disarm

Disseminating Innovative Solutions for Antiobiotic Resistance Management

Best Practice Guides

Drinking Water Quality

PROLOGUE


CATTLE


PIGS


POULTRY


SHEEP

This guide is written as part of the DISARM project 'Disseminating Innovative Solutions for Antibiotic Resistance Management', funded by the European Union's Horizon 2020 research and innovation programme under grant agreement 817591.

The DISARM project aims to reduce antibiotic resistance through a focus on disease prevention and animal health, thereby reducing the need for antibiotic use. DISARM has a wide range of resources available via our website and YouTube channel. We also have a vibrant and knowledgeable community within our Facebook discussion group (we welcome you to join, simply click this link and answer some short questions to gain access), and wider social media channels: Twitter, Facebook, LinkedIn.

DISARM also promotes the multi-actor approach – different people (farmers, veterinarians, nutritionists and other advisors) working together towards improved animal health and farm performance. If you want to find out more about this, check out our toolbox to get started!

This guide was based on the information that was gathered during the DISARM project; it should not be considered as a complete reference book. It gives a useful overview with links to practical videos, abstracts, articles, testimonies etc., to facilitate good practices. Not all recommendations will be applicable or suitable for your farm and any interventions should be discussed with your farm advisor(s).

This guide is one of the 10 Best Practice guides made during the DISARM project. The 10 guides all have the goal to inform you about a specific topic in order to reduce the antimicrobial use in the livestock industry.

The other DISARM Best Practice guides can be found here.

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Coordinated by ILVO Flanders research institute for agriculture, fisheries and food

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INTRODUCTION

Sufficient high-quality water is worth its weight in gold for every farm. Water is a critical nutrient for farm animals. An adequate and safe water supply is essential to maintain good health and production parameters. However, unsuitable water can adversely affect the growth, reproduction, and productivity of animals. The chemical composition of water is the first factor that determines its suitability. Besides that, contamination with substances that originate on livestock farms such as bacteria, organic materials, and suspended solids can make water unpalatable or even unsafe for animals. A high level of suspended **solids and an objectionable taste, odour, or colour in water can cause animals to drink less than they should.**

- Click here for access to the Inagro 'Watertool', a complete tool to help you evaluate and remediate your water quality (in Dutch)
- Click here for the checklist 'drinking water check for pig farming (ZLTO)' (in Dutch)
- Click here for the checklist 'drinking water check for dairy farming (ZLTO)' (in Dutch)
- Click here for the French guide 'Drinking water in poultry farming a major lever of success'

IMPORTANT POINTS OF ATTENTION

- Is your water clear, odourless and tasteless? No? **Take action!**
- Clear water **is not always safe water!**
- Take water samples regularly to check its quality.
- Water treatment should always be farm specific. The water quality at the point of drinking is the result of different factors. Thus, **each case needs to be individually assessed** to establish an effective water treatment protocol. Consult your veterinarian, advisor, or local qualified agricultural institute for support.
- Make a cost-benefit analysis before starting a treatment and use water samples to verify the success/failure of the chosen treatment.
- Be aware of the national and European biocide legislation: check which products/dosages are allowed. **Legislation can differ between countries!**
- Follow the safety instructions of the product(s) you are using.
- **Always check compatibility** if you are combining products (e.g. disinfection, additives, vaccines) or techniques.

WHY IS MONITORING WATER QUALITY SO IMPORTANT?

Different farms have access to different water sources (e.g. groundwater, open well water, drainage water, rainwater, tap water). The decision to use a specific source or sources for animals' drinking water depends on different factors such as availability, costs and quality. The water source and farm specific aspects determine the final quality of the water at the point of drinking where it is consumed by the animals.

