Introduction to drinking-water surveillance using risk-based approaches

Module 1

World Health Organization European Region

UNECE

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Overview

- Aims of this training package
- Definition of drinking-water surveillance
- Why is drinking-water surveillance important?
- Protocol on Water and Health
- WHO Framework for safe drinking-water
- Health-based targets
- Roles and responsibilities
- The 6 key messages

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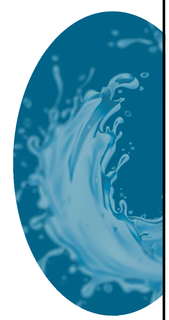
Aims of this training package

1. To understand what is meant by drinking-water surveillance.
2. To understand the context for how surveillance fits into international frameworks (i.e. the Protocol and WHO Framework).
3. To provide a rationale for decision-makers to promote and support the uptake of risk-based approaches through regulations and practice.
4. To underline the added value of risk-based surveillance for better protection of public health.
5. To guide the implementation of surveillance through 6 key messages.



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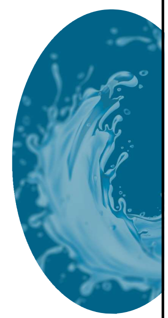
Definition of drinking-water surveillance

"Continuous and vigilant public health assessment and review of the safety and acceptability of drinking-water supplies"
(WHO, 1976)

"The external and periodic review of all aspects of water quality and public health safety"
(WHO, 2017)



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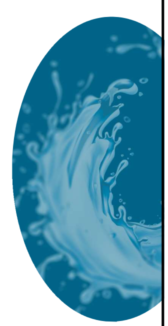
Definition of drinking-water surveillance

Overreliance on compliance testing → **Proactive approach to identifying, controlling and monitoring risk**

Previous approach | **Current approach**



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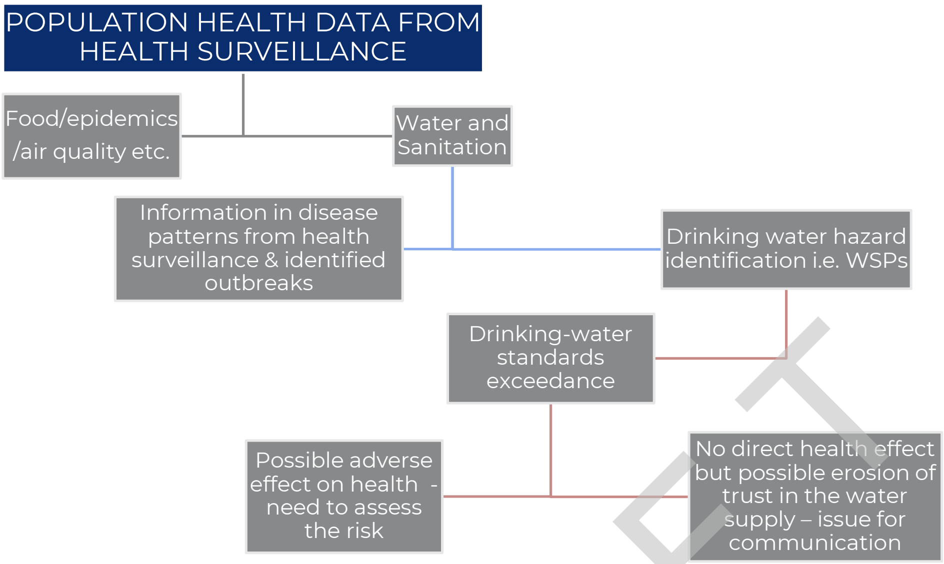
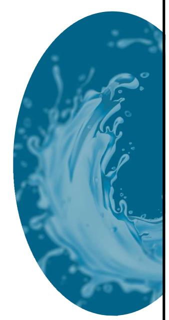
Definition of drinking-water surveillance





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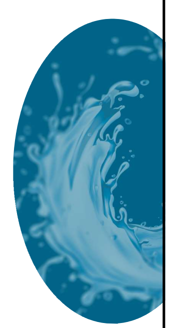
Discussion

What does the definition of drinking-water surveillance mean to you in practice?



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Why is drinking-water surveillance important?

