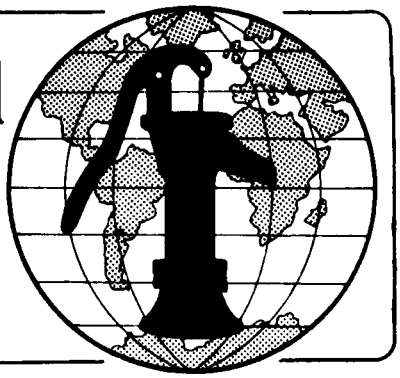
Water for the World

Planning a Water Treatment System
Technical Note No. RWS. 3.P.4



Water may need treatment before it can be used for drinking. Water treatment in rural areas stresses bacteriological treatment, the removal of pathogens through filtration, and chemical disinfection. Clarification processes are used to remove suspended matter. To remove certain dissolved chemicals and minerals, water conditioning is needed. Conditioning requires expensive equipment and chemicals and is usually not practical for rural areas.

Water subject to bacteriological contamination and turbidity must be either protected from the contamination or treated. Ground water is usually naturally protected from contamination. However, if wells are located near latrines or other sources of contamination, or near limestone or other fractured rock, water quality is questionable. If water sample analysis or a sanitary survey shows bacteriological contamination, the water must be treated.

Treatment of surface water is almost always necessary to ensure its quality. Unlike ground water, surface water is not protected from contact with people, animals and surface run-off which can introduce disease-causing organisms. This technical note discusses the basic factors which must be considered when planning a water treatment system and the choice of a treatment process or mix of processes that best meets the needs of the community.

General Considerations

The addition of any type of treatment to a water system increases the cost of developing the system, the amount of maintenance required, and the risk of breakdown.

Useful Definitions

CLARIFICATION - The process of removing suspended matter from turbid water to make it clear.

DISINFECTION - Destruction of harmful microorganisms present in water, through physical (such as boiling) or chemical (such as chlorination) means.

TURBID WATER - Water which is clouded with particles of suspended matter.

If water treatment is necessary, the following factors must be considered when choosing which treatment system to use.

1. Amount of funds available for the project. Most rural communities have limited funds and cannot afford expensive treatment methods. The choice between a treated and an untreated source and the choice of a treatment technique depends on the funds available in the community.

2. Cost of construction. The construction of a water treatment facility is expensive. Construction costs must be determined before deciding to use a specific process. Compare the construction costs of the processes that would provide the treatment needed. Also, compare the costs of developing alternative water sources. For example, a water source needing treatment is located near a village and a source needing no treatment is further away. The cost of installing a pipeline and pumping the water from the source needing no treatment to the village may be less than the cost of developing a treatment system for the closer source. If the

pipeline is cheaper or the difference in cost is not great, the development of the longer pipeline may be the better alternative.

3. Availability of trained personnel or the likelihood of establishing the necessary training programs. See "Community Participation in Implementing Water and Sanitation Programs," HR.2.I. Trained personnel are needed to operate and maintain water treatment systems and the success of water treatment depends on their skill. If trained personnel are not available or are poorly trained, the water treatment system will not function properly, water quality will be poor, and the benefits of money spent on construction will be lost.

4. Cost of operation and maintenance. The cost and availabiltiy of chemicals such as chlorine for treatment, energy to run pumps, and salaries for workers must be determined. Their total cost may be beyond the means of the community. Chemicals and spare parts must be readily available to avoid closing down the treatment system or, worse, operating it without the required equipment and materials.

The general policy should be that a water source needing no treatment is preferable in rural areas. By selecting a source of water which needs no treatment, a community can save money and have a supply that is more dependable and a water system that is easier to operate. Table 1 lists some measures to protect water sources to reduce the need for treatment. In cases where water treatment is essential, the most efficient and least expensive method should always be chosen.

The quality of a community water supply must be good. When an entire community is dependent on one or a few sources, the quality of the water is important to the health and well-being of each community member. A failure in a public supply will affect more people than failure in individual family supplies. Depending on the level of water contamination, there are simple community treatment systems that will ensure adequate water quality.

Simple Community Treatments

Simple community water treatment systems should be used under the following conditions:

(a) when a water source serves a larger population than can be served by household or individual treatment systems, especially in rural villages and towns;

(b) when a community water source is contaminated and simple protective measures can neither improve water quality nor stop the contamination;

(c) when resources in the community are adequate to cover the cost of construction, operation, and maintenance.

The best method of water treatment is one that removes the contamination, can be built with local materials at a low cost, uses few mechanical parts, requires little use of chemicals, and is easy to operate and maintain. Table 2 summarizes the different types of water treatment processes.

Slow sand filters. Slow sand filters are excellent choices for treating community supplies. They are especially good for gravity flow systems, particularly with pond or river sources; water of fairly good bacteriological quality but subject to possible contamination; and water low in turbidity.

The advantages of the slow sand filter are that it:

- Removes 90-95 percent of bacteria responsible for water-related disease,
- Removes suspended matter and reduces color,
- Can generally be built with local materials using local skills and labor,
- Needs no complex mechanical or electrical machinery, and
- Requires simple operation and maintenance.

