Coagulation, flocculation and clarification

Coagulation, flocculation and clarification processes are used when a water source contains a large amount of fine suspended matter, for example silt or mud. If this type of water flows into a sand filter, the filter will soon block and stop working. The three processes are used together to make the water clean enough for filtering.

Coagulation *is a chemical reaction which occurs when a chemical, or coagulant, is added to the water. The coagulant encourages colloidal material in the water to join together into small aggregates or " flocs ". Further suspended matter in the water is then attracted to the flocs. Rapid mixing of the water and coagulant is important to ensure thorough and even distribution of the coagulant.*

Flocculation *is a slow gentle mixing of the water to encourage the flocs to form and grow to a size which will easily settle out. This mixing is often done in a chamber or a series of chambers.*

Clarification *is the final part of the process and allows the large flocs containing much of the suspended matter to sink to the bottom of a tank or basin, while the clear water overflows and is then further treated.*

Sanitary inspections of coagulators, flocculators and clarifiers

Sanitary inspections of coagulators, flocculators and clarifiers should be carried out regularly to ensure that they are functioning properly and that an adequate water supply is maintained (see Fact Sheet 2.1). The key points and observations to make when conducting a sanitary inspection are :

- Check and record the turbidity of the water flowing into the plant and leaving the settling tank. The water leaving the settling tank should have a turbidity of less than 5 TU.
- Check that dosing equipment for coagulating chemicals is working correctly. Use coagulant stock in rotation so that older stocks are used first.
- Keep records of chemicals used ; maintain stocks ; order replacements as necessary.
- Check and keep record of flow rates ; ensure that they are within design ranges.
- The coagulator, flocculator and clarifier should all be structurally sound and have no leaks where untreated water can enter.

Operation and maintenance

The operation of coagulators, flocculators and clarifiers requires trained operators. It should be clear who is responsible for the activities identified. Maintenance work should be undertaken regularly and be well planned. The key points for the operation and maintenance of coagulators, flocculators and clarifiers are shown below.

Chemical stock. *There should be a good stock (at least sufficient for one month of operation). Chemicals should be dated on receipt and used in rotation ; that is, the oldest chemicals should be used first. If chemicals are past their " use by date " (they are too old), they should not be used.*

Dosing control. *Correct dosing of coagulant chemicals is very important for efficient and effective removal of suspended solids. Samples of raw water should be taken regularly, and tested with a range of coagulant concentrations to determine the optimum dose rate of coagulant. This test is known as the " jar test " and is described below. The results should be used to adjust the coagulant dose.*

Rapid mixing *of the water and coagulant chemicals at the point where the chemicals are added is essential. This may be achieved with a mechanical mixer or by hydraulic means, such as a weir or hydraulic jump, as shown in Figure 1.*

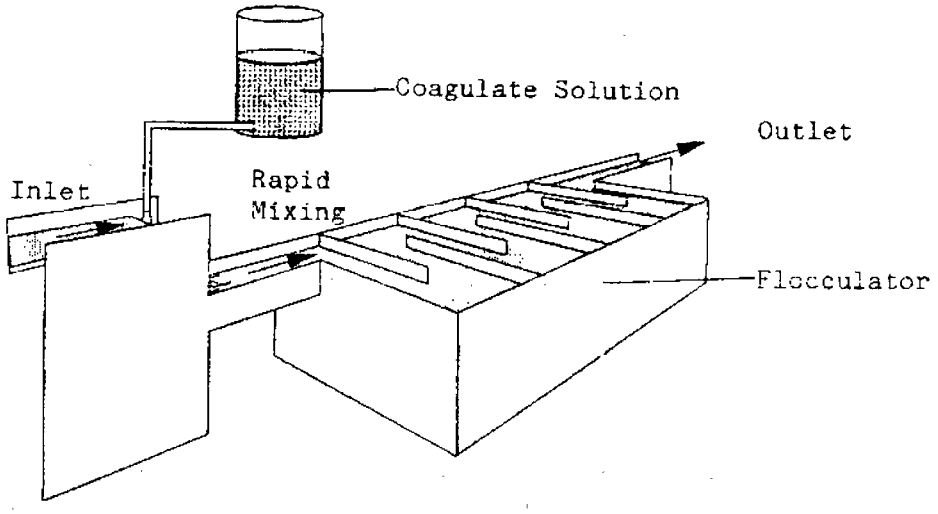

Figure 1. Rapid mixing of coagulant

Flocculation should be achieved by gentle mixing so as to maximize the number of collisions between suspended particles and flocs, without breaking the flocs up through rapid mixing. Flow rates in hydraulic flocculators should be in the range 0.1 to 0.3 metres per second, with a retention time of at least 30 minutes. A simple flocculator could be a large tank with baffles to encourage gentle mixing (see Figure 2). Where mixing is mechanical, mixers should work at a peripheral speed of 0.1 to 0.6 metres per second.