“Poor water, sanitation and hygiene accounts for 842,000 deaths each year from diarrhoea and limited effective prevention and management of other diseases including malnutrition, neglected tropical diseases and cholera as a result of unsafe drinking-water, sanitation, and hand hygiene.”

(WHO, 2014)

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Why is drinking-water surveillance important?

- Promotes improvement of the quality, quantity, accessibility, coverage, affordability and continuity of drinking-water supplies
- Is complementary to the quality control function of the drinking-water supplier
- Does not remove or replace the responsibility of the drinking-water supplier to ensure that a drinking-water supply is of acceptable quality and meets predetermined health-based targets
- Is an important part of facilitating incremental improvements in the service providers listed above
- Includes drinking-water supplies that are managed by communities and includes assurance of good hygiene in the collection and storage of household water

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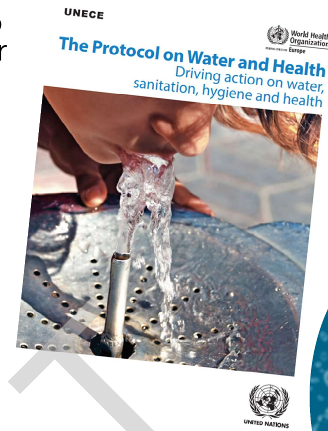
Protocol on Water and Health

"First international agreement of its kind, adopted to attain an adequate supply of safe drinking-water… for everyone."



- Surveillance related requirements:
  - Article 6, paragraph 2 (a):
    - Establish standards which need to be achieved or maintained to protect against water-related disease
  - Article 6, paragraph 5 (c):
    - Establish and maintain a legal and institutional framework for monitoring and enforcing drinking-water quality standards
  - Article 7:
    - Collect and evaluate data on common indicators, including supplied drinking-water quality
  - Article 14, (h):
    - Promote operation of effective networks to monitor and assess the provision and quality of water-related services, and develop integrated information systems

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WHO Framework for safe drinking-water

- Risk-based preventative approach
- Surveillance is a core component of the framework
- Surveillance needs to be aligned with risk management
- Sets health-based targets
- National authorities, water suppliers and surveillance agencies need to adapt and implement the framework to their context

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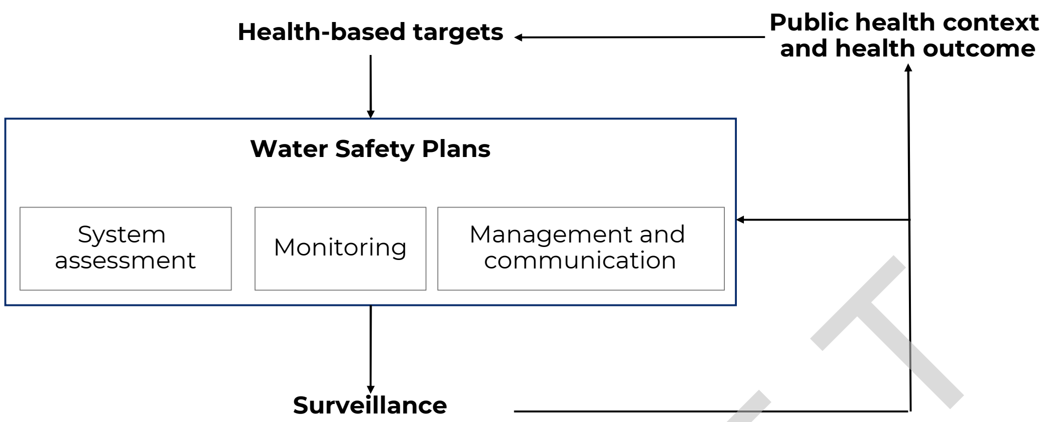
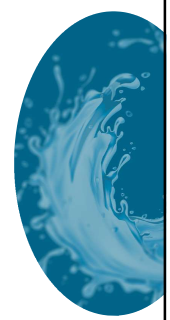
WHO Framework for safe drinking-water





Taken from WHO GDWQ 2017, Chapter 3

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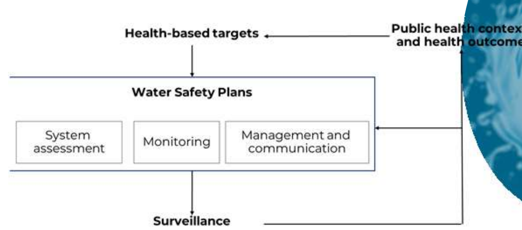
Health-based targets

