UKWIR Reports Catalogue

September 2008

Drinking water quality & health

vol. 3 Distribution, microbiological studies and treatment

The UKWIR research programme is currently divided into the following topic areas: drinking water quality and health; toxicology; water resources; climate change; wastewater treatment; biosolids; water mains and services as well as regulatory and customer issues. Volume 1 listed reports on epidemiology and microbiological studies and volume 2 included related reports on cryptosporidium, metals and algal toxins. On page 4 are listed the reports in the **Drinking water quality & health** programme area on the subjects of cryptosporidium, distribution and treatment, metals, microbiological studies that have been issued since volumes 1 & 2.

The concept of a '*water safety plan*' has been gaining momentum both in the UK and internationally after the World Health Organisation introduced the concept in 2004. The Government's water strategy *Future Water* has now confirmed the methodology as underpinning risk assessment.

The outputs from the Water Safety Plans will inform the five year investment programme from 2010.

Drinking Water Safety - Risk Based Approach (08/DW/02/48) has assessed the progress made by companies in applying the Drinking Water Safety Plans and evaluated how they integrate with the 2009 Periodic Review Process. *Drinking Water Plans - Stakeholder Communications* (08/DW/02/49) looks to provide a consensus amongst stakeholder on how to communicate the water safety planning process to customer support groups.

UKWIR reports can only be purchased via the UKWIR website:

www.ukwir.org

The website also provides information about current and proposed UKWIR research programmes

You can also download the latest version of UKWIR NEWS to obtain an update on recent projects, publications and technology transfer workshops

Incidents of discoloured water have been falling steadily. However, this remains one of the main reasons for customers' complaints. *Preventing Discolouration* (04/DW/03/21) provides strategies for operating and maintaining the distribution system to further reduce such incidents.

Figure 1. Types of complaint investigated by the Drinking Water Inspectorate in 2004

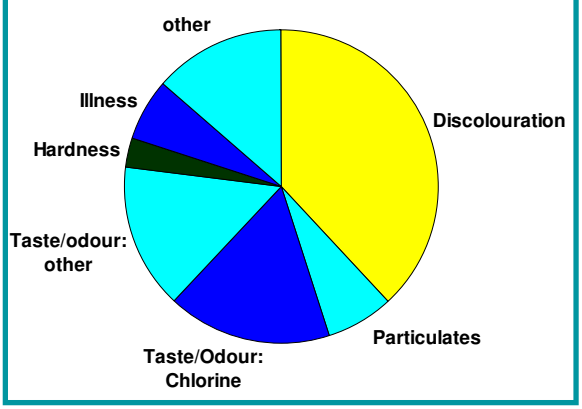
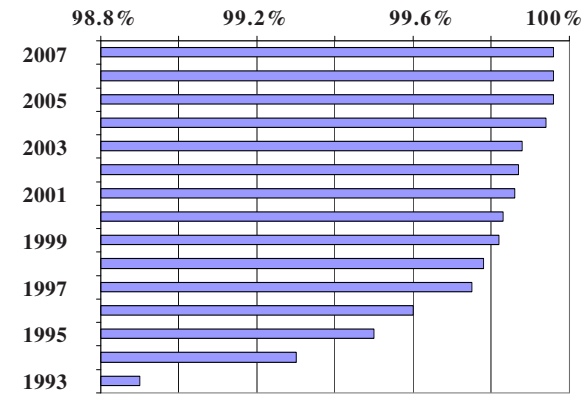


Figure 2. Drinking water compliance - customer's tap



Source: DWI reports, all samples.

UKWIR was set up by the UK water industry in 1993 to provide a framework for the procurement of a common research programme for UK water operators on 'one voice' issues. UKWIR's subscribers comprise 24 water and sewerage undertakers in England and Wales, Scotland and Northern Ireland to whom these publications are freely available.

Work is often carried out in collaboration with government departments and regulators including the Department for Environment, Food and Rural Affairs; the Drinking Water Inspectorate and the Environment Agency. Work is also done in collaboration with research organisations internationally, including the Global Water Research Coalition.

The work is undertaken by a wide range of companies, academic institutions and other organisations in the UK and overseas. Project management is undertaken by both UKWIR members and individuals employed by UKWIR.

