Water Quality in Healthcare

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The World Health Organisation (WHO) produces international norms on water quality and human health in the form of guidelines[1]. These guidelines are used as a basis for regulation and standard setting worldwide. The quality of water entering a healthcare establishment is determined by its origin. However, this can be altered or compromised by the way water is managed, especially in large buildings with complex domestic hot and cold water systems. Incorrect temperature management, water stagnation, exposure to incorrect water components (not Water Regulations Advisory Scheme (WRAS) approved), and the addition of biocide products to control legionella bacteria and other waterborne pathogens can all diminish water quality.

To understand and implement the correct management of water within buildings (especially in healthcare environments), incoming mains water should be tested for drinking water parameters to obtain an understanding of the feed water quality.

In nature, water is a universal solvent, which picks up various contaminants as it passes through and across the different substrata of rock and soil. Depending on the contact layers involved, will influence the degree and type of mineralisation. Therefore, not all water is the same quality. For people with special needs, such as infants, athletes or pregnant women, the concentration of certain minerals is extremely important. Minerals, such as sodium may be too high a quantity, others, such as magnesium, may be too little.

Sodium, along with chloride and potassium, is an essential electrolyte that regulates various functions within the human body. Evidence suggests that as a global population we consume double the recommended daily intake[2], which for the UK is 2.4g per day. The amount of sodium is drinking water varies significantly depending on geographical location. It is important to note in the context of healthcare environments that infants and young children should not be exposed to high levels of sodium in the healthcare facility drinking water supply. This is also applicable to patients with high blood pressure or impaired kidney function. Therefore, where water is going through softening processes in the healthcare environment, it is essential that it doesn’t enter the potable water distribution network.

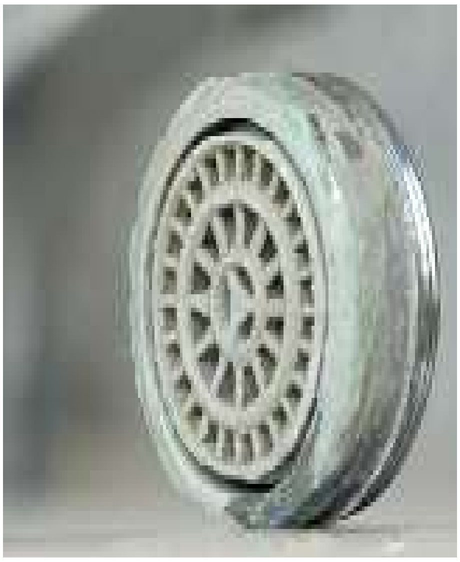
Testing of incoming water quality will include microbial levels, inorganic salts, such as calcium carbonate, sodium chloride, Total Organic Carbon (TOC) and pH. The pH standpoint for water values may vary between 6.5 and 9.5, pH levels are determined by how acidic or alkaline water is, it is identified by the number and activity of free hydrogen ions dissolved in it. The optimal pH level for drinking water (tap water) is between 7 and 8.5, as our bodies can only effectively manage lower pH levels. It is important to note the effects of pH can also be seen in engineering, acidic drinking water damages pipes with a cement lining. Metals are also sensitive: Galvanized steel is prone to corrosion from a pH that is below 7.5. Copper lines must not be used if the pH is less than 7 as acidic water washes copper from the pipes. Too much of this trace element is especially dangerous for babies and children. Knowing the pH level of drinking and tap water is very important for good water quality and waterborne pathogen control.

The level of water hardness plays a huge part in water system components and their maintenance due to scale build up. It is known that the Southeast of England and London water hardness levels are predominantly high, where Scotland, Ireland, and Wales in the main have soft water. Scale, also known as 'lime scale', is a hard, rock-like deposit of calcium or magnesium salts that forms in heat exchangers, cooling tower packing, and other water-fed equipment due to heat. Scale formation impairs heat transfer, restricts flow and can be a breeding ground for Legionella bacteria.

To effectively control waterborne pathogens within domestic hot and cold-water systems, such as Legionella bacteria, the quality of the mains water entering buildings must be understood. This knowledge is crucial before developing a comprehensive water management plan.

Water management involves more than just water temperature. Legionella bacteria need two things to spread throughout a water system of any size: the optimum temperature range, which is between 20-45ºC, and available nutrients to feed on.