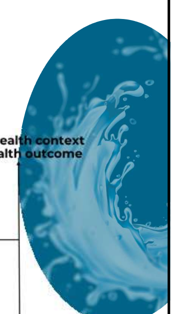
"Measurable health, water quality or performance objectives that are established based on a judgement of safety and on risk assessments of waterbourne hazards"

WHO GDWQ 2017

Types:

1. ***Health outcome*** e.g. tolerable burdens of disease
2. ***Water quality*** e.g. guideline values for chemical hazards
3. ***Performance targets*** e.g. log reductions of certain types of pathogens
4. ***Specified technology targets*** e.g. application of defined treatment process





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Roles and responsibilities

"It is a responsibility of the government to establish legal and regulatory requirements for implementation of risk-based drinking-water surveillance that adequately protect public health"

(Fawell et al., 2019)

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The 6 Key Messages

1. Surveillance is a core public health function.
2. Risk-based surveillance is a governmental responsibility.
3. Risk-based surveillance points at what needs to be looked at.
4. Microbiological drinking-water quality is a key focus of risk-based surveillance.
5. Only monitor what is necessary.
6. Risk-based surveillance aids forward-thinking and anticipation of change.

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Knowledge test

1. What is drinking-water surveillance?
2. Why is drinking-water surveillance important?

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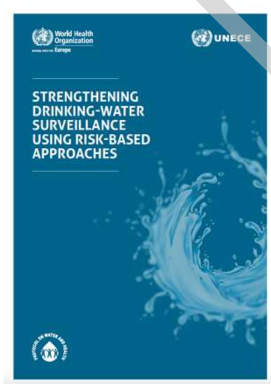
Useful references for further reading



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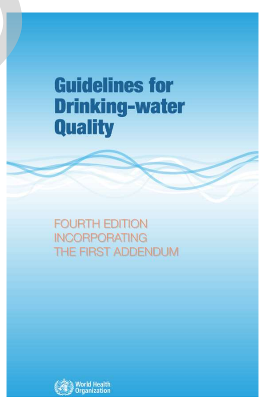

See Chapter 3 of the WHO Guidelines for further reading on health-based targets

Also: UNEP Monitoring water quality - https://www.unep.org/explore-topics/water/what-we-do/monitoring-water-quality

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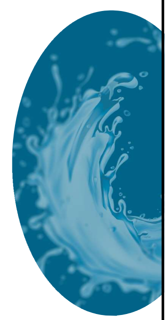
Questions?



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Key Message 1: Surveillance is a core public health function

Module 2

1

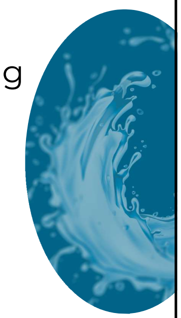
Overview

- Aims of this session
- Sources of pollutants
- The role of drinking-water in transmitting microbial disease
- How risk-based surveillance protects public health
- Risk-based surveillance points to solutions
- Water Safety Plans – why the change in approach and how to implement them
- Sanitary Inspections

2

Aims of this session

1. To be aware of the link between poor drinking-water quality and health.
2. To understand how risk-based surveillance helps to protect the health of consumers.
3. To understand the critical role of governments in establishing legal frameworks which provide adequate resources and define responsibilities which lead to the successful implementation of risk-based surveillance to protect public health.



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VIDEO PLACEHOLDER

Placeholder for video with Dragana Jovanavic discussing the core functions of drinking-water surveillance.

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REMINDER!
Definition of drinking-water surveillance

"Continuous and vigilant public health assessment and review of the safety and acceptability of drinking-water supplies"
(WHO, 1976)

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(WHO, 2017)

