Water Treatment Processes

Briefing Note

CIWEM Chartered Institution of Water and Environmental Management

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Purpose

The information included below is intended as a source of references and presentations to key academic papers on drinking water treatment processes. The processes covered are those which occur at a drinking water treatment works only.

Background

Significant research has been completed on all stages of drinking water treatment and continues to be undertaken by a number of organisations including, but not limited to; universities (e.g. Imperial College London, Cranfield, Sheffield, Newcastle and Surrey), individual water companies and private organizations (e.g. Isle Utilities and WRc). A number of organisations coordinate and fund research in drinking water (e.g. Water Research Foundation (US) and UKWIR (UK)). Further information on drinking water treatment and processes can be found through these organisations.

A range of treatment processes are included below, it should be noted that depending on the raw water quality, different processes will be employed at different drinking water treatment works.

CIWEM has produced a number of policy statements regarding treatment processes and associated issues which can be accessed here.

Processes

Raw water abstraction and screening

Raw water for drinking water is either abstracted from underground aquifers or river sources. River sources may be used directly or following storage in large raw water reservoirs.

River water will pass through screens to remove larger material as well as prevent the abstraction of fish and eels.

Raw water reservoir storage

River sources may be used directly or following storage in large raw water reservoirs. This can be an effective means of removing gross contamination by allowing particles (organic and inorganic) to settle over a period of time, or by diluting spikes of micropollutants

Storage reservoirs can present a number of challenges to the raw water quality including stratification which may result in variable raw water quality or by allowing algae to grow, particularly during the spring and summer.

Aeration/Preozonation

This process is designed to remove compounds such as carbon dioxide and hydrogen sulphide and oxidise dissolved metals (e.g. iron, manganese and arsenic), which may be present in the raw water. The oxidation process converts these metals into their insoluble states which makes them easy to remove by subsequent processes such as clarification and filtration. Various techniques maybe used to achieve this including the use of aeration towers or air injection.

On surface water sites, ozone may be used at this stage. This will carry out a stronger oxidation and will also begin the disinfection process, killing off algae so that it cannot continue to grow through the treatment process. This also helps to start the breakdown of organic carbon so that it can be more easily removed later in the process.

Chemical coagulation and pH correction

All particles carry an electrical charge, either positive or negative. If particles have the same charge, they will repel each other and not stick together, making them more difficult to remove. Chemicals are added to the water to remove these charges and allow the particles stick together and form a large particle or floc. The subsequent floc is more easily removed from the water through clarification and filtration processes.

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The control of the water chemistry is critical to the formation of a suitable floc and a number of techniques are utilised to manage this process including measurement of zeta potential (particle charge) and autocoagulation processes.

Clarification

Clarification involves the removal of floc and particles by settlement or flotation depending on the treatment works. A number of different processes are available for settlement (e.g. hopper bottom clarifiers, Actiflo, lamella clarifiers) or flotation. Clarification is capable of removing most of the particulate matter from the raw water. It does not produce pristine water though and needs to be followed by a secondary process.

Filtration

There are several different physical and biological methods of filtration which are used in the water industry to remove fine particles and contaminants from the water.

Rapid gravity filtration (RGF) may occur through a number of different medias and mechanisms for example: sand and anthracite. Water is passed through a deep deb of media, with particle removal largely being by capture within the bed. These can be washed by reversing the flow through the bed after a set period of time. Washing may be enhanced introducing air into the wash cycle.

Slow sand filtration (SSF) is a much slower process and relies largely on bacterial action in the top layer of the filter bed (the Schumtzdecke) rather than removal through the bed itself. Because of the slow nature of the filtration, these beds are much larger than RGFs and cannot be backwashed. Instead the top layer is mechanically scraped from the surface and biological action allowed to re-establish itself before these are put back into supply.
Membranes are used at some sites, particularly where there is a perceived risk from Cryptosporidium. The filtration mechanism is purely at the surface of the membrane meaning that backwashing can be much more rapid and frequent. Membrane filtration is the only process on a treatment works which is an absolute barrier to the contaminants in the water. All other processes work on the principle of a percentage.

Ozonation

This involves the diffusion of ozone gas into the water to breakdown complex compounds such as pesticides and organic material. Ozone may also be used as a disinfectant to destroy bacteria and pathogens. If not well controlled, it can give rise to byproducts, such as bromate, which is a regulated parameter.
Ozone will not remove organic material, only breaking it down into smaller organic molecules. It thus needs to be followed by GAC to mop up the organics.

Granular Activated Carbon

Granular activated carbon (GAC) is highly porous and absorbs a range of organic and inorganic compounds from the water. It is principally used to remove pesticides and other organic compounds, including those which may cause adverse taste and odours.

Reverse Osmosis and Desalination

At sites where saline ingress is possible, Reverse Osmosis (RO) may be considered to treat brackish water. RO is a membrane process which will remove all salts from the water. This means that where this is to be considered, there needs to be robust pre-treatment and the water then needs to be re-mineralised so that it is not aggressive to the distribution system or harmful to health.

Other Processes

There are a number of other treatment processes that may be used for specific pollutants (for example Ion Exchange for Nitrate removal, or Air Stripping for the removal of Volatile Organic Carbon). These will be used on a risk based approach where they are required. Blending may also be used where there is not a need to fully remove a contaminant, just to reduce the concentration to a safe level.

Control of Aggressivity in distribution

This is largely achieved by pH correction at the end of the works. The required pH will depend on the ionic make up of the water at that point. Depending on the network that the water is entering, there may be a need for plumbosolvency control through dosing Orthophosphoric Acid.

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