Multiple aspects of water quality can influence animal health and therefore antibiotic usage. It is very important that animals consume a sufficient volume of water and that no toxic components or pathogens are present. In some life stages animals can be particularly sensitive to suboptimal drinking quality, e.g. young or lactating animals. Furthermore, components in the water can indirectly influence the administration of medication and supplements, for example, due to poor solubility or interaction between the product and water components. In other words, safe drinking water is one of the keys to preventing antibiotic use.

The quality of the water source can change over time due to various factors, such as a long period of drought or rain, so it is of utmost importance to regularly monitor the water quality. And if health problems do occur, it is very important to rule out whether problems with the drinking water could be the cause.

This article describes the complex dynamics of microorganisms in water distribution systems. **"Water quality is diminished primarily through faecal contamination. The best option is an open, funnel-shaped galvanized drinking trough, possibly with a pressure system, air inlet, and anti-backflow valves."**

Click here to see a poultry farmer's testimony. **"We saw a lot of brownish dirt and slime coming out of the pipes."**

- In this article, a poultry product manager explains how you can improve egg production using water management: "The cost of doing something to prevent the build-up of biofilm is far less than the cost of doing nothing."
- Read more about the role of water in the spread of infections in this article: Drinking Water as a Risk Factor to Poultry Health

WHICH PARAMETERS DETERMINE WATER QUALITY?

The dissolved substances in water make each water source unique. These substances can include phosphorus, sulphates, nitrates, magnesium, calcium, iron, manganese, sodium, chloride, and many others. They determine water's properties, such as pH (acidity), hardness, taste and sediment content. The types and amounts of the substances in the water determine whether the water is safe or unsafe for the animals. Substances that often contaminate water supplies on livestock farms include nitrates, bacteria, organic materials, and suspended solids. An objectionable taste, odour or colour and high level of suspended solids in water can cause animals to drink less than they should. Several substances have the potential to pose a health risk. The most important parameters and possible techniques for remediation are given below.

1. Sensory Properties

Here we refer to the properties of the water that we can perceive with our senses, namely colour, odour, taste and clarity. These properties determine to a great extent water's aesthetic acceptability. Drinking water should be colourless, odourless and clear; if not, a problem with the quality can be expected.

Colour

Typical colour changes are yellowing due to organic substances (e.g. groundwater originating from peat). Iron excess makes the water orange-yellowish and can cause iron deposition in the water pipes. Yellowing can also be a sign of ammonia excess. A carbon filter can be used to decolorize the water.

▲ *Colour, odour and clarity are easy to monitor and are therefore very useful parameters to detect problems. (Source: Ildar Sagdejev/CC BY-SA 4.0)*

Odour

Odour can be caused by organic and inorganic substances naturally present in the water (iron, manganese, humus) or that are artificially added (phenol, chlorine,...). A bad or abnormal smell can result in reduced water intakes. This is particularly an issue for lactating or young animals. Odour problems can be solved using a carbon filter or sedimentation basin.

Clarity

Small particles in running water (e.g. clay or sand) cause turbidity. The more particles, the more turbid the water looks. In stagnant water, turbidity is usually caused by bacterial contamination. Severe contamination with faecal material combined with exposure to sunlight often results in strong algae growth.

Turbidity is a sign of impurity, but not always of pollution. Very turbid water can compromise certain purification processes or cause obstructions in pipes or at drinking points. Therefore, turbid water should always be filtered. Numerous filtering systems are available.

2. Temparature

The water temperature can vary substantially with the seasons. At high temperatures, there is greater risk of increased bacterial load and levels of ammonium, nitrate, and nitrite due to decomposing organic matter. Algae also thrives in higher temperatures.

Better control of the water temperature is one of the advantages of automatic flushing of drinking water pipes. Watch this video to see a broiler farmer's testimony:

3. Chemical Parameters

pH

The acidity (pH) of the water highly varies depending on its source but it is usually between 6.5 (slightly acidic) and 8.5 (slightly alkaline). Groundwater often shows a high pH value. The water pH has a major influence on the solubility of substances, which is often an issue. Some unwanted substances may dissolve easily (e.g. heavy metals, salts) or certain useful substances such as medication may barely dissolve. The acidity can also promote processes such as the conversion of ammonium to ammonia (in the presence of high pH) or corrosion of the pipes (in the case of low pH and depending on the material of the pipes).