Distribution systems

Preventing Discolouration

Contractor: Binnie Black & Veatch

Ref: 04/DW/03/21, ISBN 1 84057 344 9, 168pp, £500

Gives guidance on identifying and mitigating discolouration risks. In particular:

- explains the mechanisms by which discolouration occurs and identifies the factors which influence the risk of discolouration
- reviews 170 previous discolouration incidents to identify their causes
- proposes a process for assessing the risk of discolouration
- gives guidance on short-term measures for reducing discolouration risks

This research is based on a literature review, a review of DWI incident assessment letters, field investigations and a workshop. The report comes with a CD ROM containing training material in the form of PowerPoint slides.

Distributing Drinking Water with Low or Zero Disinfectant Residual

Contractor: WRC/KIWA

Ref: 02/DW/03/19, ISBN 1 84057 268 X, 204pp, £250

This collaborative project between UKWIR and KIWA assesses the role of maintaining a disinfectant residual in water distribution through evaluation of literature, data and practical experiences in the Netherlands and in the UK. The report describes the advantages and limitations of the use of a disinfectant in drinking water during distribution. Areas for further research to improve operational management of the quality of drinking water in the distribution system have been identified. International cooperation, enabling comparison of different approaches and practices, proved very useful in identifying the main aspects of maintaining high water quality standards.

Hydraulic Characterisation of Deposits and Review of Sediment Modelling

Contractor: Binnie Black & Veatch

Ref: 01/DW/03/18, ISBN 1 84057 241 8, 110pp, £300

Identifies the hydraulic characteristics of loose iron deposits and assess capabilities of sediment modelling to manage discolouration. The report is based on a combination of theoretical desk studies and the results of two field trials. Recommendations are given for typical sediment characteristics and values including specific gravity, particle size and sediment concentrations. Sediment transport theory and sediment analysis modules linked to hydraulic analysis software have been reviewed. Guidance is provided on assessing the risk of a discoloration when undertaking a specific network operation.

Understanding and Preventing Discoloured Water

Contractor: Pipeline Developments

Ref: 01/DW/03/17, ISBN 1 84057 215 9, 76pp, £100

Aims to advance understanding on discolouration in drinking water. Work products include:

- a literature review of corrosion and iron discolouration
- analysis of relationships between corrosion, tuberculation and pipeline environment factors using information from a national pipe condition database
- analysis of discolouration particles from distribution systems
- detailed analysis of spatial and temporal relationships between discolouration and pipe burst/repairs in a DMA.

Aspects of Modelling Chlorine Decay in Water Distribution Systems

Contractor: Pipeline Developments

Ref: 00/DW/03/15, ISBN 1 84057 204 3, 46pp, £150

Investigates the prediction of chlorine by means of a field study. The prediction of water age was successful. Further research is needed on chlorine decay. The importance of pipe material, diameter, temperature, pH, flow rate and degree of tuberculation are highlighted.

Benefits of Modelling Water Quality

Contractor: WRc

Ref: 00/DW/03/14, ISBN 1 84057 203 5, 15pp, £100

Reviews the benefits/disbenefits of modelling/GIS tools for maintaining and monitoring water quality. It concludes that there are potentially great benefits but software capability is limited. The software that is readily available in the UK is listed with a summary of the capabilities of each package.

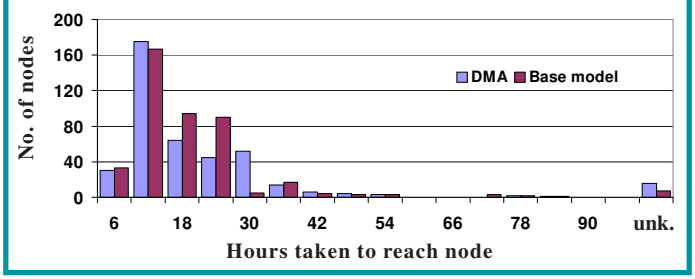
Effect of District Meter Areas on Water Quality

Contractor: WRc

Ref: 00/DW/03/13, ISBN 1 84057 205 1, 37pp, £50

The costs and benefits of the prevention of water related disease in the WHO pan-European region are examined, focusing on narrowing the gap between the Eastern and Western regions. It is estimated that 30 million water related disease incidents annually could be avoided in the Eastern region. To achieve this, an estimated annual expenditure of 30-50 Euro per capita would be required, whilst the benefits of disease prevention were estimated at about 30 Euro per capita (or 13 bn Euro, total). However, the limitations of the study are discussed, and it is argued that the net benefits are likely to be substantial.

