13 Aeration

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13.1 Introduction

Aeration is the treatment process whereby water is brought into intimate contact with air for the pur-pose of (a) increasing the oxygen content, (b) reducing the carbon dioxide content, and (c) removing hydrogen sulphide, methane and various volatile organic compounds responsible for bad taste and odour. The treatment results mentioned under (a) and (c) are always useful in the production of good drinking water. Reducing the carbon dioxide content, however, may shift the carbonate-bicarbonate equilibrium in the water so that deposits of calcium carbonate are formed which may cause problems.

Aeration is widely used for the treatment of ground-water having too high an iron and manganese content. These substances impart a bitter taste to the water, discolour rice cooked in it and give brownish-black stains to clothes washed and white enamel buckets, bowls, sinks, baths and toilets. The atmospheric oxygen brought into the water through aeration will react with the dissolved ferrous and manganous compounds changing them into insoluble ferric and manganic oxide hydrates. Sedi-mentation or filtration can then remove these. It is important to note that the oxidation of the iron and manganese compounds in the water is not always readily achieved. Parti-cularly when the water contains organic matter, the formation of iron and manganese precipitates through aeration is likely to be not very effective. Chemical oxidation, a change in alkalinity or special filters may then be required for iron and manganese removal. These treatment methods, however, are expen-sive and complex, and for rural areas in developing countries it would be better to search for another source of water. For the treatment of surface water, aeration would only be useful when the water has a high content of organic matter. The overall quality of this type of water will generally be poor and to search for another water source would probably be appropriate.

The intimate contact between water and air, as needed for aeration, can be obtained in a number of ways. For drinking water treatment it is mostly achieved by dispersing the water through the air in thin sheets or fine droplets (waterfall aerators), or by mixing the water with dispersed air (bubble aerators). In both ways the oxygen content of the water can be raised to 60-80% of the maximum oxygen content that the water could contain when fully saturated. In waterfall aerators there is an appreciable release of gasses from the water; in bubble aerators this effect is negligible. The reduction of carbon dioxide by waterfall aerators can be considerable, but is not always sufficient when treating very corrosive water. A chemical treat-ment such as lime dosing or filtration over marble or burned dolomite would be required for this type of water.

13.2 Waterfall aerators

The **multiple tray aerator** shown in figure 13.1 provides a very simple and inexpensive arrangement and it occupies little space.

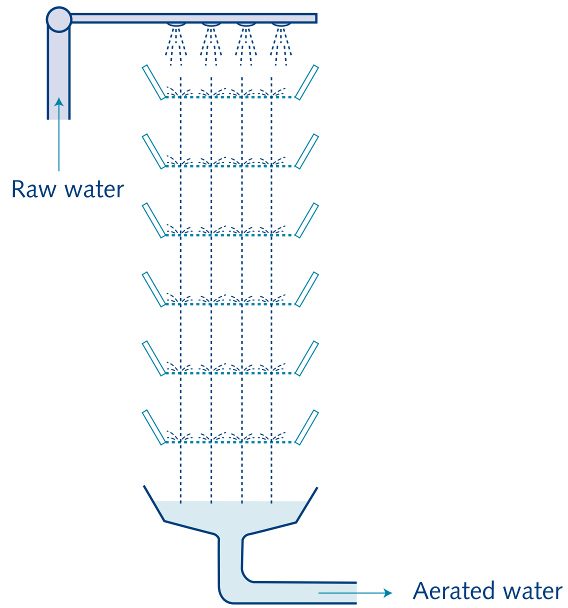

Fig. 13.1. Multiple-tray aerator

This type of aerator consists of 4-8 trays with per-forated bottoms at intervals of 30-50 cm. Through perforated pipes the water is divided evenly over the upper tray, from where it trickles down at a rate of about 0.02 m^3/s per m^2 of tray surface. The drop-lets are dispersed and re-collected at each following tray. The trays can be made of any suitable material, such as ferro-cement or plastic plates with holes, small dia-meter plastic pipes or parallel wooden slats. For finer dispersion of the water, the aerator trays can be filled with coarse gravel about 10 cm deep. Sometimes a layer of coke is used that acts as catalyst and promotes the precipitation of iron from the water. A hand-operated aeration/filtration unit for treatment of water having high iron and manganese content is shown in figure 13.2.

