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Drinking Water Purity - A UK perspective

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Abstract

Water purity is a vague term often interpreted in a subjective manner. When applied to drinking water quality, the emphasis of "pure" can mean free from all types of bacteria and viruses when defined by EPA in the United States, or being wholesome as defined by drinking water legislation in the UK. These legal definitions have significant economic, practical and potential health implications that are of concern to the Water Science Forum (WSF) of the Royal Society of Chemistry. This brief outlines a UK-based perspective on the meaning of water purity based on relevant literature and consultation with our members.

Introduction

Water is a simple compound made of hydrogen and oxygen, so "pure" water would be that which contains nothing but those elements. Pure water does not exist in nature because, even during its fall to earth as rain, water collects particles, minerals and gases from the air. Then, when the rain hits the ground creating surface water, it captures materials from soils and rocks. As it makes its way into groundwater, rivers and lakes, surface water can dissolve many different substances, envelop microorganisms and carry solid materials. Most water therefore will contain certain contaminants, bacteria, funguses and viruses; depending upon where the water falls and travels.

Despite the truism that every human on this planet needs to drink water to survive, and that the water may contain harmful constituents, there are no universally recognized and accepted international standards for drinking water [1]. Even where standards exist and are applied, the permitted concentration of individual constituents may vary by as much as ten times from one set of standards to another. Descriptions differ too; pure being replaced by words such as wholesome, healthy or potable.

Many developed nations specify country specific drinking water quality standards. In Europe, this includes the European Drinking Water Directive [2], and in the USA the Safe Drinking Water Act [3]. For countries without a legislative or administrative framework for such standards, the World Health Organisation publishes guidelines on the standards that should be achieved. China adopted its own drinking water standard GB3838-2002 (Type II) enacted by their Ministry of Environmental Protection in 2002 [4].

Most drinking water quality parameters are expressed in terms of guidelines, or targets, rather than specific requirements. Very few have any legal basis or are subject to enforcement [5]. Two exceptions are the European Drinking Water Directive and the United States Safe Drinking Water Act, which both require legal compliance with specific standards [2, 3].

In Europe, the directive includes a requirement for member states to enact appropriate local legislation to mandate the directive in each member country. Routine inspection and, where required, enforcement is enacted by means of penalties imposed by the European Commission on non-compliant nations. Example countries with guideline values for their standards include Canada, which has guide values for a relatively small suite of parameters, and New Zealand, where there is a legislative basis but water providers have to make "best endeavours" to comply [6], and Australia.

Water supply companies purify water for drinking by identifying unhealthy contaminants and then reducing or removing them. In England and Wales, drinking water quality standards are enforced by the Drinking Water Inspectorate (DWI) [7]. Should consumers wish to treat to an even higher standard, or for a specific requirement, there is a plethora of commercially available methods and equipment. These range from simple particle filters, to technical multistage systems that might combine filtration, reverse osmosis and disinfection, for example.

Where drinking water is provided by desalination, minerals have to be added to the final product because it is so highly purified that it becomes corrosive, and therefore not fit for distribution or use by many conventional piped networks and fittings.
Even in a laboratory pure water is hard to come by, because bacterial contamination and algal growth can cause a deterioration in quality. Even if organic and inorganic chemical impurities are removed to levels below their limits of detection, bacterial growth can still occur. This is despite very pure water providing an extremely harsh

environment with negligible nutrient content. To avoid metallic contamination of laboratory water, the purifiers are constructed using plastics. However, bacteria are able to utilise such materials for a carbon food source to sustain them. Then, when the micro-organisms die, they release further contaminants into the water. If this bacterial growth is not minimized, it can cause difficulties for analysts carrying out the day-to-day testing within the laboratory.

In general, discussion about water quality can, and will most probably switch from the notion of 'pure' to that of 'safe'. Guidelines for Drinking Water Quality (Forth Edition) state "Every effort should be made to achieve drinking-water that is as safe as practicable. Safe drinking-water, as defined by the Guidelines, does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that which may occur between life stages" [8]. Safe water is economical and attainable, whereas pure water is not.