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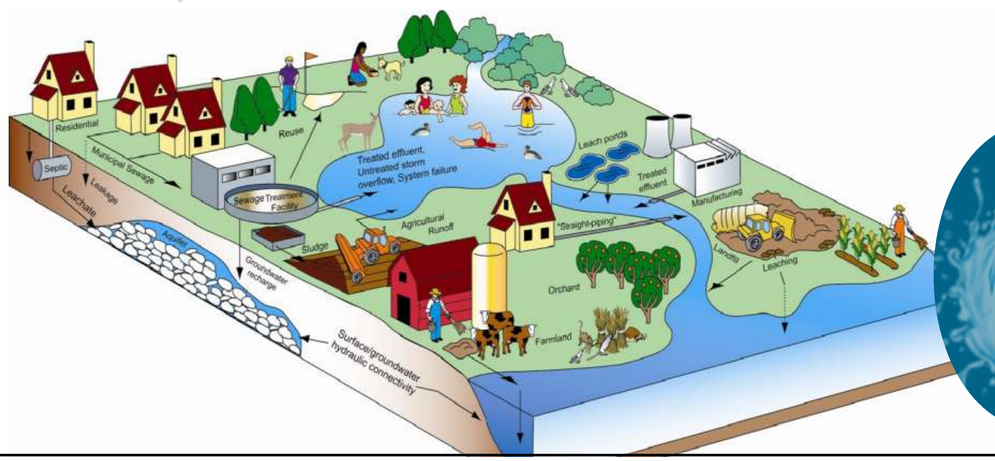
Sources of pollutants

Pathogen → Water → Exposure → Infection → Disease

Pathogen → Person to person → Exposure



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Discussion

What are the various ways in which diseases are transmitted? How do you break the transmission cycle?

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The role of drinking-water in transmitting microbial disease

"Absent, inadequate, or inappropriately managed drinking-water (and sanitation) services expose individuals to preventable health risks"

(WHO, 2022)

- Heavy rain
- Discharges of wastewater
- Malfunctioning of disinfection equipment
- Distribution network failures i.e. cross connections

Examples of frequent causes of microbial contamination of drinking water

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The role of drinking-water in transmitting microbial disease

- Drinking-water can be a significant vehicle for transmitting microbial disease
- Contamination of water sources has resulted in many waterbourne disease outbreaks – e.g. Walkerton
- Surveillance is critical to safeguard public health

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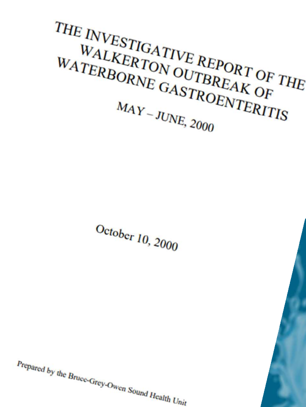
Walkerton *E.coli* outbreak – May 2000

What happened: Well 5 was 15 metres deep and situated in fractured limestone. Water was chlorinated with hypochlorite solution.

May 8 – 12 heavy rainfall (70mm fell on May 12). At the same time a new water main was being installed

Impact: First signs of illness on May 18. >2300 cases of E.coli, 7 deaths (Walkerton population ~5000)

Cause: *Escherichia coli* O157:H7. *Campylobacter* also found in the water system


THE INVESTIGATIVE REPORT OF THE WALKERTON OUTBREAK OF WATERBORNE GASTROENTERITIS

MAY – JUNE, 2000

October 10, 2000

Prepared by the Bruce-Grey-Owen Sound Health Unit

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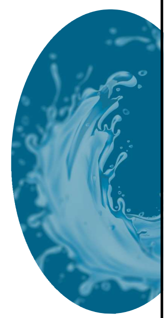
Discussion

Are there examples of outbreaks of waterbourne disease from your country or region where the causes were clear (e.g. a treatment failure) or examples where the cause was not so clear?

Was the outbreak from a large municipal supply or small community-run supply?

What subsequent action was taken and what could have been done to prevent the outbreak?



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How risk-based surveillance protects public health

- Helps to identify, investigate, report and compile outbreaks or patterns of waterborne disease
- Promotes incremental improvement and set priorities
- Builds trust in drinking-water supplies
- Supports to collate information from different sources to understand a regional situation or patterns
- Allows the development of public health-centred policies and practices and to track progress towards health targets

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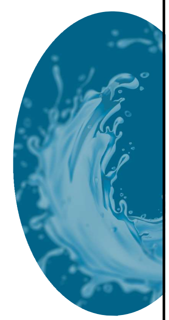
How risk-based surveillance protects public health

Surveillance requires the collection and collation of facts and knowledge about or threats to health.