Examples of types of contamination found in fluid pipe work



Scale deposits Biofilm Rust

There are three things that must be present for a biofilm to occur:

1. Moisture – this allows the bacteria to grow and spread.
2. Bacteria - this could be one species or multiple depending on the location and other factors
3. A surface - something for the bacteria to adhere to

Biofilms can adhere to various surfaces when the right conditions are present, including skin, water pipes, metal, and plastic. These biofilms serve as an effective "hideout" for bacteria, making them extremely challenging to eliminate.

Maintaining good hygiene in water management is crucial. This ensures the water flows continuously, preventing stagnation and nutrient build-up that could lead to bacterial growth. Additionally, it helps maintain the desired temperature range for cold and hot water.

Water Sampling

Microbiological sampling of the water in domestic and industrial systems, such as cooling towers, is crucial in the management of bacterial quality assurance. However, the importance of correct water sampling procedures is often overlooked. Before sampling, it is vital to have accurate information and an understanding of the reason for sampling. This could be for investigative, management, outbreak, or preventative purposes. Consideration needs to be given to the time of sampling, the area being sampled, the specific objectives, and the required analyses, the person who will carry out the sampling and where the analysis will be processed (in-house or external laboratory).

Storage facilities and the transport time frame for water sample bottles are also key factors as some samples require storage in a cool place. For example, collected water for *P. aeruginosa* analysis should be processed within two hours. If this is not possible, it should be refrigerated within two hours and kept at 2–8ºC, allowing for processing within 24 hours. Samples must be kept separate from hot and cold samples to avoid temperature cross-contamination.

The designated person involved in water sampling should be aware of the importance of the task and have sufficient training and information to carry it out correctly. Additionally, the sampling technician should have a general understanding of bacterial characteristics and appreciate the specific steps required to maintain the bacterial load of the samples until they reach the laboratory for analysis.

Although recommendations vary, the time between sample collection and analysis should, in general, not exceed 6 hours, and 24 hours is considered the absolute maximum. Samples for Legionella analysis can be taken in non-sterile sample bottles, stored in ambient temperature (approximately 20°C) and should be delivered to the laboratory, preferably within 24 hours, but not more than 48 hours. Samples for *Pseudomonas aeruginosa* and non tuberculosis mycobacteria (NTM) and other microorganisms should use a sterile sample bottle, be kept at 2–8ºC and processed within 24 hours.

Sampling strategy: Samples from both the incoming supply from the water utility provider and at point of use (POU) should include total viable count (TVC) of bacteria, in order that samples can be compared. Any significant difference between the two has important implications for the remedial plan of action as TVC is a good indicator of general water quality.

Where there are taste or odour problems in drinking water, microbiological monitoring for total viable counts (TVC) may be considered necessary. However, routine microbiological monitoring for TVC is not recommended as there is no direct association with TVC and the presence of waterborne pathogens.

BS 7592: 2022[3] provides guidance on the code of practice for sampling of Legionella bacteria in water systems, whilst BS 8554:2015[4] gives recommendations for good water sampling practice related to building services and facilities professionals. When selecting sampling points, each locality should be considered individually. However, the following general criteria are usually applicable:

- Sampling points should be selected such that the samples taken are representative of the different water sources i.e. Mains water, bore-hole water etc
- There should be at least one sampling point directly after any water treatment plant used to dose the cold supply with a biocide.
- Sampling points in the water distribution system may be classified as: fixed, random, or variable.
- Sampling points should include areas that provide representative samples from the most challenging sources or places in the supply and distribution system, examples include low pressure zones, loops, dead ends etc
- Sampling points should be positioned in such a way that water can be easily sampled from any holding tanks: cold water tanks, calorifiers, cooling towers, raw water break tanks associated with reverse osmosis systems and water components.

Fixed samples are useful when results must be compared over time, but they limit the possibility of identifying local problems. Sampling regimes using variable or random outlets have the advantage of being more likely to detect local problems but are less useful for analysing changes over time.

Areas which must be considered should always reflect the level of risk that patients and public are exposed to, this would include hydrotherapy pools, augment care wards, maternity wards, burns units, areas where patients are immune-compromised and where the public are vulnerable, such as the elderly and the very young.