A type of aerator with similar features is the cascade aerator (Fig. 13.3). Essentially this aerator consists of a flight of 4-6 steps, each about 30 cm high with a capacity of about 0.01 m^3/s per metre of width. To produce turbulence and thus pro-mote the aeration efficiency, obstacles are often set at the edge of each step. Compared with tray aerators, the space requirements of cascade aerators are some-what larger but the overall head loss is lower. Another advantage is that no maintenance is needed.

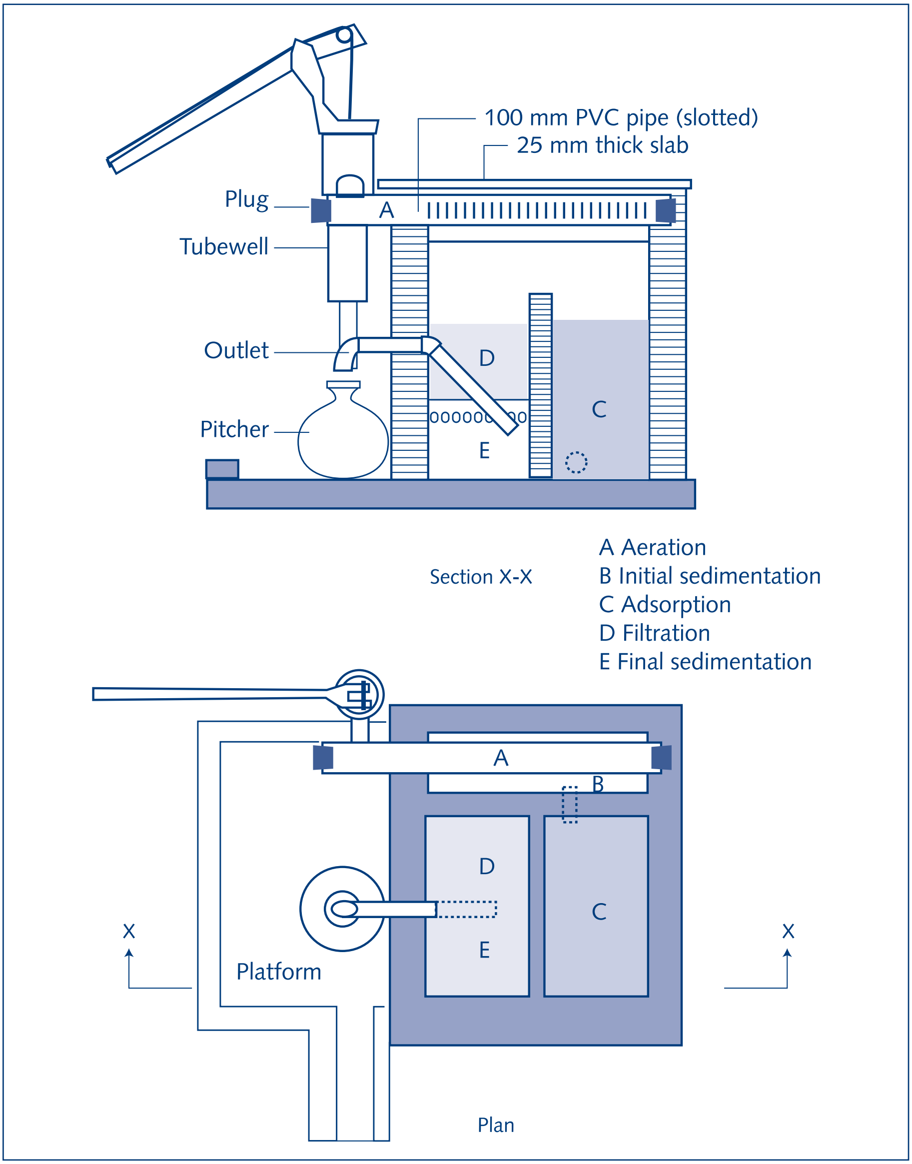

Fig. 13.2. Hand-operated aeration/filtration unit

A multiple platform aerator uses the same principles. Sheets of falling water are formed for full exposure of the water to the air (Fig. 13.4).

Spray aerators consist of stationary nozzles connected to a distribution grid through which the water is sprayed into the surrounding air at velocities of 5-7 m/s.