That knowledge contributes to assuring public health by improvement to drinking-water:

- Quality
- Quantity
- Accessibility
- Reliability
- Affordability
- Continuity



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Discussion

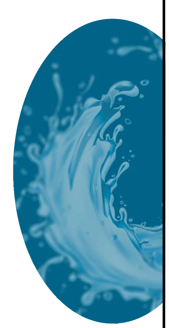
Does your country gather data on waterborne diseases?

Which diseases are notifiable in your country?

What happens to the data collected?

Which authority is responsible for surveillance in your country?

Can you state what their responsibilities are?



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Risk-based surveillance points to solutions

Risk-based surveillance helps to:

- Investigate sources of contamination
- Identify points where interventions may be required to break the cycle of waterbourne disease such as:
  - Entry into source water
  - Sanitation, including wastewater treatment.
  - Drinking water treatment
  - Post-treatment contamination

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Campylobacter outbreak in Norway – June 2019

Impact: More than 1,500 cases of campylobacteriosis in Askøy, Norway

What happened: Contamination of drinking-water occurred through cracks in a mountain reservoir, probably because of heavy rainfall after an extended dry period. No indication of contamination with faecal indicator bacteria before the outbreak from routine sampling conducted earlier (a common finding in many waterbourne outbreaks in which routine monitoring did not provide early warning of contamination nor did it prevent an outbreak happening).

Lesson learnt: Focus on proactive water safety planning to protect the water supply from contamination and to conduct risk-based surveillance, rather than reacting to contamination

Source: Hyllestad et al., 2020

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Water Safety Plans – a change from retrospective to preventive in the approach to surveillance

- **What?** The move from reliance on monitoring results to risk assessment using monitoring for verification.
- **How?** Identify hazards, establish control measures including management and operational procedures, verification monitoring
- **WHY?** "Protect rather than detect" (WHO, 2019)
- Waterborne outbreaks have occurred when results show compliance with microbiological standards standards.

Protection of public health from outbreaks of waterborne diseases has been the motivation behind changes to the management and operation of drinking-water delivery systems from compliance monitoring to risk assessment/risk management.

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Water Safety Plans – why the change in approach to surveillance

- **Water quality monitoring:** e.g. faecal indicator bacteria (E. coli, Enterococci), lack of presence assumes water is microbiologically safe BUT
- **Limitations of final product monitoring alone?** Expensive, requires time and resources, unfeasible to test all water in a supply, provides retrospective results and no early warning of a problem, does not help with when, why and where the contamination event occurred, limited capability to detect short term fluctuations. Not very suitable for detecting contamination post-treatment.
- By the time we have a result the water will probably have been drunk!

Click for a WHO video on Water Safety Plans

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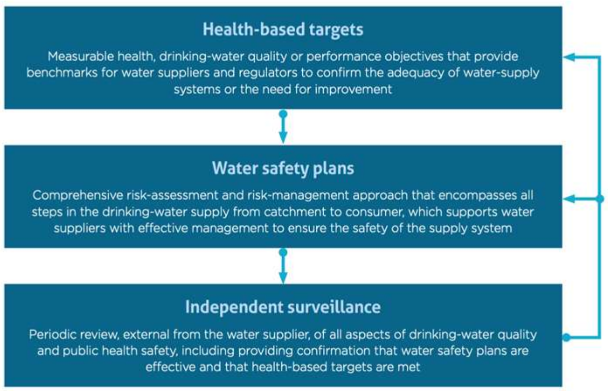
How to implement Water Safety Plans



Water Safety Planning
Identifies hazards
hazardous events,
risks and mitigation measures

Water Quality Surveillance
Prioritises water quality
Defines monitoring frequencies
Identifies monitoring locations
Verifies that the supply continues to be able to supply safe water.

Forms the core of effective water quality management practices with the requirement to put in place barriers to mitigate identified risks to water quality and to monitor the operation of the barriers (operational monitoring) on a continuous basis to ensure that they are working properly.

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How to implement Water Safety Plans

Governments need to define and set the legislative and regulatory framework to support and drive the introduction and upscale of risk assessment through Water Safety Plans. This includes the way in which they are enforced and an appropriate roles and responsibility matrix.

Many countries have introduced WSPs into their legislation.

For example, the EU Drinking Water Directive was updated to introduce a risk-based approach of which member states must comply.