Table 1. Preventive Measures to Protect Water Sources

Ground Water

- Line wells with casing, cover and finish them so that run-off flows away from rather than into the well.
- Locate wells above latrines and other sources of contamination such as manure piles and animal yards. Put individual wells at least 15m and community wells at least 50m from the nearest source of contamination.
- Cover and protect wells and install pumps to lift the water from the well.

Surface Water

Springs

- Protect springs with a covered spring box to seal them off from contamination.
- Remove all sources of contamination above the spring. Do not use water from springs directly below animal yards or latrines. Locate springs above such sources of heavy contamination.
- Install a fence and diversion ditch for run-off above and along side of the spring.

Rivers and Streams

- Install riverside wells or infiltration galleries on stream or river banks so that water from the stream flows underground and loses its impurities.
- Whenever possible, install intakes at a point in the river above all inhabited areas and pipe the good quality water to the community.

Ponds and Lakes

- Practice good watershed management to ensure water quality without treatment. If a watershed is small, fence it and make sure it supports no farming or livestock. Water from ponds and lakes usually needs treatment, as it is difficult to keep out small animals and birds.

Rain Catchments

- Clean roofs and gutters to remove leaves and bird droppings between rainfalls or at least once every one or two weeks.
- Install a device between the catchment troughs and the cistern for directing the first wash (foul flush) to waste.
- Make sure the cistern is watertight and covered to prevent the entrance of contamination.

Sand filters are not the best choice in all situations. There are certain conditions under which a slow sand filter is not very effective. If a source is highly turbid, slow sand filtration is not the best treatment method. Very turbid water clogs the filter in a few weeks and makes the system require frequent maintenance. Pre-treatment of the water by sedimentation is necessary. If large quantities of clean, suitably sized sand are not available or cannot be obtained easily, the slow sand filter is not a good alternative. If land is in short supply, a slow sand filter is not the best choice since it requires large areas of land.

If people dedicated to the maintenance of the filter are not available, an alternative method must be found. Slow sand filters require frequent, though easy, maintenance. Skimming the top 10-25mm of the bed may be needed every two to three months. If workers are not available for the periodic cleanings, slow sand filters should not be used.

Plain sedimentation. Sedimentation is a practical method of water treatment for rural communities. Plain sedimentation is used to remove turbidity, and provide some improvement in bacteriological quality. Plain sedimentation is used as a pre-treatment process and for treatment of sources with good bacteriological quality. Sedimentation occurs in especially constructed storage tanks or in reservoirs formed by dams, large ponds or lakes. If water is stored for long periods of time, and further contamination is not introduced, bacteria die and improvement in bacteriological quality results.

Do not plan to use only plain sedimentation if the bacteriological quality of the water is poor or if possible sources of contamination are located near the supply. Generally, some other type of treatment must be used with plain sedimentation when water contains pathogenic organisms.

Chlorination. Chlorination is another popular form of rural water treatment. Chlorine can be used to disinfect most sources of water. Chlorine is most useful for disinfecting wells, spring boxes and other structures after construction, treating a source that is physically and chemically aceptable but is bacteriologically contaminated, and treating water that already has been through filtration and sedimentation. The advantages of chlorine are that it is inexpensive and easily available in many rural areas. In sufficient doses chlorine effectively destroys disease-causing organisms. Further, it is easy to use and simple chlorination requires no machinery. The skills of dosing and testing can be learned quite readily. Chlorine is a very good disinfectant when there has been accidental contamination of a source during construction and is excellent for disinfecting a well or protective structure. Only a small amount is needed for disinfection.

Under many conditions, chlorine is not acceptable. If water cannot be tested every four to six weeks, chlorine use should be discouraged. For effective treatment, the level of chlorine in the water must be checked to make sure the quantity or chlorine residual is sufficient. Water can be tested either with portable kits or in laboratories. If testing is not possible, the use of chlorine may not be practical. If chlorine is difficult to obtain, discourage chlorination except for small scale disinfection or emergency treatment.

Household Treatment Systems

Basic household treatment systems are designed for relatively small volumes of water used by one or several households. They are most effective in the following situations:

- Where small amounts of water are being supplied from a well, spring, or cistern, particularly if water is collected and transported by hand;

- Where a source is contaminated and simple protective measures can neither improve water quality nor stop contamination;

- Where community resources are inadequate to meet the cost of a simple commmunity treatment system;

- Where a community uses several water sources or homes are widely separated, making it difficult to develop a centralized treatment system;

- Where an emergency situation causes disruption of service and contamination of the water supply so that a rapid, short-term solution is needed.

Storage. Water storage is one of the most practical methods of water treatment available to rural areas because it reduces the amount of turbidity, color and bacteria. Storage can be used for water with mild turbidity and low to moderate levels of bacteriological contamination. Storage in well-protected reservoirs for a two-week period will kill 90 percent of the disease-causing bacteria in water. Storage also has the advantage of creating a reservoir which permits access to water not only of better quality but in greater quantity.