A very simple spray aerator discharges the water downwards through short pieces of pipe of some 25 cm length and with a dia-meter of 15-30 mm. A circular disk is placed

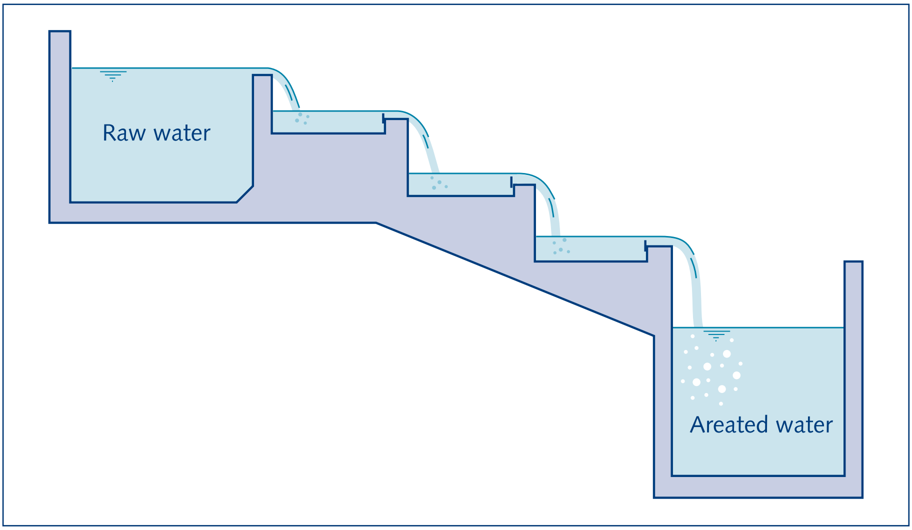

Fig. 13.3. Cascade aerator

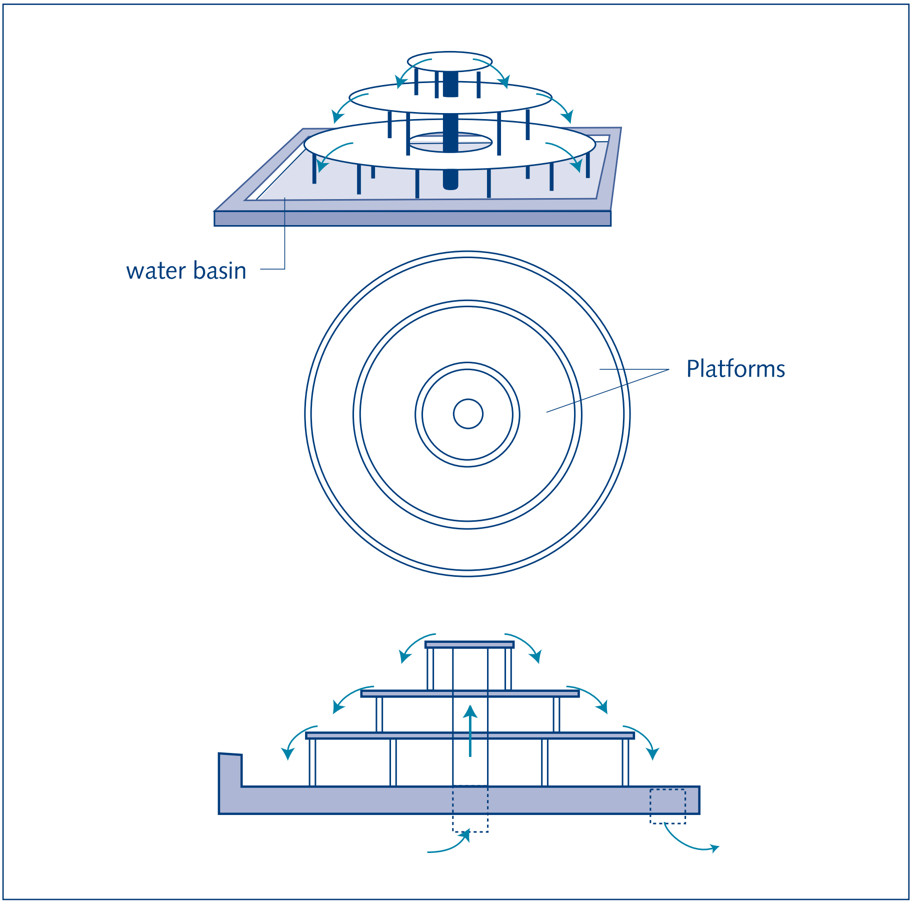

Fig. 13.4. Multiple platform aerator

a few centimetres below the end of each pipe, so that thin circular films of water are formed that further disperse into a fine spray of water droplets.

Another type of spray aerator uses nozzles fitted to feeding pipes, which spray the water upwards (Fig.13.5). Spray aerators are usually located above the settling tank or filter units, so as to save space, and to avoid the need for a separate collector basin for the aerated water.