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Responsibility structure for risk assessment in Belarus

- Ministry of Health has overall responsibility for setting government sanitary and epidemiological standards and for carrying out government sanitary surveillance
- Ministry of the Environment is responsible for surveillance of water resources
- Government sanitary surveillance takes two forms: preventive and operational
- Lists of parameters and frequencies of testing are determined for each water supply system based on the environmental situation, water treatment methods used, etc.
- Non-compliance with regulations and standards gives rise to the issuance of notices and recommendations to owners of water supply systems
- Risk assessment is carried out regarding both end products (drinking-water, treatment materials and technologies) and utilities
- Data collected on the characteristics of water sources and utilities using hazard assessment and critical control points (HACCP) methodology
- Some parameters are obligatory, while others (chemical criteria only) may be waived or dropped, if justified by risk assessment

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Water Safety Planning in England and Wales

Supply type	Regulator	Enforcement stages	WSP requirement
Large, public	Drinking Water Inspectorate (DWI)	1. Guidance and advice 2. Formal – advisory letter, civil enforcement, financial penalties	Required by law. Audited by DWI
Private, typically small	Local authorities		Required by law. Actions enforced by local authorities

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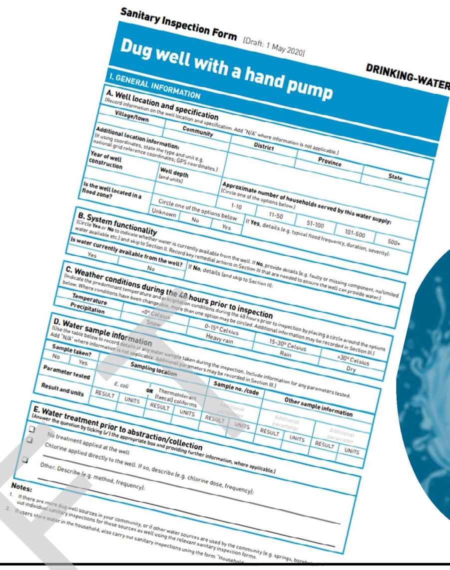
Sanitary inspections

- An element of WSPs. A vital element of drinking-water quality surveillance, particularly for small supplies
- A visual survey of risk factors that may contribute to the likelihood of faecal contamination in water systems
- Considered an effective and low-cost tool for risk assessment of small supplies



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Knowledge test

1. What is the definition of drinking water surveillance?
2. Why is surveillance important?
3. What are the disadvantages of relying solely on water quality testing to check if a water supply is safe to drink?
4. What are the benefits of risk assessing drinking-water supplies?
5. Name a method of risk assessing small drinking water supplies. Can you briefly describe the steps?

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Session summary

- Risk-based surveillance is a vital component at the heart of assuring public health, operating on different levels and providing the information necessary to identify problems.
- Risk assessment/risk management approaches can bring substantial benefits in terms of increased compliance with national standards and reduced microbial and chemical contamination of drinking-water.
- Risk-based water quality surveillance helps to protect the health of consumers in the most cost-effective way by identifying whether the hazards and risks are under proper and continuing control.
- Governments must set the legislative framework, including enforceable action, to support and encourage the implementation of the risk-based approach.

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Useful references for further reading

Sanitary inspection packages for drinking-water

- Dug well with a hand pump
- Spring source
- Rainwater collection and storage
- Household practices: collection, storage, treatment and handling
- Download the zip file for all four packages

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Questions?

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Key Message 2: Risk-based surveillance is a governmental responsibility

Module 3

World Health Organization European Region

UNECE

1

Overview

- Aims of this session
- Roles and responsibilities of organisations involved in surveillance
- The role of government
- Key principles for good risk-based legislation and enforcement structures
- Reporting by authorities
- Activities of surveillance agencies
- Activities of water suppliers

2

Aims of this session

1. To understand the role of government in setting the framework for a country's risk-based surveillance programme.
2. To understand the relationship between and the main activities of water suppliers and surveillance agencies in terms of risk assessment management.

3

Video Placeholder

Placeholder for video with Bettina Rickert.