When sampling water that contains or may contain traces of chlorine or other biocide product (i.e., copper and silver), the biocide product must be inactivated. If it is not, microbes may be killed during transit and an erroneous result will be obtained. The bottles in which the samples are placed should therefore contain sodium thiosulphate to neutralise any chlorine present or copper and silver.

Cleanliness, at every stage of the sampling process is crucial. It should include cleaning and disinfecting the container used to carry samples after every use, to avoid contaminating the surfaces of the sample bottles and the hands of the person sampling.

Importance of risk assessment, testing and monitoring

1. Risk Assessment

To implement the correct scheme of control for Legionella and other waterborne pathogens, a risk assessment must be carried out. This will include the domestic water distribution system, water components and the area within which persons could be exposed to water and water aerosols.

A qualified and competent person must carry out a Legionella risk assessment. This person must have a full understanding of the legal requirements to provide a site-specific and compliant risk assessment. They must also have a full appreciation of the characteristics of the different bacteria and their impact in the healthcare environment.

It’s crucial that the risk assessor considers not only the physical aspects of the risk assessment, such as the water source, components, and distribution system, but also the environmental aspects. They should also consider the channels through which waterborne pathogens can affect patients and the public.

The most serious form of disease caused by Legionella is Legionnaires’, the predominant cause of Legionnaires’ disease is *L. pneumophila* bacteria. Legionellae are opportunistic pathogens of humans and normally inhabit warm, moist, or aquatic environments where they grow in association with other organisms.

The transmission pathway of Legionella bacteria to humans is predominantly via aerosols and breathing in bacteria that remain airborne. It is also possible for the bacteria to be inhaled into the lungs under certain circumstances such as through aspiration. Person to person transmission rarely occurs.
When addressing *Pseudomonas aeruginosa* bacteria, the risk assessment must include water hygiene and control measures. Working with potable water requires meticulous personal hygiene to prevent contamination of the water system. *P. aeruginosa* can be found in faeces, soil, water, and sewage. It can multiply in water environments and on surfaces in contact with water. It has been isolated from various moist environments, including sinks, water baths, hot water systems, showers, and spa pools. It is predominantly transmitted through direct contact with surfaces such as hand-to-hand contact, or hand-to-surface contact. Therefore, maintaining good hygiene and keeping surfaces clean and dry is critical.

All risk assessments must consider the likelihood and consequences of waterborne pathogen hazards. This includes the potential for hazardous events, the types of use, the bacteria we could be exposed to, the extent and frequency of exposure, considering the susceptibility of those who might be affected.

2. Testing and Monitoring

Why and what should be tested to ensure water quality is always maintained? Sampling of water is a starting point in obtaining the understanding of water quality at the specific time and place. However, to ensure water quality is monitored and maintained correctly we need to ensure specific steps are taken in testing and monitoring, those amongst others will include temperature testing to ensure domestic hot and cold water is stored and distributed at the correct temperature.

In normal circumstances temperatures should be delivered below 20°C but there is growing evidence that supply temperatures may rise above 25°C in summer months. Climate change and the improvements in thermal performances of building materials could add to the challenge of managing water supply temperatures. The design aim should be to ensure that cold water temperature draw-off is as close to the supply temperature as possible. The stored cold water should preferably be below 20°C, whilst hot water temperature out of the calorifier should be at a minimum of 60°C.

In healthcare hot water temperatures on the flow and return to all outlets should be a minimum of 55°C and at the start of the hot water return. It should be a minimum of 50°C at the final connection to the calorifier. Temperature monitoring is one of the essential strategies in Legionella control.

Where control of legionella bacteria in water systems is difficult the addition of a biocide product maybe used (i.e., copper, and silver ionisation, chlorine dioxide chemical and many others that are available on the market). All biocides must be monitored at the frequency that is required by the Health and Safety Executive Technical Guidance HSG 274[5]. The levels must not exceed the drinking water permissible concentration values.

As an example of some of the biocide products available, chlorine dioxide is unaffected by water pH or hardness, but the copper and silver ionisation process is. Dosing levels may need to be increased for pH levels above 7.6. Tests for pH levels should be conducted when monitoring copper and silver levels in domestic hot and cold water systems when chlorine dioxide is used as a biocide product. It is therefore important to conduct the necessary tests on the potable water to ascertain the correct biocide product.

