CONVENTIONAL WATER TREATMENT TECHNOLOGIES

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Summary

Limited freshwater sources lead to the use of some sources for multiple purposes, such as for drinking water, irrigation, navigation and for waste disposal and hence deterioration of quality. Concern for quality of water, particularly, for drinking and domestic purposes, has resulted in a variety of water treatment technologies that purify water to varying degrees. Depending on the quality of raw water, single or chains of treatment processes are adopted, to produce water of desirable quality. The suspended and colloidal impurities in water are removed in steps by rapid mixing of coagulants, flocculation and sedimentation processes. These processes can be effectively carried out applying mechanical or hydraulic actions. Colloidal and other finer particles, apart from dissolved organic and microbial impurities can be removed also by filtration techniques. A variety of filtration techniques have been developed all over the world, to suit local

water quality requirements. As a final step of water quality improvement, disinfection of water is carried out to kill disease-causing microorganisms, by using chemicals or irradiation techniques.

1. Introduction

More than 80% of diseases that affect humankind are waterborne and most of these diseases can be averted by processing water used for domestic purposes through simple treatment. Thus, the need for treatment of water for supply to communities, whether it is from groundwater sources or surface water sources, cannot be overstated. Especially when the same source is being used for multiple purposes, such as irrigation, navigation, and domestic, apart from a drinking water source, the concern for water quality can be alleviated only through adequate treatment using appropriate processes.

2. Treatment Processes

The most common water treatment processes used for treatment of raw water from a surface source are:

- rapid mixing
- flocculation
- sedimentation/clarification
- filtration
- disinfection.

Depending upon the quality of raw water and impurities present in it, these processes either alone or in combination with others form part of treatment schemes for community water supplies. Table 1 presents the details of these unit treatment operations/processes.

Unit operation/ process	**Conventional technologies**	**Modified technologies**	**Remarks**
Rapid mixing	Hydraulic mixers; mechanical backmix reactors	Injection-type flash mixing facility	Suitable for water treatment plants of all sizes. Higher percentage of coagulant utilization leads to better treated water quality.
Flocculation	Hydraulic and mechanical type flocculation	Tapered flocculation	Less energy input, better floc formation.
		Gravel bed flocculation	Simplicity, effective flocculation, suitable to be used in low-cost package treatment plants
		Alabama flocculator	Economical to

			construct, operate, and maintain; minimum supervision needed
Sedimentation	Rectangular horizontal flow sedimentation	Solids contact clarifier	Smaller size, better efficiency
		Tube settler	Modular design; high loading rates (2 to 10 times greater than conventional system) and hence compact; useful in upgrading existing sedimentation tanks.
Filtration	Rapid sand filtration	Dual media filter Coarse media filter Declining rate filter	Better filtration efficiency; longer filter run.
		Direct filtration	No sedimentation; smaller flocculation facility, low chemical and energy requirement.
Disinfection	Chlorination	ClO_2	No THM formation
		O_3	Better disinfection with lower chemical use.

Table 1. Unit operations/processes of water treatment.

The unit operations and processes and their variants/modifications are further discussed in detail below.

3. Rapid Mixing

The purpose of rapid mixing is to disperse coagulant chemicals uniformly throughout the raw water as rapidly as possible in order to destabilize the colloidal particles (i.e. neutralize the negative charges around the colloid surface) present in water. Theoretical and experimental studies have shown that the contact between coagulant and colloidal particles should occur before the hydrolysis reaction with alkalinity-causing components of water is completed. This requires very rapid dispersion of coagulant in the mass of water within a few seconds. To facilitate the rapid dispersion, the water is agitated vigorously with the aid of mixing devices and the coagulant is added at the most turbulent zone.

Effective rapid mixing can basically be accomplished either hydraulically or mechanically.

3.3. Hydraulic Mixers

The hydraulic mixer is the most basic type of rapid mixer that utilizes the potential head of water for generation of turbulence and eddies for mixing. Commonly, a hydraulic jump is used for this purpose.

A hydraulic jump is created when flow in an open channel is abruptly transferred from supercritical conditions to sub-critical conditions. Hydraulic jump mixers are suitable for raw waters that require short mixing time (of the order of one to two seconds).

As considerable head loss takes place in the hydraulic jump mixers, when sufficient natural ground slopes are not available, its use becomes uneconomical, because all the treatment units located downstream of the hydraulic jump will have to be placed deeper in the soil. This will result in higher excavation costs, increased soil pressures on the structures, and increased head of water to be lifted.

There are two other types of hydraulic mixers: weir mixers, and turbulent pipe flow/plug flow mixers.

Weir mixers. The weirs used in weir mixers can be of any shape such as V-notch, rectangular or trapezoidal. Flow over the weir causes turbulence and therefore the coagulant is fed where the flow falls from the weir, as shown in Figure 1. The baffles that follow the weir help the flow in the subsequent channel to be kept within a tranquil region.