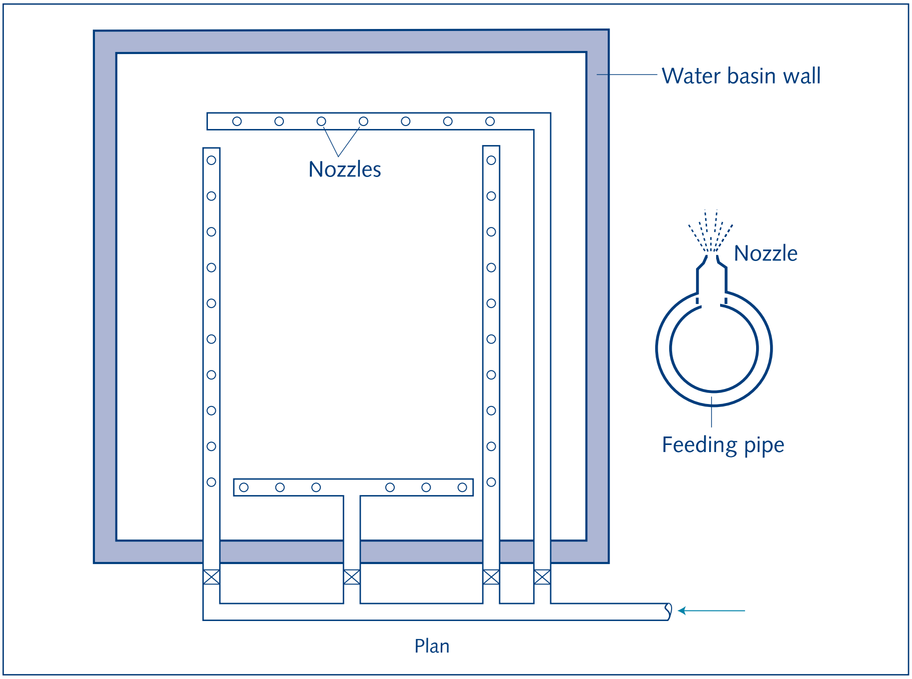

Fig. 13.5. Nozzled spray aerator

To avoid clogging, the nozzle openings should be fairly large, more than 5 mm, but at the same time the construction should be such that the water is dispersed into fine droplets. Many designs have been developed to meet these requirements. A simple spray aerator using a baffle plate is shown in figure 13.6.

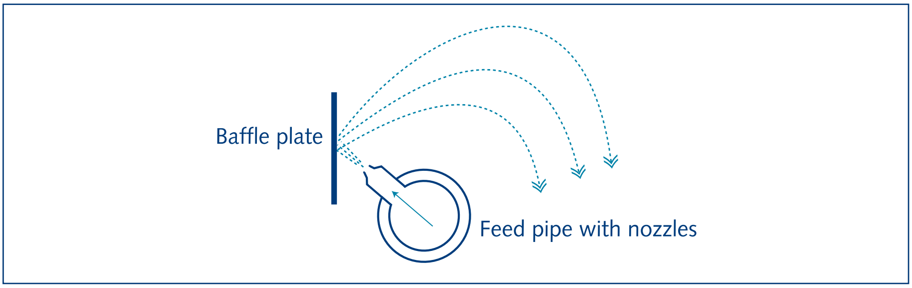

Fig. 13.6. Simple spray aerator using baffle plate

Figure 13.7 presents several examples of specially de-signed nozzles.