To ensure accurate testing and monitoring of temperature or biocide levels, all equipment must be serviced and calibrated by an accredited service at intervals specified by the manufacturer, where applicable.

Monitoring of drinking water: where there are doubts about the drinking water quality, water testing should be carried out and monitored. Ideally, drinking-water should not contain any microorganisms known to be pathogenic or any bacteria indicative of faecal pollution. To ensure that a drinking-water supply satisfies these guidelines, samples should be monitored regularly.

Drinking water in England and Wales is regulated by the Drinking Water Inspectorate[6] (DWI) an independent regulator ensuring that the water utility companies supply safe drinking water to its consumers and meets the standards set down in law.

Devices will be introduced into the organisation based on an identified need and to minimise contamination of the water it should be kept in a clean environment protected from external contaminants (i.e. Dirt, dust, rust, scale, animal/ bird faecal contamination) and it should be constantly moving to avoid stagnation. Regular monitoring of water systems, cleaning and disinfection of tanks, pipework and outlets is essential, along with monitoring of low use outlets such as those in clinical rooms, areas where the use has changed e.g. a shower room becoming a storeroom.

All tests, monitoring, and surveillance play a crucial role in maintaining water quality. They inform strategy and enable management systems to be put in place. The Department of Health, Health Technical Memorandum 04-01[7] recommends establishing a multidisciplinary group called the "Water Safety Group" (WSG) to commission, develop, and manage the water safety plan (WSP). The WSG also advises on remedial action when water systems or outlets are found to be contaminated, increasing the risk to susceptible patients.

Other Opportunistic Plumbing Pathogens of significance

Micro-organisms of significance are those which fall under the category of bacteria that are antibiotic resistant.

Pseudomonas aeruginosa is commonly found in the wider environment, requires low levels of nutrients to grow, and is considered an opportunistic pathogen in that it often occurs as a secondary infection to an underlying existing disease. It has an ability to selectively inhibit various antibiotics, therefore making it a multi-drug resistant bacterium[8]. It is an aerobic, gram-negative rod-shaped bacterium (very similar to legionella) with polar flagellum, which help these organisms to move in any water system, with and against the water flow.

When attached to a surface they produce a protective layer associated with 'slime' which makes it very difficult for biocides to effectively break through and kill the viable organisms beneath. *Pseudomonas aeruginosa* can be found in and on medical equipment and any lumened device, such as endoscopes are a potential hazard for cross contamination.

Areas of the human body where infection by this organism can occur:

- Urinary tract
- Respiratory systems
- Skin
- Soft tissue
- Blood stream
- Bone and joints
- Gastrointestinal
- Central nervous system
- Ears
- Eyes

Control of *P. aeruginosa* bacteria in the healthcare environment is always challenging, therefore it is essential to carry out clinical risk assessments as advised by the Department of Health HTM 04-01[7] and the latest BS8580-2:2022: Part 2[9], to establish the correct scheme of control.

The most effective strategy in controlling and eliminating *P. aeruginosa* in healthcare environments is the implementation of strict cleaning and decontamination practices. Staff from facilities management and housekeeping services are required to have relevant training as their actions can have a significant impact in managing waterborne pathogens.

All staff, patients and visitors should be encouraged to undertake the correct hand hygiene process given the direct transmission route of the organism.

The main intention is to prevent the opportunistic plumbing pathogens from establishing themselves in the fluid systems network and damp environments where biofilms can become established.

Causes of biofilm formation:

- Dirty taps, shower heads, adjustable flow shower heads
- Rust and scale on flow straighteners in taps
- Unsuitable materials of construction
- Contamination during construction or repair of water distribution systems
- Non-compliant hot / cold temperatures

- Stagnation of water (low use outlets)
- Poor design of cold water tanks and expansion vessels
- Complex components incorporating plastics and rubber
- Blocked drains
- Inappropriate use of clinical hand wash basins and sinks i.e. disposing of tea/coffee, patient bathing water, filling containers, storing of accessories or equipment to be decontaminated etc
- Contaminating the tap outlet by touching it with hands during the washing process
- Incorrect cleaning process of the wash hand basins/sinks and tap outlets
- Refilling non-refillable hand soaps/sanitiser bottles
- Poor management of the cleaning equipment - mops/buckets, floor cleaners etc
- Inappropriate installation and positioning of hand wash basin taps compromising proper use i.e. use of elbows to turn on/off vs hands
- Drain outlets of sinks and showers not positioned to avoid patient contact
- Inadequate cleaning or infrequent replacement of static hose connections
- Equipment used for patient or environmental cleaning left damp/wet