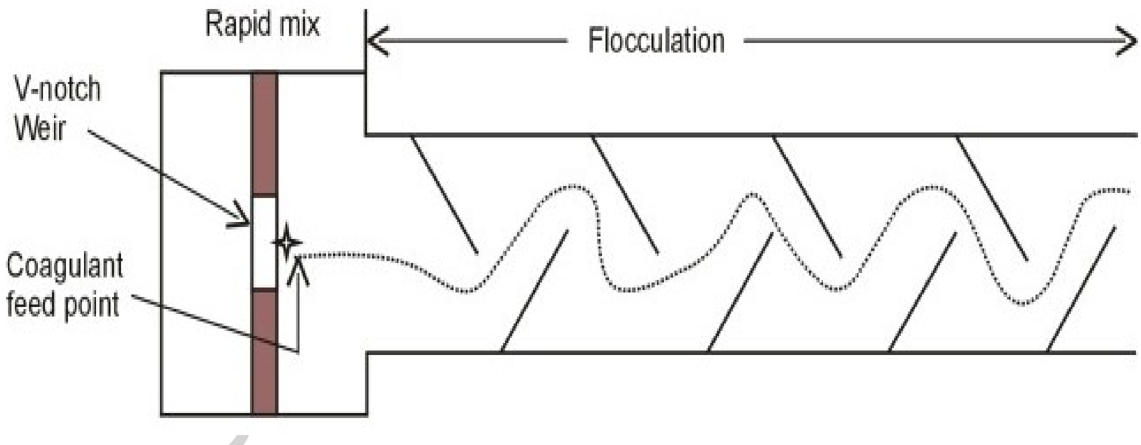

Figure 1. Weir mixer (plan view).

Weirs are relatively inexpensive and simple to install. But, siltation in the upstream of the weir makes periodic cleaning necessary. Rectangular weirs are more suitable for larger flows and triangular weirs (V-notch) are more suitable for smaller flows.

Rectangular weirs are preferred for coagulant mixing because of their better uniform flow distribution over that of triangular weirs. Weir mixers are extensively used in many developing countries, such as India, Brazil and Kenya.

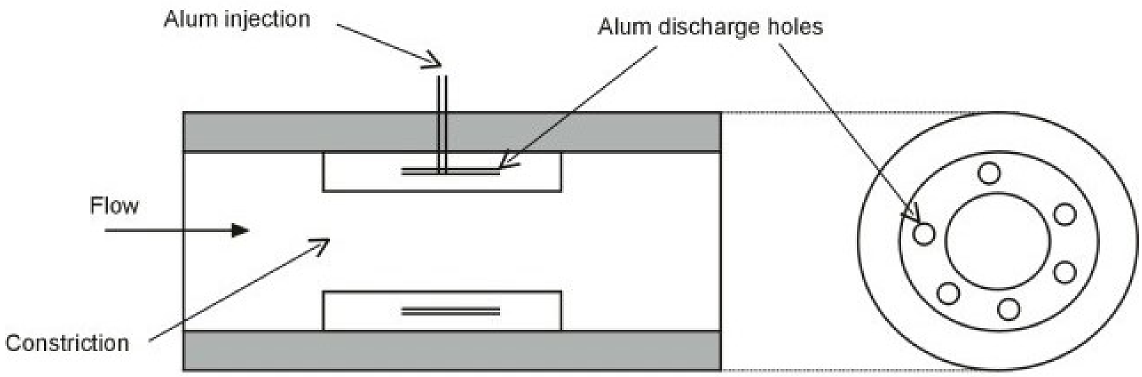

Figure 2. Typical turbulent pipe flow/plug flow mixer.

Turbulent pipe flow/plug flow mixers. Rapid mixing using this type of hydraulic mixers involves flow through a pipe with a constricting device to cause turbulence. There are several ways of effecting turbulence; most convenient method is to incorporate an orifice. Instead of an orifice, other devices such as grids, tapers, baffles, and eductors can also be used. The turbulent flow in this type of mixers is followed by plug flow that helps slow mixing. Figure 2 shows a typical turbulent pipe flow/plug flow mixer.

If the constriction is an orifice, the coagulant is dosed just before the orifice. Coagulant is fed through holes in the constriction and diffuses along the flow into the most turbulent region, which is just after the constriction. Flow becomes tranquil further down and the plug flow provides subsequent slow mixing required for flocculation.

This type of mixers gained popularity due to their simplicity, practicality and low costs. However, the disadvantages with these mixers are the limited access for routine maintenance and potential for clogging.

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Biographical Sketches

S. Vigneswaran is currently a Professor and a Head of Environmental Engineering Group in Faculty of Engineering, University of Technology, Sydney, Australia. He has been working on water and wastewater research since 1976. He has published over 175 technical papers and authored two books (both through CRC press, USA). He has established research links with the leading laboratories in France, Korea, Thailand and the USA. Also, he has been involved in number of consulting activities in this field in Australia, Indonesia, France, Korea and Thailand through various national and international agencies. Presently, Dr. Vigneswaran is coordinating the university key research strengths on “water and waste management in small communities”, one of the six key research centers funded by the university on competitive basis. His research in solid liquid separation processes in water and wastewater treatment namely filtration, adsorption is recognized internationally and widely referred.

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