Animals will eat less when their drinking water is too acidic (pH < 3.5). On the other side, excessively basic water (pH ~ 9) can cause stomach problems, diarrhoea, poor digestion, and decreased water and food intakes.

As the water at the source often has a rather high pH, acidification is a commonly used technique to obtain an optimal pH, especially in poultry and pigs.

Example of ▸ pH strips. (Source: Lilly_M/ CC BY-SA 3.0)

Conductivity

The conductivity is a measure for the amount of salts present in the water (salinity) and varies greatly depending on the water source.

Salt excess is a common problem and leads to diarrhoea and subsequently growth reduction, production decline, disease, or death in the animals. Tolerance for salts depends on the species, age, water requirement, season and the condition of the animal. Pregnant animals, lactating animals and poultry are generally more sensitive. Reverse osmosis and nanofiltration can be used to decrease the salinity of water, but these are rather expensive techniques that can lead to a low flow rate. Mixing the saline water with rainwater which typically has a low salinity, can also do the trick.

Ammonium/nitrate/nitrite

Ammonium occurs naturally in low concentrations in both groundwater and surface water. The concentration is usually lower than 1 mg/l in groundwater. Higher values are seen in coastal areas and in rainwater or the open well water of some farms. Ammonium is produced during bacterial degradation of plant and animal material. Nitrate in groundwater mainly originates from fertilizers.

The intensity of fertilization and the composition of the soil largely determine the nitrate levels in the groundwater. Especially sandy soils allow nitrate to seep through easily. Nitrate is also detected in surface water, but in lower concentrations. The presence of nitrite in the water indicates organic pollution, usually from urine and / or faeces. Nitrite (NO^2) is an intermediate step in the bacterial conversion of ammonia (NH^3) to nitrate (NO_3).

Nitrite values that are too high can lead to hypoxia and asphyxiation symptoms in animals. The greatest risk of ammonium lies in the conversion to nitrate with nitrite as an intermediate step.

Furthermore, ammonium of more than 1.5 mg/l causes odour nuisance. When converted into ammonia in the intestine, it can lead to intestinal inflammation and diarrhoea.

High nitrate levels in drinking water are not necessarily harmful, but the risk comes from its potential conversion to nitrite. Excess nitrate in surface water also causes algae growth (eutrophication).

Water can be cleared from ammonia and nitrite using a bead filter, lava filter or sedimentation basin. Nitrate and nitrite can both be removed with an anion exchanger or zeolite filter.

Sulphate

Sulphate is one of the most abundant anions in natural waters. High sulphate concentrations can cause diarrhoea but can also lead to severe odour nuisance due to the reduction of sulphate to sulphide under anaerobic conditions. This sulphate reduction can also result in the corrosion of concrete sewers. Water can be cleared of sulphate excess using an anion exchanger.

Chloride

Chlorine is naturally present in water in different concentrations in compounds such as sodium chloride (table salt). Industrial waste flows, fertilization and the salting of roads with calcium chloride ($CaCl_2$) are important sources of chlorides in the environment. Chloride excess causes corrosivity of the water.

Increased hardness / Ca / Mg / (bi)carbonates

The calcium and magnesium content of water determine its hardness. The hardness of the water can be expressed in French (F°) or German degrees (D°): 1 F° x 0.56 = 1 D°. The hardness of groundwater and surface water varies greatly depending on the soil. Rainwater, on the other hand, is soft. Three different types of hardness are distinguished, namely:

- **Temporary hardness** (substances that are removed by boiling: calcium bicarbonate $(Ca(HCO)_3)_2$ and magnesium bicarbonate $Mg(HCO)_3$)
- **Permanent hardness** (Ca and Mg- ions that are still present in the water after boiling)
- **Total hardness** (sum of temporary and permanent hardness).

