Drinking Water Production Using Moving Bed Filtration

Small to medium sized package units for surface water treatment

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KEY WORDS

Surface water; moving bed filtration; drinking water

INTRODUCTION

Small to medium sized drinking water plants in the South East Asian area are normally located in rural areas to produce drinking water for small communities. Although properly designed some of these plants lack operators attention and will therefore under perform. It is therefore vital to design a plant which is economic and at the same time suitable to operate with low operators attention and maintenance requirements. This paper is dealing with the features of moving bed filtration which has been successfully applied for both ground water and surface water sources as the core component in drinking water production schemes. Based upon installed reference plants the operating envelope will be discussed and the overall process schemes, including intake facilities will be presented.

MBF Features

The moving bed filtration process is a treatment process developed as an alternative for conventional rapid sand filters (RSF). The particular features allows MBF to be used as an alternative for a broader range of processes: flocculation – settling – RSF. Therefore it is essential to understand the specific features of the MBF process.

In the MBF, the water to be treated flows in an upward direction through the sand bed (typical filtration rates: 5 –12 m/h). During the upward filtration process impurities are retained within the pores of the filter bed. The filtrate – free from solids - is discharged in the upper part of the filter via a fixed overflow weir.
Simultaneously the filter bed is constantly moving downward (typically with velocities of 0.3 – 0.8 m/h), as it is sucked into the airlift at the center bottom of the filter. The suction of sand and retained solids is induced by the airlift principle: feeding a small amount of compressed air into the airlift pipe starts the suction process, forcing a mixture of dirty sand and water upward through a central pipeline.

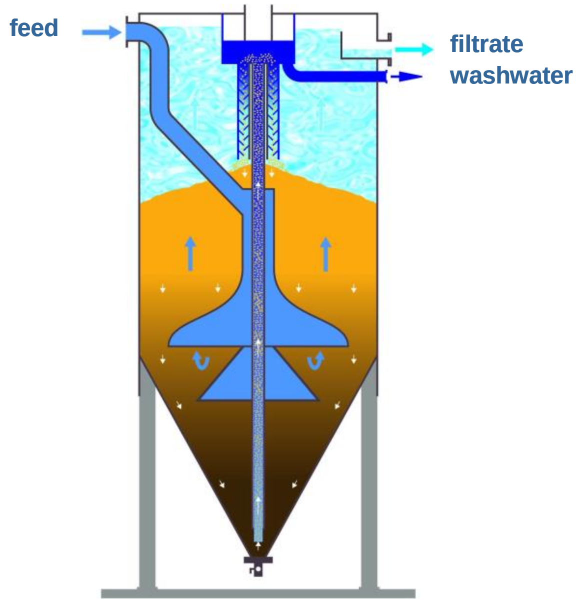


Figure 1: MBF operation

The intensive scouring movements separate the impurities from the sand particles. At the top of the pipeline the sand grains are released in the washer section and start to settle in a hydraulic washer. The grains are finally washed by a small amount of clean filtrate, flowing through the washer counter currently. This particular flow is generated by a constant difference in discharge levels of the filtrate and the wash water overflow weirs.

High Load Capacity

Due to the very nature of the continuous filtration and washing process a constant balance is reached between the feed solids entering the filter and the solids discharged from the filter with the wash water outlet. Other than in RSF processes no accumulation of solids in the filter is occurring and the head loss over the filter is constant at fixed operation conditions. In a RSF a high solids load results in short filter runs. This is the case if the feed water contains voluminous flocs (for instance after dosing a flocculant) and/or a high suspended solids content. Due to the continuous mode of operation a MBF can handle a high load without the drawback of short filter runs. This makes the process favourable if high turbid water sources are to be treated.

Washing Efficiency

In the MBF each sand grain will eventually be sucked into the airlift and washed properly. Dead zones with poor washing capacities are not existing due to the structure of the filter. Therefore the full filter area will contribute to the filtration process and maximum efficiency is reached. In RSF however the nozzle floor which is used for backwashing is prone to clogging and this will result in poorer backwashing efficiencies in part of the filter area. After a while this will decrease the overall run time and filter performance of the RSF.

The MBF is continuously washed without human interference. This will prevent the operators from extending filter runtimes, causing filter clogging and mud ball formation.
Finally the continuous washing principle and washing the sand with a small amount of filtrate does not require additional facilities for clean and dirty wash water storage tanks and backwash water pumps.

Feed Screening
An essential feature in MBF is the homogeneous sand circulation over the full filter area. Therefore it is essential for the sand to be sucked into the airlift evenly from all directions. The filter internals are therefore constructed into the filter tank perfectly in the centre of the tank. Moreover to prevent any disruptions in the sand suction process it is important that particles > 6 mm are not fed into the filter, as they might cause these kind of problems. A proper feed screen is therefore recommended under all circumstances. An example of such a feed screen is given in the figure.