Harmful contaminants, whether man made or naturally occurring, are constantly being identified. Disinfection by-products, harmful bacteria, metals and numerous chemicals, have their removal threshold legally set based on Best Available Technology principals. The WSF is striving to keep its members on the forefront of these developments as outlined in this brief.

Water Purity – an evidence-based approach?

In practice, water purity is considered within the context of its anticipated use. In England and Wales drinking water must be wholesome, and meet all regulatory requirements. The DWI website lists all the current legislation [9], guidance and codes of practice [10], and safety guidance to health and water professionals [11].

Water destined for use by industry, agriculture or horticulture should be "fit for purpose" where the quality standards are determined for the most part by the user. In the case of environmental waters, they would be expected to have achieved satisfactory ecological status as described in the EU Water Framework Directive [2].

In order to determine if water has achieved the required standards for a specific end use, evidence-based decision making is employed involving:

- Preventative risk management based on appropriate evidence-based quality standards
- Appropriate risk based monitoring and testing carried out by accredited laboratories
- Professional accreditations to develop competent technical staff

Examples of evidence based quality standards include the WHO drinking water standards [8], and UK Environmental Quality Standards [12].

Preventative Risk Management

A preventative risk management approach to ensuring water achieves the required purity standards has been adopted in UK, EU and internationally.

For example, the Australian Drinking Water Guidelines (2011) incorporates elements of a Hazard Analysis Critical Control Point (HACCP) system, ISO 9001 Quality Management and AS/NZS 4360:2004 Risk Management [13]. These different regulations and guidelines recommend maintaining robust multiple barriers appropriate to source water condition, in recognition of the fact that no single barrier is effective against all contaminants all of the time. They encourage understanding of the entire water supply system, from catchment to consumer, including the hazards and events that could compromise drinking water quality, and the preventative actions required for safe and reliable drinking water. As a result, a holistic approach to water management is fostered which emphasises prevention and positions drinking water quality monitoring as a verification task. Implementation of such a framework has seen greater emphasis on river basin management, this being the first line of defence for safe drinking water.

European Drinking Water Directive

This directive (98/83/EC) concerns the quality of water intended for human consumption and forms part of the regulation of water supply and sanitation within the European Union [2]. The directive is intended to protect human health by laying down health and purity requirements which must be met by drinking water suppliers within the European Union. It applies to all water intended for human consumption, except for natural mineral waters, and waters which are medicinal products. In setting contaminant levels the directive applies the precautionary principle. For example, the EU contaminant levels for pesticides are up to 20 times lower than those in the WHO drinking water guidelines, because the EU directive not only aims at protecting human health but also the environment.

WHO contaminant levels

WHO contaminant levels are already set such that there would be no potential risk if the contaminant was absorbed continuously over a person's lifetime. The WHO specifies health related guideline values rather than one fixed blanket limit, irrespective of substance toxicity. For example, "because of their low toxicity, the health-based value derived for AMPA alone or in combination with glyphosate is orders of magnitude higher than concentrations of glyphosate or AMPA normally found in drinking-water under usual conditions, therefore, the presence of glyphosate and AMPA in drinking-water does not represent a hazard to human health. For this reason, the establishment of a formal guideline value for glyphosate and AMPA is not deemed necessary" [14]. This also applies to metaldehyde, where many millions of pounds have been spent trying to remove totally harmless levels.

Risk based monitoring and testing

Within the UK there is a risk based regulatory sampling and inspection system for both drinking water, environmental waters, and aquatic emissions [15]. The analytical laboratories are accredited to ISO/IEC 17025:2005; General Requirements for the Competence of Testing and Calibration Laboratories [16]. In addition, laboratories are required to comply with the Drinking Water Technical Standards (DWTS) issued by the Drinking Water Inspectorate (DWI) in England and Wales, and Drinking Water Quality Regulator (DWQR) in Scotland. DWTS is necessary in addition to ISO 17025 to ensure fit for purpose results. These sampling and testing programmes apply to public water supplies. Private water supplies often suffer more variable quality, and are less frequently or comprehensively monitored. Regulations still apply, but are not enforced as rigorously as those for public water supply [17].