Increased hardness or excess of calcium and magnesium in the water can cause blockages in pipes, taps, drinking nipples, etc.) and an excess of magnesium results in an unpleasant bitter taste. Calcium, on the other hand, makes the water taste good. Water hardness is also the most important parameter to determine whether acidification with organic acids will be effective: the harder the water, the more acid will be needed to reach the target pH. Hard water usually doesn't pose a health risk to animals, though bicarbonate excess increases the risk of diarrhoea in chicks and weaned piglets.

Hardness can be decreased by means of a zeolite filter or cation exchanger.

▲ *Rust or black discoloration can be an indication of iron and manganese excess, which has unwanted side effects such as blockages in the piping system, bad taste and promotion of biofilm.*

Iron / manganese

Iron and manganese usually occur in oxidised form (Fe^{3+}, Mn^{4+}) and are therefore insoluble in natural waterways. In some circumstances, higher iron levels can occur in groundwater. Iron concentrations are usually limited in rainwater and surface water.

The presence of iron or manganese does not pose a health risk but has unpleasant side effects such as discoloration of the water (iron: rust colour, manganese: black discoloration), deposits of precipitation, blockages (in pipes, taps, nipples, etc.), bad taste of the drinking water, and promoting bacterial growth.

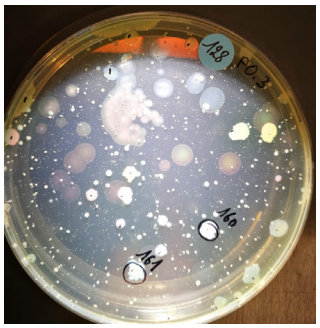
Iron removal can be achieved by a combination of filtering and oxidation, or with a cation exchanger.

Other

Several other components can be monitored, such as: sodium (indicator for salinity), potassium (indicator faecal contamination), zinc (excess causes turbid water and bad taste), boron (excess poses health risk), phosphorus (excess causes eutrophication) and fluorine (essential element but high levels are toxic).

4. Microbiological parameters

Total bacterial count



The total bacterial count is used as a hygiene parameter. Environmental bacteria are detected by culturing at 22°C. Incubation at 37°C allows selective culture of potentially pathogenic organisms.

E. coli / Enterococcus

The number of E. coli bacteria present is an indicator of recent faecal contamination of the water. Enterococci are indicators of older (as well as recent) contamination with manure, since they are more resistant to the aquatic environment compared to E. coli.

Pathogenic bacteria

Pathogenic bacteria (Salmonella, Campylobacter, Clostridium perfringens, Pseudomonas, Actinobacillus pleuropneumoniae, etc.) can also be present in the water.

A large range of techniques for disinfection is available; each one of them has its own pros and cons.

Biofilm

Biofilms are an invisible but frequent and persistent problem which affect the water quality at point of drinking. A biofilm is a slimy layer that sticks to the inside wall of the drinking water pipe that is created by the growth of microorganisms on mineral deposits or organic material. E. coli, Pseudomonas, Salmonella, Enterococcus, Listeria, Clostridium perfringens, Aspergillus and Candida are examples of common microorganisms in these biofilms.

Due to the presence of biofilm in the pipes, the bacterial pressure can rise 1 to 2 log units and even more (!) between the water source and drinking point. The presence of biofilm can also cause underdosing of vaccines and antibiotics, thus contributing to the development of antibiotic resistance. According to this study, regular purging of the pipes in poultry stables, slows down the formation of biofilm. Read more about biofilm prevention in the DISARM abstract 'Why and how to prevent biofilm formation in drinking water pipes'.

- A pipe-cleaning protocol is essential to limit development of biofilm and preserve animal health. This study provides information about the validation of biofilm measurement indicators (in French).
- Click here for an enlightening explanation on biofilm by Prof. Dr. Susan Watkins.