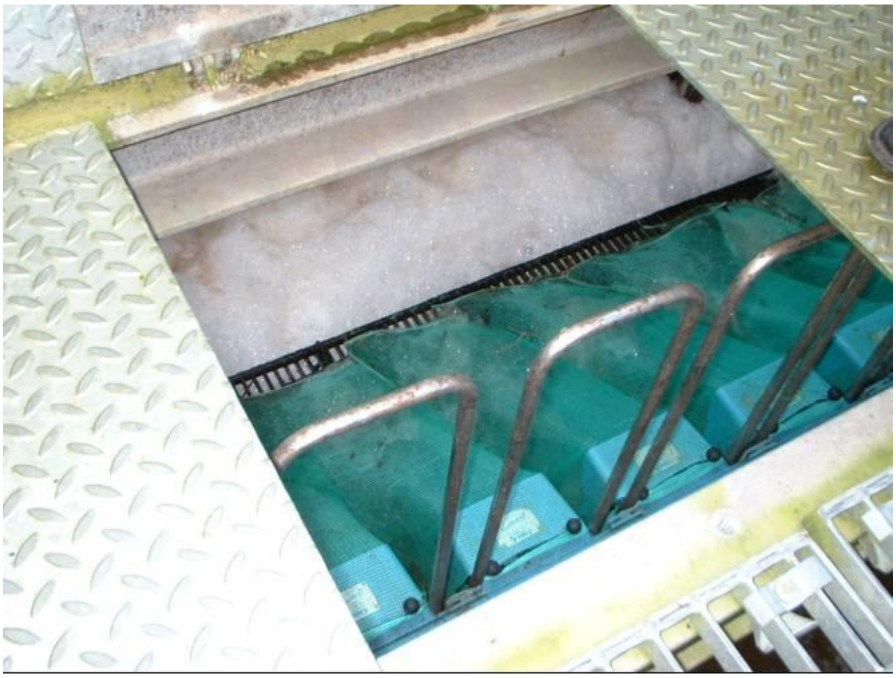


Figure 2: Surface water: 6 mm pre screening

Filter Control
Due to the continuous sand circulation the filtration process has become time-independent. With a constant feed water quality the filtrate quality will also be constant in time.
The sand circulation rate affects the filtration efficiency. The lower the circulation rate, the better the efficiency. A lower circulation rate implies the retention time of every sand grain in the filter bed is higher, causing a deeper penetration of impurities in the bed. As a result the filling degree of the pores will be higher, increasing filter efficiency.
It will be clear that the applied circulation rate must not be lower than the clogging front movement: if the upward clogging front movement is higher than the downward sand movement, breakthrough will occur. If the applied circulation rate is too low and

an equilibrium between the supply and discharge of impurities is not achieved, the filter bed resistance will not become stable and starts to increase.
In the MBF the sand circulation rate is an extra control parameter, which may be used to optimise the filtration efficiency: the actual filter load is linked to the actual sand circulation rate in order to establish optimised filter efficiencies under all operating conditions. Varying the air supply to the airlift will guarantee the MBF to be operated in the optimal efficiency range.

Surface Water Treatment

For surface water treatment the solids loading to the filter is based upon variable feed water quality, as the river water quality may vary considerably with respect to turbidity, colour and suspended solids. The MBF is capable of handling higher solids loadings and may therefore be used as a single process step avoiding the need for pre-treatment by settling. In order to efficiently remove colloidal matter an in line dosing of flocculants is normally projected. An indicative process selection diagram, related to feed turbidity and feed organic material (expressed in chlorophyll-a) is given in figure 3. Figure 4 is a photograph of one of the reference plants in Brasil, figure 5 a typical process flow diagram for the set-up. The final filtrate may be disinfected by using UV or chlorine.

