Water treatment WSP

Rapid gravity filtration: water quality benefits and risks

Technical guidance

Information derived from:
- Recognised water treatment text books
- WHO drinking water quality guidelines
- Feedback from water suppliers

Related tools:
- Water treatment processes
- Statistical process control

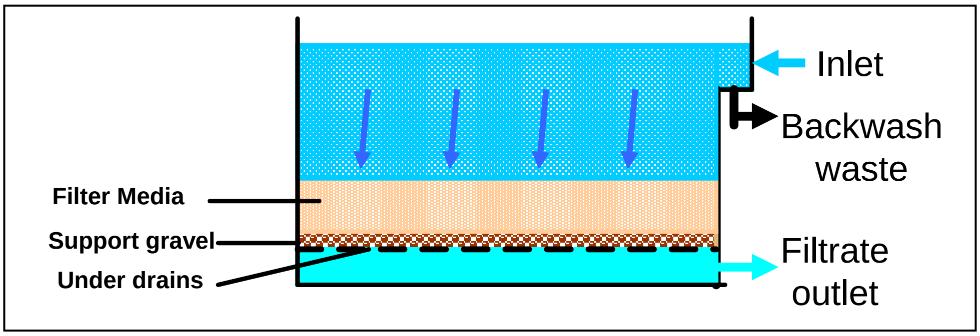
Important Notes to users:
This document provides general guidance to support improved management of drinking water quality. It cannot however be definitive and users must ensure that they assess local factors and particularly take account of any national or regional legislative requirements before adoption. This may also require close collaboration with others. The priority to be given to implementing controls to manage identified risks to water quality will depend on a proper prioritisation process by each water supplier.

Summary
Rapid gravity filters are used extensively in many waterworks across the world where they provide a critical part of the water purification process. This document summarises the basic functions and operation of such filters and identifies possible risks to water quality which need to be assessed and managed as part of a treatment water safety plan.

Detailed information

Description of process and basic operation

Rapid gravity filters are commonly used for treating surface water, often following a flocculation/clarification process. A typical rapid gravity filter design is shown below, although precise arrangements will vary considerably from plant to plant. Water is fed into the top of the filter and allowed to permeate through the filter media by gravity. The filtered water is then removed via under drains to the next part of the treatment process. The choice of filter media is important. Typically the main media is sand supported on a bed of gravel but other suitable material can also be used. In some situations dual or even triple media filters are used. Periodically the filter media must be backwashed to remove the trapped material thus maintaining filtration efficiency.



Properly designed and operated filters can remove a wide range of potential contaminants and are thus a key part of the water purification process. They are effective in removing suspended & particulate matter including associated substances such as:
- Natural organic matter, including material which can promote biofilm growth within the network and also act as precursors for disinfection byproducts such as trihalomethanes.
- Some metals particularly after an oxidation process
- Microorganisms including protozoal parasites such as cryptosporidia
- Algae

Potential risks which could compromise water quality

Although filters are a key barrier against many important water contaminants, depending on the precise design there are a number of risks associated with their operation which could compromise their effectiveness and which need to be managed. These include:

- *Hydraulic overloading*
  It is important to check that filters continue to operate within their design maximum loading rates or within loading rates that are subsequently shown to be optimal for filter performance. Allowance must be made for increased loading on remaining filters when one or more is out of action for cleaning. Particular risks can occur under abnormal situations e.g. when plant output has to be increased to cope with unexpected demands. Where multiple filters operate in parallel, check that the hydraulic distribution between individual filters is balanced so that overloading of one particular filter does not occur.
- *Filter media loss/damage*
  Over a period of time filter media can be lost, reduced in size through attrition or its effectiveness compromised by for example poor backwashing. Both the depth and integrity of filter media should be checked periodically.
- *Ineffective backwash arrangements*
  Regular backwashing to remove accumulated particulate material is vitally important. The frequency depends on local circumstances but is often triggered by headloss across the filter or increasing turbidity on filter outlet. Modern filters normally also use air as well as water for backwashing since this improves removal of accumulated debris and prevents formation of so called “mudballs” within the filter media. When filters are returned to service after backwashing the first few bed volumes of filtrate are often of poorer quality. In some countries it is therefore common practice to adopt a “slow start” approach to returning filters to service and in some cases the first few bed volumes of filtrate are run to waste. If significant seasonal variation in water temperature, and hence water density, is experienced, it may be necessary to adjust backwash rates accordingly.
- *Feed water quality deterioration*
  Filters are normal designed to cope with certain levels of feed water quality. Typically this might be no more than 5 NTU turbidity but in some cases higher levels of turbidity can be adequately dealt with. If feed water quality deteriorates then the filter performance can be affected and as a minimum increased frequency of backwashing will be required.
- *Failure of under drains*
  If the under drainage system fails for any reason, then filtration effectiveness can often be rapidly impacted
- *Failure of control valves*
  Depending on filter design, it may be possible for failed or leaking valves to allow dirty or unfiltered water to enter the filter outlet system, particularly during the filter backwash cycle
- *Ingress of extraneous material*
  Filters are sometimes incorporated within buildings but can also be outside. In this latter situation the filter surface can sometimes be contaminated by a range of extraneous material including leaves and other debris, bird droppings, insects and similar factors which might adversely impact water quality. In such circumstances it may be necessary to install some form of cheap temporary cover.

Typical Control Points

The most appropriate control points to monitor the effectiveness of filter performance can only be determined locally taking into account a range of factors. However typical controls could include:

- *Turbidity*
  This is one of the most common and important indicators of filter performance. WHO advises that a well operated filter can typically achieve turbidity levels of 0.1 NTU or ideally less. The use of statistical process control techniques (see separate tool) can be a very useful way of detecting early evidence of deterioration in filter performance. Even for plants which normally achieve very low turbidity values, any unexpected deterioration in filter turbidity should be investigated.

- *Physical inspection*
  As indicated above visual inspection of the filter media and backwashing operation by experienced operators can often reveal early signs of problems. Simple sieve analysis can be used to monitor changes in media size.
- *Headloss*
  As described above, filter headloss is often used as a trigger for filter backwashing. However, it can also be used as a potential control point since unexpected change can indicate deterioration in filter performance.

If a plant has a number of filters operating in parallel it is particularly important to check that any of the above risks are not just occurring in one filter. For example if filter performance (e.g. turbidity) is only measured on the combined outlet from the whole bank of filters then a deficiency in one filter might be missed. For this reason measuring/assessing individual filter performance is recommended.

Reference for further detailed information:

- There are a number of recognised water treatment text books that provide much more information about filter design and operation
- Operating and maintenance manuals supplied by the filter manufacturer should always be readily accessible to relevant operational staff
- Guidance from WHO: http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/index.html
- Cryptosporidium in water supplies: Report from UK expert group 1998 chaired by I Bouchier provides useful information: http://www.dwi.gov.uk/pubs/bouchier/index.htm

Typical resources needed:
This is very dependent on a number of factors including raw water quality, type of plant, design and number of filters involved. However introduction of basic water safety plan principles for filters should not require significant resources.

Document creation:

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