Algae

The so-called blue-green algae, which are actually bacteria (cyanobacteria), impose an important health risk for both humans and animals. When the algae are blooming, they are visible as a green-blue layer on the water. When the layer gets thicker algae start to decompose and toxic substances are released in the water. The appearance of white or blue foam at the edge or sudden bird or fish mortality are signs of blue-green algae presence.

▲ *It is very important to prevent algae growth. Once algae bloom has become visible, it is too late to act. (Source: eutrophication&hypoxia/CC BY 2.0)*

5. Interference

When medication, vaccines or supplements are administered via water, interference with other components in the water can prevent the product from reaching the drinking point in the right form and concentration. Properties including water pH and hardness, as well as residues of other substances e.g. chlorine, can inactivate or reduce the solubility of the product. The components present in the drinking water and their potential effects must be considered at all times.

Click here to read more about the risks of interference when using water medication. This abstract sums up useful tips to achieve effective vaccination via the drinking water.

Piping systems in poultry stables are prone to **biofilm** development: the temperature is ideal for bacterial growth and during the first days of a round, the water flow is very low.

Emissions from housing on pig farms result in ammonia precipitation so on pig farms that use rainwater, ammonia pollution is common. *(Picture: ILVO)*

Water quality is extremely important when applying vaccinations via drinking water.

HOW CAN WATER QUALITY BE EVALUATED?

Water quality should be monitored regularly. Some parameters can be checked by the farmer, but frequent lab analysis is indispensable. Your veterinarian/advisor and the consulted lab have the expertise to help you to interpret the lab results and determine the next steps if necessary.

The Watertool, a complete tool to help you evaluate and remediate your water quality (in Dutch)

Sampling

The basis of a reliable water analysis is a proper water sampling method. It is important to differentiate between the quality of the water source and the quality of the water at the drinking point. To analyse the source quality, the sample needs to be taken preferably from the source itself or from a tap as close to the source as possible.

To evaluate the quality of the water that the animals are consuming, a sample needs to be taken at the drinking point.

Click here for a practical step-by-step plan for water sampling and watch the steps in this video

Sensory Properties

Clarity, odour, and colour can easily be monitored by the farmer. With a "dirty water sensor", like the example in this video, the clarity can be continuously monitored. When water is not clear, odourless and colourless, this is often a sign of contamination or abnormal levels of certain compounds. Such water should be analysed in the lab immediately. Also, the piping needs to be checked for biofilm and limescale.

Chemical and microbiological parameters

Some basic parameters such as pH and bacterial or organic contamination can be tested by the farmer with commercially available kits.

For more profound data, e.g. identification of bacteria, lab analysis is required.

Water quality can easily be monitored with low-cost sensors.

The quality of pond water in extensive livestock farming should be monitored throughout the growing season or growing period.

HOW CAN WATER BE REMEDIED?

1. Systems for quality improvement at the source

A. Filters

Numerous types of water filters are available, and each of them has specific properties and indications. A selection of commonly used filters is given below.

Carbon filter A carbon filter can be used to remove taste, odour, colour and remnants of pollution with plant material. This type of filter needs to be replaced regularly, otherwise the effectiveness will decrease substantially. Moreover, when poorly maintained, it can become a hotbed for bacteria and consequently increase the bacterial pressure in the water.

Coarse and fine filters These filters catch suspended particles and improve the clarity of the water.

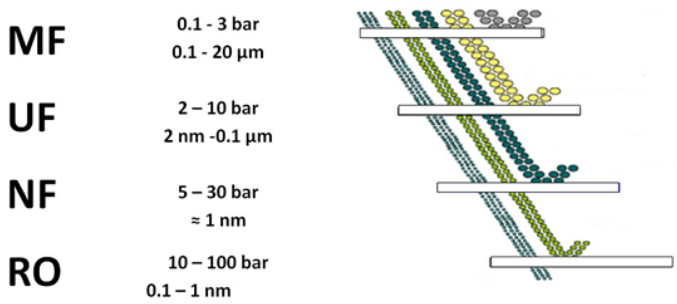
Sand filters (rapid or slow) Rapid and slow sand filters capture suspended particles.