Figure 3. Effect of DMAs on transit time - rural model



Operational and Maintenance Strategies for Maintaining Water Quality in Distribution Systems

Contractor: WRc

Ref: 00/DW/03/12, ISBN 1 84057 192 6, 18pp, £100

Various operational and maintenance strategies (and the activities that comprise the strategy) are adopted by water suppliers in order to maintain water quality at acceptable levels. Conversely, activities applied to a network for reasons other than water quality maintenance can be detrimental to the quality. Activities applied to networks were reviewed and ranked according to their impact on water quality. Guidance on designing a strategy for maintaining water quality is given. The procedure for undertaking a risk assessment of failing to conduct activities to maintain water quality is also provided.

Toolboxes for Maintaining and Improving Drinking Water Quality

Contractor: WRc/Pipeline Developments

Ref: 00/DW/03/11, ISBN 1 84057 190 X, 52pp, £150

Toolboxes (or guidance documents) have been developed to facilitate implementation of the key findings from research on maintaining and improving drinking water quality in distribution. Individual documents have been written on seven key factors: disinfectant decay, trihalomethane formation, iron discolouration and particulates, tastes and odours, biofilms, coliforms, pH. 'Rules of thumb' for maintaining water quality are given in each toolbox. Guidance is also given on combining the rules. The toolboxes will be of interest to staff directly working in network operations as well as staff one step removed from the "front-line".

Chlorine and Monochloramine Demand of Materials for Drinking Water Distribution Systems

Contractor: Nancie

Ref: 98/DW/03/9, ISBN 1 84057 144 6, 70pp, £100

Classifies disinfection demand of new pipe materials (polyethylene, PVC, grey iron, cast iron, bitumen lined or exposed ductile iron, cement and epoxy lined iron) and for old cement pipes, taking into account both the pipe wall and water effects. Defines a protocol allowing independent quantification and determines kinetic constants for models of chlorine and monochloramine decay during transit in pipes.

Changes in the Quality of Treated Water During Storage

Contractor: WRc

Ref: 97/DW/03/8, ISBN 1 84047 008 3, 118pp, £100

Analyses and discusses the results of a survey of treated water from twelve works to quantify 'shelf life' and changes over time in terms of disinfection by-products and biological growth with respect to temperature, water type and disinfectant residual. Also assesses interaction of chlorine and monochloramine with biofilms and determines the formation of taste and odour compounds.

Visit www.ukwir.org to purchase reports

Migration Studies on Cement and Bitumen Coated Pipes

Contractor: The Water Quality Centre

Ref: 97/DW/03/7, ISBN 1 84057 065 2, 25pp, £50

Extracts of cement and bitumen coated pipes were tested for total organic carbon, polycyclic aromatic hydrocarbons, aluminium and pH. A general gas chromatography mass spectrometry scan was performed. The results are discussed in the context of such linings having to have, from December 1999, full approval under Regulation 25 of the Water Supply (Water Quality) Regulations 1989.

Review of the Identification Systems for Heterotrophic Bacteria Isolated from Water Distribution Systems

Contractor: CAMR

Ref: 96/DW/03/4, ISBN 1 84057 055 5, 27pp, £30

Reviews the literature of commercial available techniques for isolating and identifying bacteria from water distribution systems. Evaluates three methods: API, Biolog and Cherlock MIDI using thirty eight water hetrotrophs isolated from borehole, upland and surface/lowland waters. Concludes that, due to the limited number of water isolates in the databases, no systems were suitable.

To Quantify the Effect of Different Source Waters on Bacterial Growth in Chemostat Distribution Systems

Contractor: CAMR

Ref: 96/DW/03/3, ISBN 1 84057 054 7, 47pp, £30

Quantifies the extent of bacterial growth in distribution systems from a borehole, a surface/lowland and an upland source using chemostat distribution simulators. Reports the results of two runs varying the feed rate of the three test waters.

