Biocide Selection and Monitoring

Introduction

Ensuring levels of bacterial activity in membrane water treatment plants is as low as possible is often mandatory and always good practice. Without some form of disinfection bacteria can multiply rapidly in nutrient rich feedwaters leading to membrane fouling (thin film composite) or membrane degradation (cellulose acetate) as well as disruptive fouling of feed piping and equipment.

Avista Technologies offer a range of membrane compatible, non-oxidising biocides and biostats to ensure the level of bacteria in membrane systems is kept under control. This paper reviews the selection and optimisation of biocide treatments and suggests ongoing biological monitoring programmes for membrane systems.

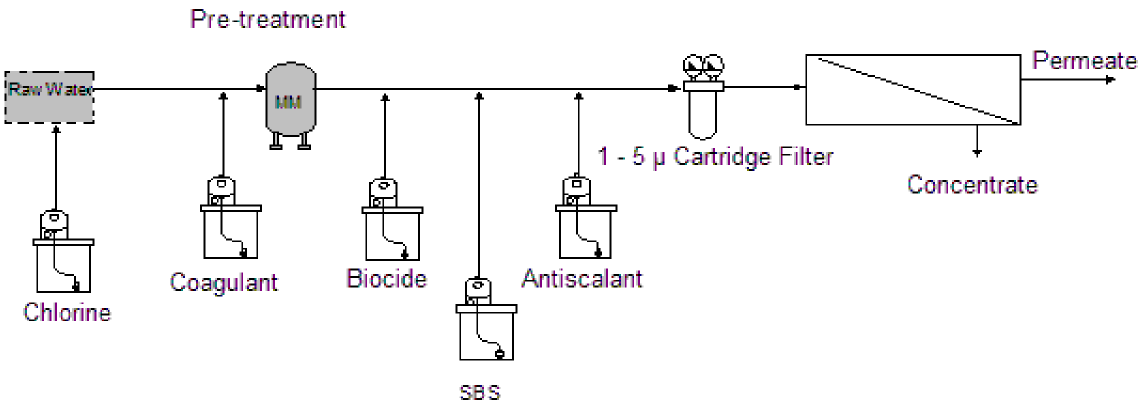

Figure 1: Typical Membrane System Pre-treatment Chain

Background on Membrane Plant technology

Membrane water treatment plants are employed on a wide variety of sources to produce numerous product water qualities. These include seawater and brackish water reverse osmosis for drinking water production, seawater nanofiltration for reduced sulphate waterflood injection, brackish water reverse osmosis for industrial water production, waste water treatment for water conservation, and waste discharge control.

A diagram of a typical membrane treatment system is included in Figure 1. The process sequence is typical of most membrane plants in that pre-treatment is required to condition the feedwater for membrane application. Biological fouling may occur at any stage in the process and all systems must be monitored and, if necessary, treated to prevent frequent cleaning and reduced membrane life.

Pre-treatment for spiral wound membrane units varies depending on the source of the feedwater but frequently includes: chlorination, coagulation, multi-media filtration, 'guard' cartridge filtration, dechlorination, and antiscalant dosing, upstream of the membranes.

This traditional chlorination/dechlorination of feedwater provides biological protection to systems upstream of the membranes and

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further measures to protect the downstream systems are described later in this note. (Cellulose Acetate membranes are compatible with chlorine and the full system can be protected in this way, without the necessity for a dechlorination stage.)

Bacteria, which colonise membrane surfaces, produce extra-cellular layers of slimy matter, (saccharides or exopolymers), to which particles can stick. This sticky foulant is very difficult to completely remove with cleaning and any remaining bacteria can quickly re-populate the system. Prevention, or control, is therefore much better than remediation where biofouling is concerned.

The diagrams below illustrate the process of biofilm formation on a surface. It is useful to note that all systems will have some degree of biofilm present, it is only thick, rapidly growing biofilms that interfere with production that require action.