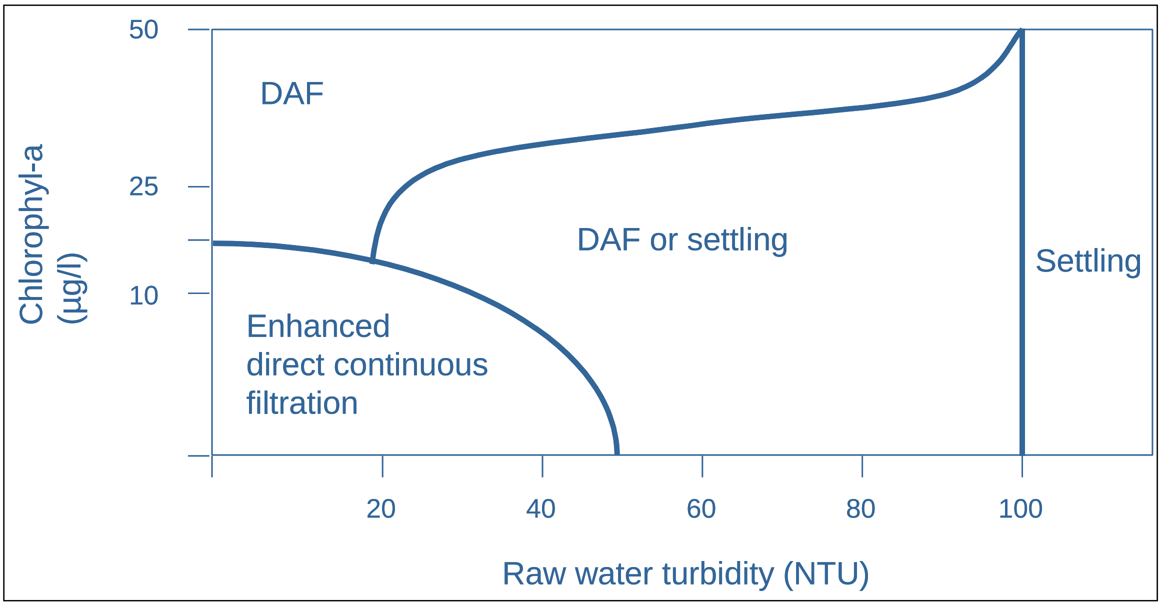
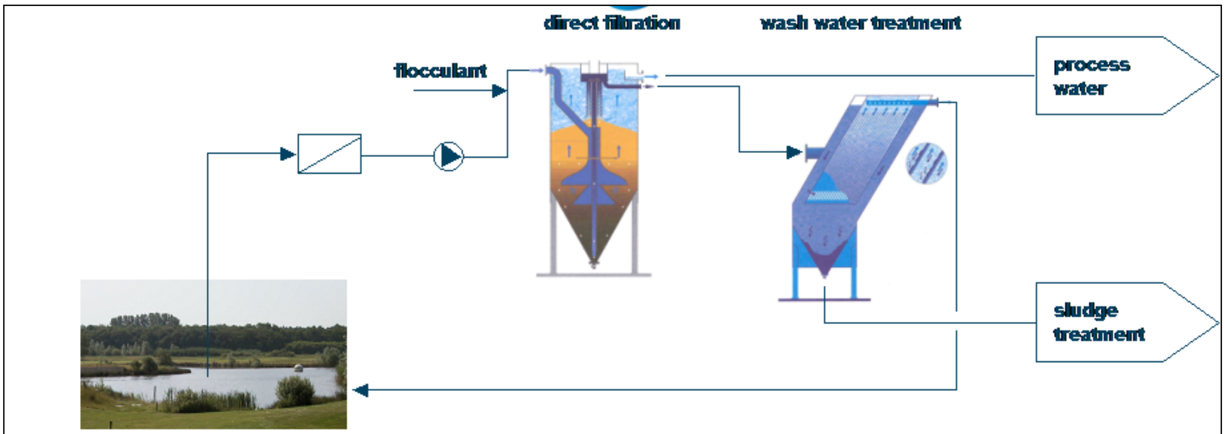


Figure 3: Surface water process selection diagram

Figure 4:
MBF for surface water treatment for drinking water production in Brasil



Removal of		Typical feed	Typical filtrate
TSS	(mg/l)	5 - 200	0.5 - 10
turbidity	(NTU)	1 - 100	0.2 - 5
colour	(mg/l, Pt-Co)	5 - 50	1 - 10
PO_4-P	(mg/l)	0.5 - 3	0.05 - 1

Figure 5:
Surface water treatment MBF process scheme and typical feed/filtrate operating window

Table 1 illustrates typical results of a surface water treatment scheme, based upon direct filtration. The effluent criteria are consistently met by the MBF filtrate.
The plant has a design capacity of 160 m^3/h; a flocculant is dosed in-line, using alum. Typical dosages are in the range of 2-6 mg/l Al. The alum dosage is controlled in function of feed turbidity.

Table 1:
Surface water treatment plant with MBF direct filtration - Water quality data

Parameter	Raw Water	Filtrate	Criteria
Turbidity (NTU)	20-25	0.1-0.2	< 0.5
TSS (mg/l)	1-50	0,5	<1
Temperature (°C)	1-25		
Transmission (%)	30-50	> 96	
Fe (mg/l)			< 0.05
Al (mg/l)	0.05-0.60	< 0.1	< 0.1
Mn (mg/l)			< 0.05

CONCLUSIONS

The use of MBF technology has proved to be reliable and effective for both ground water treatment and surface water treatment schemes for drinking water production. The simplicity of the process allows uninterrupted production capacity and very limited operators attendance.
Due to the nature of the process with a continuous balance between feed solids and wash water solids, the process is suitably operated over a wide range of feed water qualities. The introduction of the enhanced filter control allows a constant high quality filtrate to be generated.
As a result the MBF process is effectively applied in drinking water production schemes for small and medium sized communities.

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