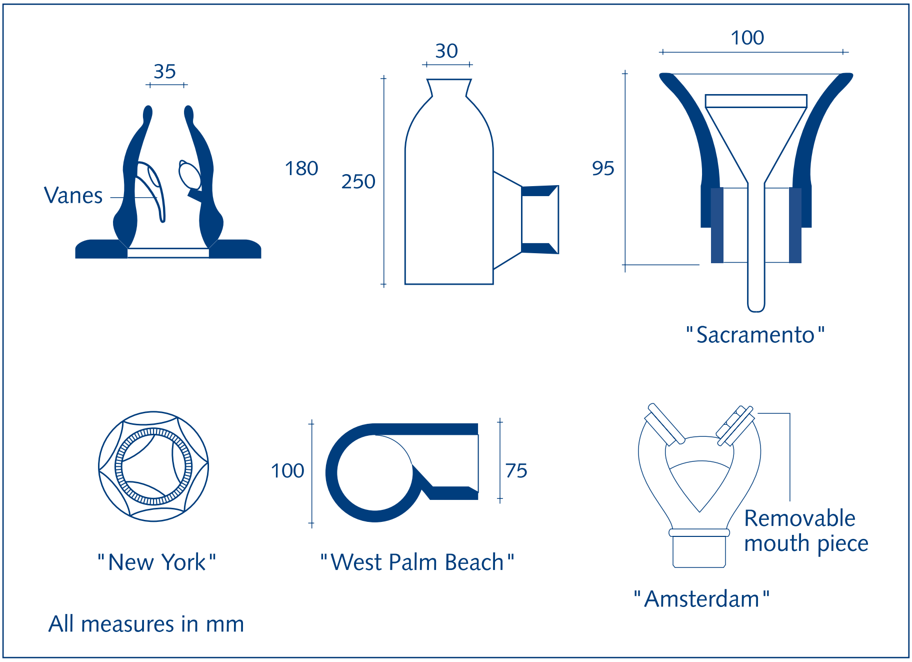

Fig. 13.7. Nozzles for spray aerators

13.3 Bubble aerators

The amount of air required for bubble aeration of water is small, no more than 0.3-0.5 m^3 of air per m^3 of water, and these volumes can easily be obtained by a sucking in of air. This is best demonstrated with the venturi aerator shown in figure 13.10. The aerator is set higher than the pipe carrying the raw water. In the venturi throat the velocity of flow is so high that the corresponding water pressure falls below the atmospheric pressure. Hence, air is sucked into the water. After passing the venturi throat, the water flows through a widening pipe section and the velocity of flow decreases with a corresponding rise of the water pressure. The fine air bubbles are mixed intimately with the water. From the air bubbles, oxygen is absorbed into the water. The release of carbon dioxide in this type of aerator is negligible, because the air volume of the bubbles is quite small.

Compared with spray aerators, the space requirements of venturi aerators are low; the overall head loss is about the same.

A submerged cascade aerator can operate by entrapping air in the falling sheets of water that carry it deep into the water collected in the troughs. Oxygen is then transferred from the air bubbles into the water. The total fall is about 1.5 m subdivided in 3-5 steps. The capacity varies between 0.005 and 0.05 m^3/s. per metre of width.

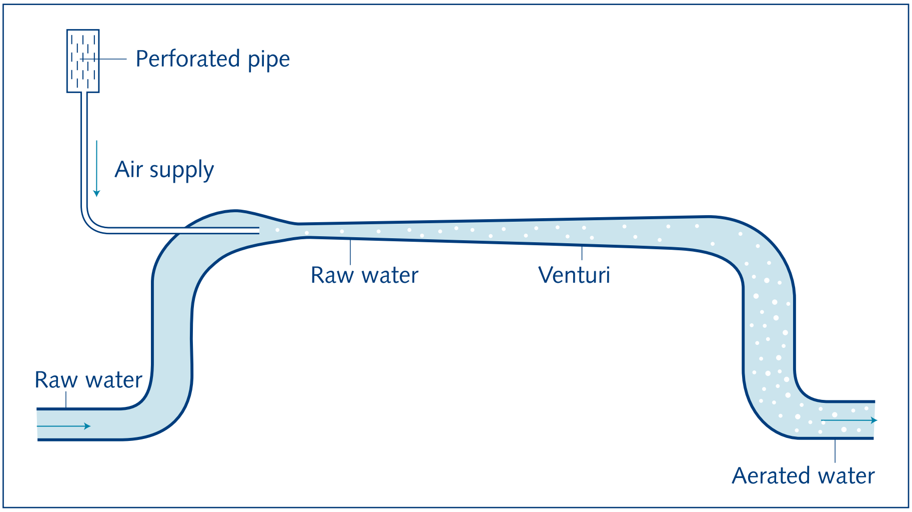

Fig. 13.8. Venturi aerator

Table 13.1 Aeration equipment characteristics (drinking water treatment)

Type	Hydraulic head required (m)	Air contact time (s)	Application	Notes
Spray*	1.5-7.6	1-2	CO_2 removal taste and odour	Not so effective for iron and manganese
Cascade	0.9-3	0.5-1.5		
Multiple tray	1.5-3	0.5-1.5		

Source: Montgomery, James M.,1985

* typical area needed 10-30m² per 100 l/s flow rate.

Some additional information is available in the Degremont Water Treatment Handbook (1991), chapter 17 with some useful illustrations.

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