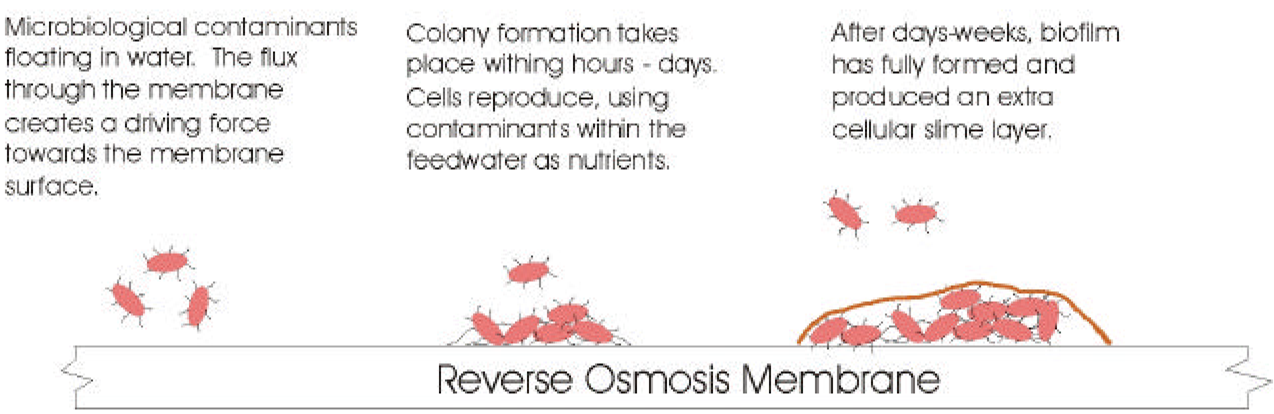
Biofilm can be anything from a few micron thick to several millimetres. The base of the film is always in the boundary layer between the turbulent flow and the pipe wall (or membrane surface). Hence it is very difficult to remove every last trace of organic matter.

Traditional Biogrowth Protection: Chlorination / Dechlorination

Where the feedwater is low in nutrients chlorination/dechlorination, coupled with regular maintenance cleaning of the membrane system, is often sufficient to control biogrowth and prevent a severe biofouling problem. Plants with borehole or beachwell intakes and those fed from mains water sources are commonly treated in this fashion.

Biogrowth control is more challenging in warm, shallow, nutrient rich intakes, e.g., from rivers, estuaries or seashores, and waste streams. Nutrient rich conditions can also be found around offshore installations where intakes are close to platform discharges or are sited in depths of water susceptible to algal blooms. When designing plants in such areas it is advisable to gather as much information as possible from other installations in the area or in similar operating conditions.

Continuous chlorination/dechlorination in nutrient rich feed sources has been known to cause problems. It is suggested that the chlorination breaks down long chain organic matter, (indigestible humic acids), into AOM, (assimilable organic compounds), increasing the food supply to the bacteria which survive the chlorination process. This ready food



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supply is supplemented by, nutrients from any excess bisulphite dosing. The combination can lead to rapid biofouling downstream of the dechlorination point.

This effect can be minimised by adopting an intermittent chlorination /dechlorination regime, such as dosing 24 hours per week. This prevents significant bio-growth in the plant intake system but does not add unduly to the AOM burden and may control the problem adequately. This approach can only be adopted if the whole intake system is used for the membrane plant. If sidestreams are taken from the intake for other purposes then this system of shock dosing may not be appropriate.

In a small number of sites UV or ozone is employed for disinfection purposes. These techniques have their own limitations and design considerations but for the purposes of this document the situation downstream of the disinfection point can be considered to be the same as the situation downstream of the dechlorination point. That is, a mass of dead bacteria which have been in part reduced to AOM are present in the system.

Where these traditional approaches cannot be used or do not prevent significant biogrowth on the membrane trains, then the Avista range of membrane compatible biocides can be applied to effect control.