If water is highly turbid or heavily contaminated, simple storage is not adequate. Other treatment processes must be used instead of or in addition to simple storage. Users must be educated about the importance of storage time to the treatment of water, the need for periodic cleaning of the storage tank, and how to use the water so that it is not recontaminated. Unless these measures are taken, water quality may suffer and the purpose of storage will be lost.

Boiling. Boiling water is one of the most effective methods of treatment for individual households. Turbid water should be filtered before boiling. When water is boiled for two or three minutes, all disease-causing organisms are killed. Boiling does not require chemicals or expensive equipment.

Boiling is only practical if fuel is available in large quantities. It requires expensive energy that people may prefer to use for other activities. Boiled water has a "flat" taste since dissolved oxygen and carbon dioxide are boiled off. Some people find the taste disagreeable. For these reasons, boiling may be a better short-term emergency treatment method than a long-term solution to water quality problems. Water used to dissolve powdered milk, infant feeding formulas, or dehydrated foods should always be boiled if the water quality is doubtful.

Filtration. Water filtration is used to remove turbidity from water. It is especially effective when the water is of good bacteriological quality but is moderately turbid. Sand filters can be made from local materials at very low costs and in some areas can be purchased at a reasonable price. A filter provides for some storage and protection of water from outside contamination.

Most filters do not remove all disease-causing organisms. If water passed through a filter is bacteriologically contaminated, it will also need disinfection. All filters require maintenance to operate effectively. If a sand filter is used, the sand must be cleaned every two or three weeks to keep up its filtering capacity. Filter candles in manufactured filters must be scrubbed or changed periodically. Users of filters must be educated about the importance of their maintenance. Unless the users understand the need for a clean filter, this form of water treatment will fail. Some household sand filters can be designed to remove bacteriological contamination. These filters need constant attention and maintenance to be effective. See "Designing Basic Household Water Treatment Systems," RWS.3.D.1.

Chlorination. Chlorine can disinfect most bacteriologically contaminated water effectively. Turbid water should be clarified before it is chlorinated.

The advantages of chlorination are that chlorine is effective, relatively inexpensive, generally available, and easy to apply in liquid, powdered, or tablet form.

Where chlorine is easily available and a water supply needs treatment, chlorination is a good choice. Unfortunately, unless equipment for testing the amount of chlorine needed and the amount of chlorine remaining in a water supply is available, a correct dosage is difficult to determine. A rule of thumb is that enough chlorine should be added to give the water a slight odor or taste. Specific information on chlorine dosage is available in "Designing Basic Household Water Treatment Systems," RWS.3.D.1.

Summary

The type of treatment chosen depends on the conditions at the site, available materials, water quality and the size of the supply to be treated. Choose the form of treatment that ensures good quality water at the least cost. Remember that the best water source is one that needs no treatment. Measures to protect the water source from contamination are generally not expensive and they help ensure good water quality. The following list summarizes the preventive measures that can be taken to preserve water quality.

Table 2 shows possible water treatment methods and indicates the conditions under which each form of treatment is most appropriate. The

Table 2. Water Treatment Processes

	TREATMENT PROCESS				
WATER QUALITY	Sedimentation	Slow Sand Filtration	Chlorination	Protection Against Possible Contamination	Advanced Methods
Clear and uncontaminated				Develop best method to protect water from sources of contamination	
Low level contamination, low or medium turbidity		Use of slow sand filter will remove turbidity and contamination	Chlorination can be used for sources with low turbidity	Source of contamination should be discovered and attempts made to protect water supplies from all contamination	
Low level contamination, medium to high turbidity	Pre-treatment by sedimentation removes most turbidity	After pretreatment, contamination and the rest of turbidity removed	Effluent water should be tested to see if chlorination is necessary		For high turbidity an advanced method may have to be used (see "Methods of Water Treatment," RWS.3.M)
High level contamination with low turbidity		Most bacteria should be removed; test water after treatment	Post-chlorination may be needed to ensure water quality		
High level contamination with high turbidity	Turbidity must be decreased before further treatment	Slow sand filters will remove bacteria once turbidity reduced	Test water to see whether chlorination is needed to improve water quality		Advanced treatment methods necessary

best water treatment method is one that both removes bacteria and clarifies the water. Under most conditions, the slow sand filter is the best form of treatment for a rural community when water is not turbid or when measures are taken to remove turbidity. With the addition of a sedimentation tank or basin, the slow sand filter becomes a very efficient treatment method. Other methods are less effective and require materials or chemicals that must be obtained outside the community. If water treatment needs cannot be met with a slow sand filter, chlorination, or sedimentation, expert advice should be sought about more advanced methods.

Individual treatment requires constant attention by the user. An important incentive for good maintenance is the education of the users to the need for good quality water. If people do not maintain their systems, water quality suffers. Individual treatment fails in most instances because people do not keep up the maintenance needed.

Water treatment adds to the cost of a water system and should be avoided whenever possible. The least costly and most efficient way of ensuring good water quality is to choose a source that requires no treatment and protect it from sources of contamination.