Bead filter Suspended particles are removed through mechanical filtration, while ammonium and nitrite are converted into nitrate in the biofilm present on the beads.

Lava filter This biological system uses porous lava rocks. As water passes through the rocks, beneficial nitrifying bacteria consume oxygen to convert ammonium and nitrite into nitrate, producing an anaerobic environment in which denitrifying bacteria can convert the nitrate into harmless nitrogen and oxygen. Plants provide the bacteria with oxygen and nutrients and remove nitrate from the water. To keep this system balanced, it is important to maintain a stable water level.

Zeolite filter Zeolite is a porous natural rock that can be used in two ways. As a filter it can remove suspended particles, iron and manganese. As an ion exchanger, the zeolite filter softens the water and removes nitrate/nitrite and heavy metal cations.

Membrane filtration When membrane filtration is applied, pre-treatment of the water is usually necessary to prevent blockage of the membranes. Microfiltration, ultrafiltration, nanofiltration and reverse osmosis are different types of membrane filtration. Each of these types filter out a specific size of particles/cells/molecules/ions. Membranes are the only filtration type that efficiently reduce the bacterial load in water.



Each type of membrane filters out a particular size of particles/molecules. (MF, microfiltration; UF, ultrafiltration; NF, nanofiltration; RO, reverse osmosis). Adapted from: watertool.inagro.be.

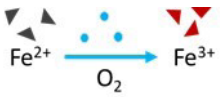
B. Sedimentation basin

This technique removes suspended particles, iron and manganese if their concentrations are not too high. The water in the sedimentation basin gets aired periodically to precipitate the iron and manganese. As the suspended particles pile up on the bottom of the basin, the basin needs to be cleaned regularly.

C. Iron removal

Iron and manganese can be removed from the water based on two principles: the classical oxidation + filtration technique or by cation exchange (see e. Cation exchange unit).

Click here for more information on solutions for iron and manganese removal.



Iron oxidation (Source: watertool.inagro.be)

D. Algae control

Prevention of algae, especially blue-green algae (cyanobacteria), is crucial. If blue-green algal blooms are already present, it is too late for action. Prevention needs to start in early spring.

Techniques to control algae include light shielding, aerating/stirring the water, ultrasonic sound waves and water plants.

Click here for more information on solutions for blue-green algae.

E. Ion exchange unit

There are two types of exchange units: cation (positively charged ion) and anion (negatively charged ion) exchange units. The cation exchange unit exchanges different cations such as iron (Fe+) and manganese (Mn+) cations for sodium (Na+) ions. By exchanging calcium (Ca++) and magnesium (Mg++) ions it softens the water.

Since this system is based on the addition of salt, the salinity of the water will increase when applying this technique. Salt excess can cause health problems like diarrhoea.

An anion exchanger can clear the water from anions such as nitrate and sulphate, by exchanging them for another ion like Cl-.

An overview of possible methods to remediate drinking water quality in dairy sheds is given in this article (in Dutch).

"In recent years, the trend has been to disinfect drinking water without using chemicals."

2. Systems for pipe cleaning and disinfection

Maintaining the pipes free from biofilm is crucial for the water quality at the drinking point. Unfortunately, preventing biofilm formation is not always easy. High pressure flushing and treatment with a combination of strong acid, strong base and disinfection product are possible solutions.

▲ This video *shows the advantages of high pressure flushing in a broiler farm*

Example of a complete cleaning and disinfection protocol for pipes.

Example of a protocol to clean water lines in a swine facility.