Comparison of AOC and BDOC with Surrogates for Determining Nutrients in UK Drinking Water

Contractor: WRc

Ref: 95/DW/03/2, ISBN 1 84057 043 1, 64pp, £50

Measurements of nutrients in drinking water is currently carried out by one of two approaches, Assimilable Organic Carbon (AOC) or Biodegradable Dissolved Organic Carbon (BDOC). These approaches have evolved different analytical techniques. There was concern that the use of different methods may account for the apparent differences between typical AOC concentrations quoted for treated waters in the UK and those in mainland Europe. This work compared the KIWA AOC method with methods used in the UK for AOC and BDOC. Potential surrogates for AOC and BDOC were investigated. Waters from treatment works were monitored for nutrient content over a 24 hour period to investigate variability due to variation in flowrate. A desk study of the feasibility of reducing nutrients in water using current UK drinking water treatment practices was assessed.

Strategic Review on Factors Controlling Microbiological and Chemical Quality of Water in Distribution Systems: Parts I - IV available as a set

Contractor: WRc

Ref: 95/DW/03/1, ISBN 1 84057, 93pp, £500

Reviews the literature on the topic areas of: factors that affect disinfectant residuals in distribution systems, the use of simulation systems for distribution networks, the biological stability of water taste and odour, and water quality modelling. Lists current organisations involved in this research and sets out priorities for UKWIR research.

Microbiological studies

Drinking Water Safety Plans - Stakeholder Communications

Contractor: MWH UK

Ref: 08/DW/02/49, ISBN 1 84057 500 X, 46pp, £150

Investigates the communication of Drinking Water Safety Plans with four critical stakeholders: the Drinking Water Inspectorate (DWI), Consumer Council for Water (CCWater), Health Protection Agency (HPA) and the Environment Agency. The aim of the interviews with the stakeholders was to provide a consensus for communication on approaches to risk assessment between the industry, regulators and customer support groups. The project provides an arena for the exchange of information, clarification of particular requirements and exploration of future ways of working and relationships.

Drinking Water Safety Plans - Risk Based Approach

Contractor: MWH UK

Ref: 08/DW/02/48, ISBN 1 84057 499 2, 102pp, £300

Assesses the progress made with DWSPs by the UK water companies, the approaches taken to risk assessment and any strengths, weaknesses or issues with the DWSP process. An evaluation of how DWSPs integrate with and support the 2009 Periodic Review (PR09) process was carried out. The project provides a clear view of progress made by the industry with the development of DWSPs.

A Briefing on Microorganisms and Drinking Water Supplies - A Review of the Literature 2005-2006

Contractor: WRc

Ref: 06/DW/02/42, ISBN 1 84057 419 4, 38pp, £100

This review of the literature for 2005-2006, reveals, as in previous years, that there are no immediate or foreseeable threats to the safety of drinking water supplies in the UK. The review recommends that the microbiological topics of most immediate, operation importance are:

- the efficacy of UV disinfection as an effective barrier to cryptosporidium
- the potential microbiological challenges of using poorer quality source waters for drinking water supplies during droughts.

Some potential threats were identified, and in depth reviews of these should be considered, such as the growing evidence of associations between bacterial pathogens of concern and protozoa. These relationships could allow pathogens to survive water disinfection and enter supply.

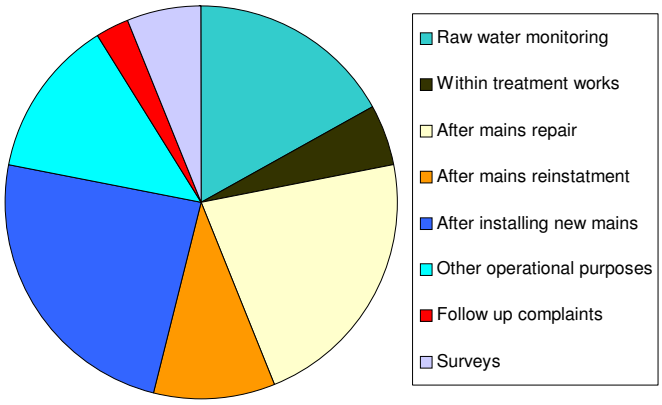
Bacteriological Indicators of Water Quality