While monitoring guidelines vary internationally, risk based emphasis has also been adopted elsewhere. For example the Australian Guidelines for Water Quality Monitoring and Reporting are applied to monitor system performance according to the hazard characteristics and risk profile identified for the particular water supply system. Overall, monitoring might be undertaken for catchment, treatment, and distribution; verification of drinking water quality; investigative studies; validation monitoring of new barriers; and incident and emergency response. Similarly to the UK, in Australia quality assurance of laboratory results is important and it is therefore recommended that accreditation by the National Association of Testing Authorities (NATA) is used whenever possible.

Professional accreditations

The UK risk based regulatory sampling and inspection system standards also set out the required competencies of the people involved in determining if the necessary standards have been met. Demonstration that the competencies have been achieved and verified by a third party, can be done by gaining relevant professional accreditations such as Chartered Chemist (CChem) status within the Royal Society of Chemistry. Other scientific based professional registers and accreditations include those granted by the Science Council.

The Professional Registers consist of three designations:

Chartered Scientist (CSci) is a well-established award, with over 15,000 scientists having achieved it since its launch in 2004. Candidates will typically be in senior scientific or managerial roles, qualified to at least Qualifications and Credit Framework (QCF) level 7, and applying their knowledge in their roles.

Registered Science Technician (RSciTech) is a new award to provide recognition for those working in technical roles.

Registered Scientist (RSci) is a new award to provide recognition for those working in scientific and higher technical roles.

Reuse of Water - The next challenge

Whilst there are no regulations covering the quality or safety of reused water in the UK, the British Standards Institute (BSI) has produced some guidelines for both greywater and rainwater reuse [18]. For the first time, the guidance introduces embedded water quality parameters for water reuse applications. Compliance with these parameters is designed to ensure public health is not compromised. The guidelines in BS 8525 have taken the standards included in the Bathing Water Directive and developed values based on detailed research into specific applications where greywater is to be used. The guidance recommends that whilst frequent water sampling is not necessary, it is good practice to observe water quality during maintenance checks. More detailed information is available in the Environment Agency publication - Greywater for domestic users: an information guide [19].

Although there is no specific guidance for water reuse in the UK, internationally specific guidelines have been developed in regions where water scarcity has been a particular issue. For example, the US EPA 2012 Guidelines for Water Reuse (originally published in 1980) and the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks 2006 (Phase 1- covering use of recycled water for commercial and residential irrigation, toilet flushing and industrial uses) and 2008 (Phase 2 - covering recycled water to augment drinking water supplies, rainwater harvesting and managed aquifer recharge).

The US guidelines emphasise an integrated water management approach, where the focus is on broader water resources management, with reuse being a key factor in this more holistic strategy. Under these guidelines, opportunities to reduce the demand for freshwater are exploited. Alternative resources might include wastewater and greywater reuse, storm water use, rainwater harvesting, groundwater recharge, increased surface water detention, sewer mining, and the use of dual distribution systems to potable and non-potable water separately among others.

In Australia, as with drinking water, a risk management approach is adopted in order to anticipate potential issues and therefore implement strategies to prevent them from arising. The guidelines consider both risks to human and environmental health. Both US and Australian Guidelines emphasise the importance of public consultation. Sewer mining schemes have been explored in Western Australia, but there are currently no live systems [20]. Indeed, public opposition to proposed recycled water systems has resulted in schemes of all kinds being rejected.

Conclusions

Water purity can be a confusing concept since it is determined by different standards that are required for specific end use. Within the UK, EU and internationally, measures are employed to achieve evidence-based decision making based on water being "fit for purpose". The Water Science Forum (WSF) of the Royal Society of Chemistry have created this brief based on the literature and consultation with our members. Three key areas were highlighted to achieve evidence based decisions:

- Preventative Risk Management based on appropriate evidence-based quality standards
- Appropriate risk based monitoring and testing carried out by accredited laboratories
- Professional accreditations to develop competent technical staff

Building on these principles, WSF is striving to promote secure, safe and affordable water.

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