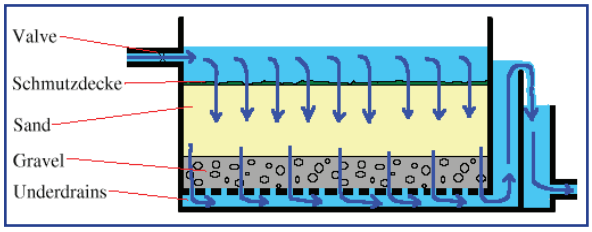

Figure 10- Slow Sand Filter

Rapid sand filter with sand particles of 0.5 -0.8 mm size is used to remove larger particles of impurities in water. However the rapid sand filters are less effective in removal of pathogens. A cross section of a rapid sand filter is shown in figure 11.

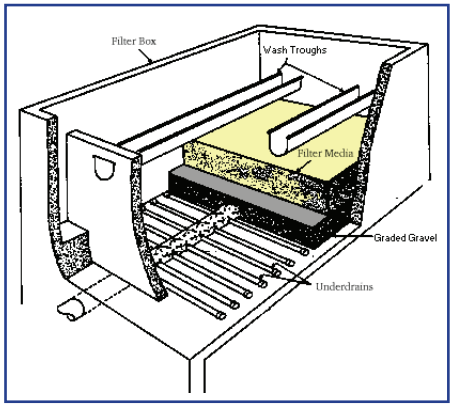

Figure 11 Rapid Sand Filter

Mechanism of a sand filter is not only straining. Settling and adsorption too as shown in Figure 12 take place within a sand filter.

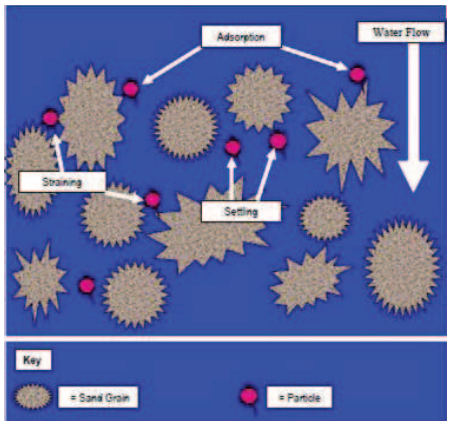

Figure 12-Filtration mechanisms

Disinfection

After all of the above water treatment steps disinfection has to be practiced at the point of consumption of water to be safe from the harmful effects of pathogens. Boiling and chlorination are common disinfection methods.

Boiling water can ensure the bacteriological safety of water as almost all the pathogens get killed. This is the most commonly practiced household water treatment technique.

Adding chlorine solution drops is another successful means of household disinfection. It makes water safe for drinking from any source although the taste will be a drawback.

How to make use of water treatment processes

The processes mentioned above could be utilized to treat water to make it safe for drinking. But the selection of unit operation modules explained above should be done based on the quality of raw water. For example the water in the well of your home may be very clean and no treatment is needed. To be safe from pathogens you may just boil and drink this water. If the well water looks clean but creates brownish color in the surrounds, presence of iron in water could be suspected and aeration and rapid sand filtration could be tried as the treatment.

Figure 13 Domestic Slow sand filter (Bio sand filter)

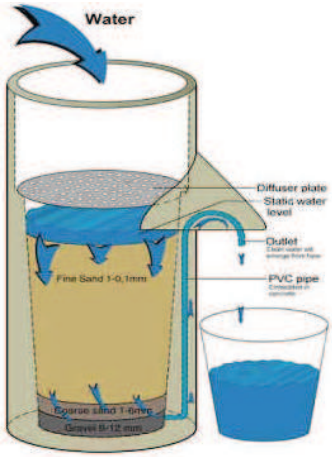

Figure 14 Domestic Slow sand filter (Bio sand filter)

Figure 15 Household water treatment, boiling and disinfection by Chlorine liquid

Figure 16 Conventional water treatment plant at Thanthirimaley (A joint effort by the Research & Development Unit, the central workshop and the Anuradhapura regional Office of the NWSDB)

So water treatment could vary from simple domestic to conventional treatment as described. However we should be careful to be aware of raw water quality variations annually. Long term water quality variations can occur due to climate change effects and human activity. Currently, pollution induced mainly by human activities at source is a major problem. Hence we should not pollute or disturb our catchments in order to protect our precious and limited fresh water sources.

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