Contractor: WRc

Ref: 05/DW/02/41, ISBN 1 84057 394 5, 80pp, £300

Shows that analysis of the results of regulatory monitoring for total coliforms and heteroptrophic plate counts provides information on the condition and performance of the water supply system which can be usefully used as part of a risk management strategy. There is a consensus view that the detection of coliforms in a sample should initiate an investigation by the operator but should not, on its own, be considered a failure to supply safe water.

Figure 4. Purposes of non-regulatory sampling



A Briefing on Microorganisms and Drinking Water Supplies – A Review of the Literature 2004-2005

Contractor: WRc

Ref: 05/DW/02/40, ISBN 1 84057 392 9, 40pp, £100

This review focuses on the period of April 2004 to March 2005. Literature containing information relevant to the microbiological quality of water was appraised and the implications for the Industry assessed. No immediate threats to the safety of drinking water supplies were identified. However, there were some topics that merit further consideration when prioritising future research needs. These are:

- increasing evidence that UV irradiation .can provide an effective barrier against Cryptosporidium
- suggestions that drinking water could be responsible for sporadic cases of campylobacterosis
- the public health significance of the release of Helicobacter and Mycobacteria from biofilms
- the role that chlorine residuals in distribution have in protecting public health.

Catchment to Consumer: Water Safety Plans Part 2

Contractor: Black and Veatch Consulting Ltd

Ref: 05/DW/02/39, ISBN 1 84057 391 0, 28pp, £400

An Electronic Guidance Manual has been produced to guide water companies through developing and implementing Water Safety Plans (WSP). The manual is based on the framework developed during Part 1 of the UKWIR project *Managing Microbial and Chemical Risks from Source to Tap: Report and Toolbox* (03/DW/02/31, published in 2003). It provides a practical interactive methodology, and incorporates the knowledge and flow paths compiled for Part 1 of the UKWIR project and the World Health Organisation (WHO) Guidelines for Drinking-Water Quality, 3rd Edition, 2004.

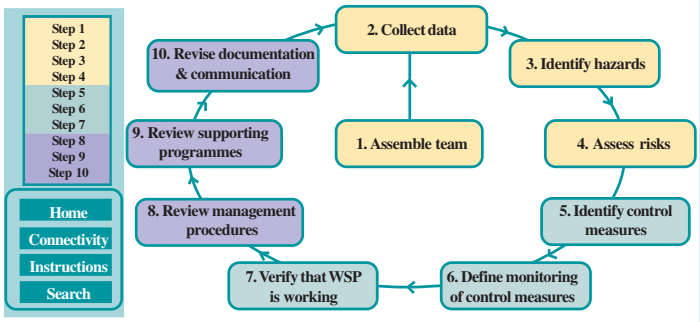
A Review of Ct in Water Disinfection

Contractor: WRc

Ref: 05/DW/02/37, ISBN 1 84057 377 5, 34pp, £100

The inactivation rate of microorganisms by disinfection is commonly expressed as the product of the concentration (C) and the contact time (t). In this report, methods for determining the optimum Ct value have been reviewed, as have influential factors such as temperature and pH. In the United Kingdom, water companies have developed their own strategies based essentially on chlorine residual measurement, contact time and compliance with statutory microbial standards. This has generally produced Ct values of around 15-30 mg.min/l that should be adequate to achieve compliance with the UK and European regulations and inactivate pathogenic bacteria. Provides a useful guide to the origins of the Ct concept, methods for its determination and factors.