3. Continuous water treatment

A. Disinfection

The choice of the purification and/or disinfection technique and the dosage of the products depend on the infection pressure in the water. The higher the contamination pressure before application, the greater the residual pressure will be after a product has been applied.

Appropriate commercial products for chemical disinfection must be applied correctly and regularly if they are to ensure that bacteriological pressure is kept under control.

Bottlenecks, such as a dosing pump that is not set correctly or exhausted product stock, can lead to less effective disinfection. Attention needs to be paid to the presence of biofilm in the pipes, because this can 'consume' a lot of product.

Proper filtering before the disinfectant is dosed ensures that there is less nuisance from suspended particles in the water. Suspended particles that deposit in the pipes can form a breeding ground for a biofilm.

Consult an expert to obtain tailored instructions for disinfecting your water piping system and follow these instructions carefully to get value for your money.

- Cleaning a water system and choosing organic acids for pigs

▲ *This video shows how organic acid blend can be a reliable source for reduction of antibiotics in piglet production*

- A Dutch broiler farmer testifies: "I use apple cider vinegar in the drinking water; a practice that is used often in pigeon sport. Together with good management this keeps my chicks healthy. It is nonsense that the animals should be given antibiotics to stay healthy."

B. Acidification

Acidifying the water lowers the pH and reduces its temporary hardness. The optimal pH depends, among other things, on the animal species. In practice, installing a dosing pump on the drinking water pipe enables the required dosage of acid or acid mixture to be added to the water.

A pH of less than 4 helps to reduce pathogenic bacteria. This low pH cannot always be obtained with organic acids when the water hardness is too high. It is crucial to determine the correct dosage of a certain acid/acid mixture for your water when using it for the first time. This needs to be revised whenever the water type and/or acid (mixture) is changed.

Consumption of water that is too acidic can cause acidosis in ruminants. Water pH 6.5- 8.5 is acceptable.

Acidification benefits

- Better taste -> higher water intake -> health benefit & higher feed intake
- Low pH (~4) leans towards stomach pH -> better digestion
- Prebiotic effect
- Positive effect even more clear in chicks and piglets
- This study showed that lowering the pH of the drinking water in newly weaned pigs reduces the faecal shedding of E. coli.

Points of attention

- Protocol and safety instructions for the specific product need to be followed carefully
- Always check compatibility with other water treatments!
- In some cases acidification initiates mucus formation in the pipes due to microbial growth -> combine with proper cleaning protocol.

Click here to see a practical step-by-step plan to determine the correct acid dosage for your water.

inagro **Special thanks to INAGRO (watertool.inagro.be) for the valuable contribution to this guide.**

Property	*Sodium hypochlorite*	*Chlorine dioxide*	*Peroxide*	*Electrochemical activiation*	*UV-disinfection*	*Ozonation*	*Thermal disinfection or heating*
Bactericidal	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Residual disinfection	*Yes*	*Yes*	*Yes*	*Yes*	*No*	*Limited*	*No*
Biofilm degrading	*No*	*Yes*	*Yes*	*Yes*	*No*	*Minimal*	*Only within reactor*
Taste influence	*Yes*	*No*	*No*	*Limited*	*No*	*No*	*No*
Unwanted byproducts	*Yes*	*No/yes*	*No*	*Possible, limited*	*No*	*Possible, limited*	*No*
Shelf life	*Decreasing disinfection activity*	*On-site preparation*	*Decreasing disinfection activity*	*On-site preparation*	*Shelf life of the lamp*	*On-site preparation*	*-*
Corrosive	*Yes*	*Less*	*No*	*Less*	*No*	*Yes*	*Increased risk of corrosion due to higher temperature*

▲ *Source/adapted from text: www.lv.vlaanderen.be*

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- External Biosecurity
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- Precision Livestock Farming for Early Disease Detection
- Potential of Breeding and Genetics for Robust and Resilient Animals
- Youngstock Management and Early Rearing
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