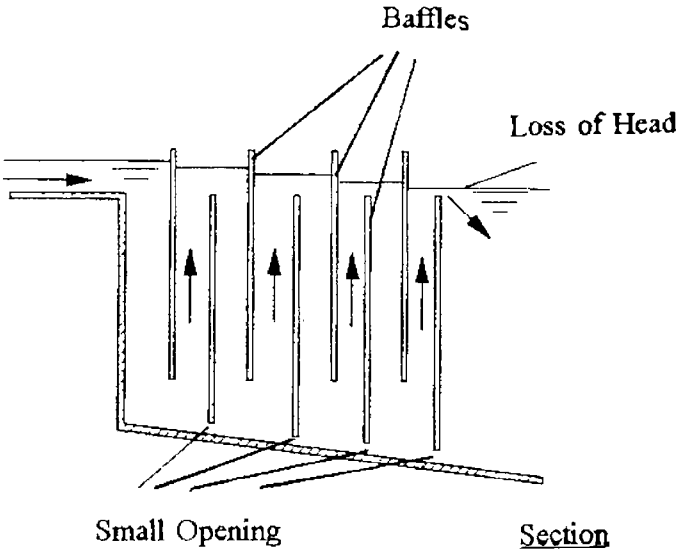

Figure 2. A simple flocculator

Plant layout. The flocculator and clarifiers should be located close to one another and water should flow slowly between them so as not to break up the flocs. A water velocity of 0.1 to 0.5 metres per second is recommended. At this stage the water should not flow over a weir or pour into the water in the settler, as this is likely to break the flocs.

Clarification is achieved in clarifiers, settling tanks or sedimentation tanks. Settling basins are similar but larger structures. In both sedimentation tanks and settling basins, water flows slowly, at around 0.1 to 1.0 centimetres per second, with a retention time of two to four hours. Many larger water treatment plants employ clarifiers in place of sedimentation tanks or settling basins. These clarifiers vary widely in design and operational characteristics. Many are cone-shaped with wide end uppermost. Water enters at the bottom and flows upwards so that its velocity decreases. A loose " blanket " forms in the tank, and clear water rises to the surface where it is taken off by outlets at the surface.

Jar test

The jar test is a means for deciding whether the dose of coagulant is correct. If too much or not enough coagulant is added, the removal of suspended matter will be less efficient. If too much coagulant is added, the cost of treating the water will also increase. The jar test is carried out as follows :

- Six jars are each filled with 1 litre of raw water from the source used to supply the treatment plant.
- To each jar is added a different dose of coagulant. One jar will have the same dose as that used in the treatment plant. The other jars should have slightly higher or slightly lower doses of coagulant. For example if the normal dose for the treatment plant is 30 milligrams per litre of coagulant, the jars will be dosed as follows :

- The jars are immediately placed in a stirrer with paddles, as shown in Figure 3.

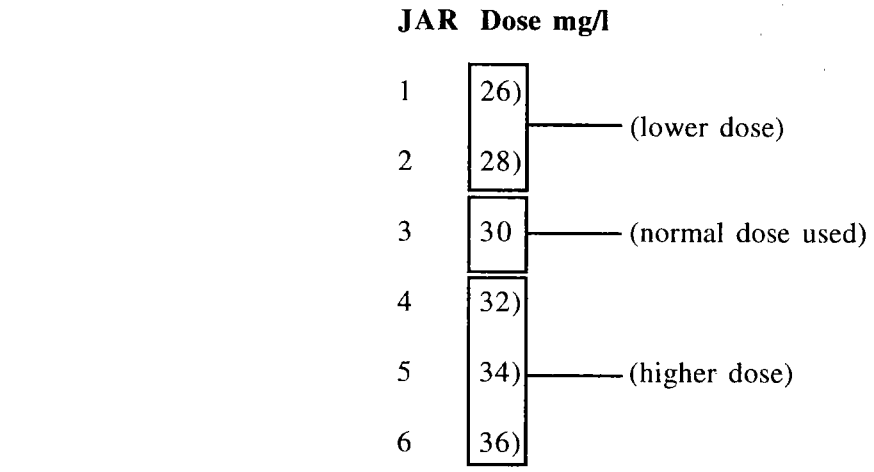

Figure 3. Laboratory stirrer for the jar test

- The paddles are first operated at high speed (80 rpm) to mix the coagulant with the water thoroughly for one minute.
- Reduce the speed of the paddles to 20 rpm and leave to stir for 30 minutes. This allows the flocs to form.
- Check and record the results of flocculation. Well-coagulated water has well-formed flocs with clear liquid between them.
- Stop the stirrer and leave the samples to settle for 30 minutes.
- Check the settling characteristics. If the water sample is hazy, coagulation has not worked well.
- Record all results in a log book as excellent, good, fair or poor.
- Always try to perform the jar test on water at the same temperature as the water being treated in the plant.

The jar test can only be used as an indication of what is happening in the plant. It is therefore important to observe the plant in operation to see if the dose of coagulant is correct.

There are also other factors which affect coagulation and flocculation, and may be tested for if a laboratory is available : pH and alkalinity.

These two tests can be carried out at the same time as the jar test. Both can change in the raw water and upset coagulation and flocculation. The results of these two tests should be noted regularly in a log book, so that it will be obvious when there are any changes. Both pH and alkalinity of raw water can be adjusted, if necessary, by adding water treatment chemicals.

Turbidity

Some plant operators measure the turbidity of the raw water and the dose of coagulant needed at the same time. They then use the results taken over a year or more to plot a graph of turbidity against coagulant dose. This means that a plant operator can decide what dose of coagulant to use simply by measuring the turbidity of the raw water. This is very useful when there are sudden changes in the raw water, for example during heavy rain.