Figure 5. Water supply plan process from UKWIR toolbox



Agencies

WHO and EUREAU Support - Progress 2005-2007

Contractor: John Fawell

Ref: 08/DW/11/2, ISBN 1 84057 488 7, 26pp, £100

Intended to assist UK water companies in further developing their Distribution Operation and Maintenance Strategies (DOMS). The purpose of a DOMS is to ensure customers are supplied with water of consistent or improving quality through appropriate operation and maintenance of the distribution system. This Guidance defines the scope and key concepts of DOMS and details an eleven-step development process, linked to the Common Framework Planning Process. Steps include addressing organisational issues, forward-looking analysis, site-specific studies, and feedback processes to ensure the DOMS is effective. The Guidance Manual has been developed through consultation with water companies and Regulators, review of current DOMS and relevant literature, and analyses of company data including development and application of an approach for quantifying the benefits of interventions.

Cryptosporidium

UV Inactivation of Cryptosporidium

Contractor: WRc

Ref: 08/DW/06/20, ISBN 1 84057 474 7, 68pp, £150

Potential changes to the UK Drinking Water Quality Regulations could make cryptosporidium inactivation using UV the most cost-effective treatment option in many situations. UV disinfection is well established in water treatment in the UK and elsewhere. There is now a substantial body of evidence to indicate that UV can provide high levels of inactivation of cryptosporidium at doses typically used for water treatment disinfection. Turbidity below the regulatory limit of one NTU should not impair the disinfection performance of UV. Other water quality factors that could impair UV performance by affecting absorbance of UV or fouling of lamps can be dealt with effectively through operational control systems. Provides information and guidance on implementation of UV disinfection to inactivate cryptosporidium, based on a review of regulations and standards from other countries, particularly the USA.

Metals

Investigation into the Emerging Issue of Fluorapatite Formation

Contractor: Black and Veatch Consulting

Ref: 08/DW/04/11, ISBN 1 84057 497 6, 36pp, £150

Fluorapatite is a crystalline compound of calcium phosphate incorporating fluoride ions in its structure. Crystals are hard and highly insoluble within the normal range of potable waters. Formation of the compound is accelerated by an increase in temperature and this study was commissioned as a result of problems experienced with fluorapatite scale in heating equipment, notably domestic boilers. Identifies water characteristics that influence fluorapatite formation and maps areas where fluorapatite has been observed in the UK to date and areas that are considered to be at risk should fluoride dosing be introduced in the future. Includes a simple Excel utility that allows companies to review the risk of fluorapatite precipitation for the specific water quality prevailing in their supply areas. Also includes a number of methods of reducing the risk of fluorapatite formation.

Investigations into the Occurrence of Water Supply Zones that Demonstrate Resistance to Phosphate Dosing for the Control of Lead in Drinking Water

Contractor: WRc

Ref: 08/DW/04/10, ISBN 1 84057 471 2, 80pp, £150

Investigation of thirteen UK water suppliers found three companies with a zone or zones that were resistant to phosphate use for plumbosolvency control and, despite application of an appropriate dose and good control, lead concentrations had not decreased over several years. No common cause could be identified. Zones with greatest resistance had a history of exposure to significant background levels of phosphate in the source water and this requires further investigation. The majority of zones investigated had responded to phosphate and some demonstrated apparent resistance because the dose was insufficient, not applied for sufficient time or not well controlled. The investigation was hampered by a lack of robust data on lead pipe populations.

Treatment

Membrane Treatment - Technical Guidance Document

Contractor: Cranfield University

Ref: 05/DW/14/1, ISBN 1 84057 390 2, 34pp, £450

Provides background information on the various proprietary membrane processes. Gives case study information and general methodologies for fouling amelioration and integrity testing along with appropriate strategies provided for membrane plant maintenance and recommended ranges of values for key plant operational parameters, based on practical experiences. Evidence provided across seventeen UK membrane plants and ten in the USA, reveals that the USA plants generally perform with fewer problems encountered concerning periodic fouling and loss of membrane integrity, despite generally poorer qualities of water being treated. The observed differences appear to be associated with more frequent backflushing, lower design operating fluxes and a rigorous cleaning protocol. Recommends that UK plant be operated under conditions that more closely resemble those of the USA plant where benefits from optimal membrane operation are self-evident. Any strategy which extends membrane life through adopting the most effective cleaning protocols and pre-treatment processes is likely to be favoured provided the amortised cost of these does not exceed that from recovered membrane expenditure.

Statements contained in this UKWIR catalogue do not necessarily represent the views of UKWIR or the Water Industry