Avista Product Range

Avista Technologies provide three types of proprietary non-oxidising biocides, which are compatible with both thin film and cellulose acetate membrane systems. These are:

- RoCide DB5 / RoCide DB20
- RoCide IS2
- RoCide LC / RoCide SC

The biocides are compatible with membrane systems and Avista coagulants, antiscalants and cleaners. They are broad-spectrum biocides, which are effective against a wide variety of algae, bacteria and fungi that are found in water systems. The biocides are effective against both organisms in the main flow (planktonic) and against organisms in biofilms on surfaces (sessile).

- The RoCide DB range has excellent biocidal properties and is best suited to shock dosing either online or as the first step of a CIP operation.
- RoCide IS2 is an efficient biostat and as such should be applied at low doses on a continuous basis to maintain bacterial control.
- RoCide LC and SC are suitable biocides for applying as the first stage of a CIP cycle or for long term membrane storage(1). These are applied in systems where the product is for potable water or food applications.

Further details on these products can be found in the product catalogue.

Treatment Design

When reviewing plant disinfection options there are many factors to take into account. These include: feedwater source, temperature, intake geometry, the environment, product water legislation and cost. In any case it is important to provide as much flexibility in the biocide dosing system as possible in order to ensure that a wide range of applied doses or applied biocides can be accommodated.

It is good practice to include a dosing point for biocide injection in the plant intake and upstream of the membranes, even if no other equipment is provided.

Application	Possible Dosing Regime
Potable Water	Chlorination/dechlorination for pre-treatment (continuous or intermittent) Periodic membrane sterilisation using RoCide LC/SC in CIP cycle
Large industrial plant with biofouling risk	Chlorination/dechlorination for pre-treatment (continuous or intermittent) Periodic membrane sterilisation using RoCide DB5/20 on-line
Small industrial plant with high biofouling risk	Continuous RoCide IS2 Periodic membrane sterilisation with RoCide DB5/20 in CIP cycle
Industrial plant with low fouling risk	Intermittent RoCide DB5/20 either online or as first stage of CIP

Good practice also dictates that all equipment is physically cleaned out and sterilised during commissioning to minimise any bacteria feed sources.

It is also important to ensure that the biocide is applied at the point where any other continuous dosing ceases; for example, at the SBS dosing point, to prevent bacteria from untreated areas upstream immediately colonising the disinfected areas.

Several typical biocide dosing regimes are outlined below and applications suitable to these regimes are indicated.

Details of recommended dose and application is included in the product datasheets.

In all cases where biocide treatment is necessary an occasional treatment with an alternative biocide is recommended. This mitigates the effect of 'population shift', or kills bacteria which are resistant to the usual biocide.

It is also worth remembering that biofilms can increase the rate of other fouling by reducing turbulence, impeding flow or creating sticky surfaces for particles to adhere to. Maintaining low bacterial counts in the system may prevent other fouling as well as biofouling.

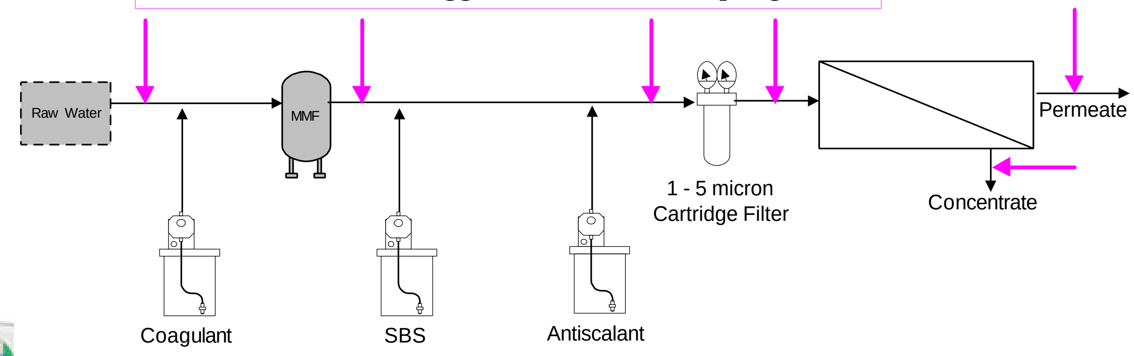
How to Evaluate Effectiveness and Optimise Dosing