Pseudomonas and Legionella are indicator organisms of the microbiological quality of a water system, there are many other water and environmental microorganisms such as Klebsiella, Stenotrophomonas, Carbapenem resistant organisms (CRO), Aspergillus, Cupriavidus and more (see the Summary of findings report of the NHS Greater Glasgow and Clyde incident[10]), that survive in the water environment and present a potential hazard in healthcare if general hygiene standards and water management are not adhered to as per the numerous guidance and standards documents mentioned previously.

What does UKAS accreditation mean and how to choose a Laboratory

Laboratories undertaking water analysis should be carried out in accordance with the current ISO standard methods for analysing water samples for Legionella. In the United Kingdom, laboratories and organisations providing certification, testing, inspection, and calibration services must be accredited by the government appointed accreditation body, The United Kingdom Accreditation Service[11] (UKAS). UKAS accreditation includes the use of the current ISO standard methods for the detection and enumeration of Legionella within the scope of accreditation to BS EN ISO/IEC 17025[12], which sets general requirements for the competence of testing and calibration laboratories.

The Health and Safety Executive HSG 274[5] technical guidance recommends, these laboratories should also take part in a water microbiology proficiency testing scheme such as that operated by the UK Health Security Agency (UKHSA), or an equivalent scheme[13] accredited to ISO 17043[14]. It is important to note, alternative quantitative testing methods may be used if they have been validated using ISO 17994[15] and meet the required sensitivity and specificity. This Standard was last reviewed and confirmed in 2019 and is still current.

The International Organization for Standardization (ISO) is an international organisation that develops standards for various industry sectors. A standard is a technical document that establishes standardised specifications and practices, allowing practitioners and manufacturers to follow a scheme to ‘comply’. This minimises errors and ensures alignment to a common understanding.
Not all ISO standards require UKAS accreditation. For example, ISO 9001 is a certification standard rather than an accreditation standard. Therefore, UKAS does not conduct assessments or provide accreditation for this standard.

The differences between certification and accreditation are as follows:

Certification is a written assurance from a third party that a service, product, or process meets specific requirements. This assurance is typically obtained through education, audit, assessment, or external review. The third party certifies the service, product, or process by stating that it is fully satisfactory. Certification is relevant to all company activities within an industry. Obtaining certification from an official certification body is highly valued, as it demonstrates the achievement of a worthwhile designation.

Accreditation is formal recognition of an organisation’s competency towards specified standards by an authoritative independent body, such as UKAS. These bodies assess, test and supervise the organisation, and ensure they comply with internationally set standards. Accreditation is based on specific activities and not all activities within an organisation.

Microbiological analysis can take between 24 hours and 28 days to report a result. While it’s ideal to use a UKAS-accredited laboratory, other quantitative test methods like Polymerase Chain Reaction (PCR) can provide rapid on-site results. However, PCR will identify DNA from both live and dead organisms, and its unit count doesn’t have the same equivalence to Colony Forming Unit (CFU/ml) that TVC can provide. Maintenance Managers, Responsible Persons, and Duty Holders may consider rapid test methods as part of an identified remedial action plan, when standard analysis indicates potential systemic or distal contamination, and water hygiene protocols have been instigated that require additional checks.

Summary

The Water Safety Group (WSG) manages the network of cold and hot water distribution systems throughout the built environment in healthcare. This water supply often feeds downstream medical equipment or specialist water systems, designed to purify potable tap water further, to meet the required water quality parameters for applications such as Surgical Equipment Washer Disinfectors, Clinical Analysers, and Renal Dialysis. These systems refer to other Standards, Health Technical Memorandums (HTMs), and Health Building Notes (HBN) for guidance. Water quality assurance therefore requires a holistic approach involving a multidisciplinary team to ensure that ‘water’ quality is understood and managed across all areas, prioritising patient, staff, and visitor safety using risk assessment methodology where there is a requirement to derogate from outdated guidance and standards documentation.

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