It is important to know that the biocide applied is controlling the levels of bacteria in the system and preventing biofilm growth. Take regular samples from upstream and downstream of each unit operation in the system. (See figure below for suggested dosing points in a typical system)

In addition, samples should also be taken from any deadlegs or areas of low velocity as these are places where bacteria are most likely to colonise.

Ideally, samples should be taken of both the water and the internal surface of the piping.

Pink Arrows Denote Suggested Bacterial Sampling Points



If biofilm samples cannot be obtained then the water samples can be used as an indication of the trend in bacterial population.

Water samples should be collected in sterile sample bottles and sent for microbiological evaluation. (Care should be taken not to contaminate the samples with bacteria from the outside of the sample pipework). Biofilm samples can be collected by swabbing known areas of piping or can be taken from plugs or coupons in a biofilm monitoring flow cell. In membrane systems sacrificial coupons are often installed in the brine stream to provide an indication of the effectiveness of the membrane sanitisation programme.

Whatever the source of the sample, the total viable count (TVC) or total general heterotrophic bacterial count (GHB) in each sample should be ascertained.

TVC can normally be established by a local water analysis laboratory within 48 hours. If this is not available a range of on-site test kits can be purchased to allow GHB or similar to be established.

Both aerobic and anaerobic bacteria may be present in the depths of a biofilm so total viable bacterial counts should be measured to provide information of the size of the whole population.

Monitoring frequency should be determined by application, site conditions and ongoing site experience. Monthly for the first year if there are no other determining factors is recommended

If an intermittent dosing regime is being followed the sampling should co-incide with treatment with both pre and post treatment samples being collected for evaluation.

The aim of biocide dosing is to reduce the TVC to as close to zero as possible throughout the system, and to prevent any accumulation of bacteria. Providing there is no evidence of bacterial increase across the system, and the over time there is no significant increase in the bacterial levels, the existing biocide programme can be safely continued. The regime can be assumed to be killing planktonic bacteria and halting the growth of biofilms.

If there is a bacterial increase across the whole system over time, but there are no other factors, (such as increased membrane differential pressure or increased changeout frequency of cartridge filters), then the biocide dose should be increased and the tests repeated after a few days. This should be continued until the system is brought back under control.

If there is a significant rise in bacteria at any point in the system then the unit operation exhibiting the rise should be sanitised independently, and then the tests repeated. For example, if the multi-media filter outlet contained significantly more bacteria than the

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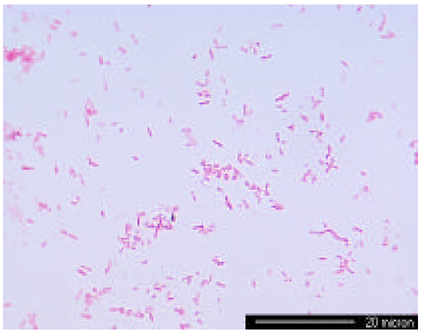
inlet, then shock dose the filter with biocide during its next backwash. Once the offending unit operation is disinfected, the overall biocide dosing level should be increased.



Example photo showing Gram negative bacilli, 1800X.

Ongoing Monitoring

The process of sampling, set up to optimise the biocide dose, should be continued to ensure ongoing effectiveness. It should be noted that the effective dose of biocide may vary during the year due to nutrient and temperature level variations so vigilance is always required.

In addition to the regular monitoring programme, it is good practice to inspect pipe and vessel internals taking samples of any slimy wall deposits at least once per year. If biological slimes are found the system should be mechanically cleaned and sanitised.

References

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4. W Bates. Reducing the Fouling Rates of Surface & Waste Water RO Systems. IWC-98-08

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