In order to protect public health, the German Drinking-water Ordinance stipulates tasks for those responsible for supplying water, as well as for independent surveillance by the local health agencies. It is the responsibility of the water supplier to provide drinking-water that is not harmful to health. The self-checking required for this is part of the surveillance concept. Independent of the water supplier, the local health agency also checks the compliance with the drinking-water parameters. The authorities' surveillance addresses the complete water supply system, and includes the inspection as well as taking and analysing water samples. The enforcement of the drinking-water ordinance is the responsibility of the 16 Federal States and is conducted by the Federal State authorities responsible for drinking-water. Therefore, the Federal States may have their own requirements for the implementation.
Reporting of drinking-water quality at the national level is done for supplies supplying more than 5000 persons / providing more than 1000 m^3/day, with a separate report for supplies supplying more than 50 persons / providing more than 10 m^3/day.
The authorities at the Federal States' level are reporting to the national Ministry of Health / UBA annually about the drinking-water quality in water supply zones that provide at least 10m^3/day / supply at least 50 persons.

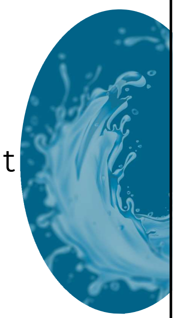
4

Roles and responsibilities of organisations involved in surveillance

"It is a responsibility of the government to establish legal and regulatory requirements for implementation of risk-based drinking-water surveillance that adequately protect public health"

(Fawell et al., 2019)

Note!
Different countries have different administrative structures. Examples of structures are provided here but these may vary. Health ministries should always be involved!



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Roles and responsibilities of organisations involved in surveillance

GOVERNMENT

Sets health targets, establish quality standards and legislation

↓

MINISTRY OF (PUBLIC) HEALTH, REGIONAL OR DEPARTMENTAL OFFICES

Implementation and enforcement of legislation

↓

SURVEILLANCE AGENCIES

Ensure and encourage compliance with the standards. If necessary impose penalties.

↓

WATER SUPPLIERS

Ensure the delivery of safe drinking-water at all times and verify that the water is safe including through WSPs and meeting relevant standards.

↓

BUILDING OWNER/MANAGER

As per water suppliers where suppliers do not have the mandate or responsibility to manage beyond the point of transfer to premises.

6

An example of regulatory-defined roles in Norway

- Around 4.6 million people (90% of the population) are provided with drinking water from approximately 1500 regulated water-supply utilities
- Most of supplies are in public ownership, but some smaller water supplies are private
- The Norwegian Food Safety Authority (NFSA) provides oversight to water utilities that produce more than 10 m^3 of drinking-water per day
- Drinking-water legislation is regularly updated and now requires an assessment and management of hazards from catchment to consumer
- Water utilities are obliged to manage the risks relevant to their water-supply system systematically in terms of long-term planning and in day-to-day operation
- Water utilities establish a risk-based routine monitoring plan based on the assessment of local hazards
- NFSA receives yearly reports with data on water quality and system information from the water utilities
- These data are used by the NFSA to perform risk-based inspections and audits surveillance system

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Discussion

Who carries out the roles and responsibilities in your country and how does this map to the 'Roles and responsibilities' slide?

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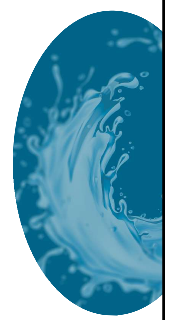
The role of government

To sets health targets, establish quality standards and legislation



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Key principles for good risk-based legislation and enforcement structures

Approach towards risk assessment and management should allow water suppliers to develop approaches that work well for them but which can be shown to be effective.

The regulator inspects records and information on operational monitoring including trends that can indicate changes in conditions and identify "near misses" and the actions taken to ensure a situation is not simply repeated.

The regulator also inspects emergency plans and ensures appropriate support is available.

The regulator must have the authority to enforce the regulations and the standards.

The regulator agrees any deviations or derogations from the standards and agrees appropriate timetables and targets for remediation.

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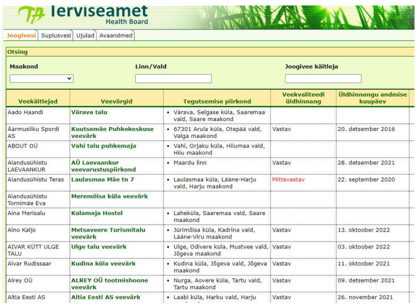
Reporting by authorities

Publish periodic reports to disseminate information and for transparency e.g. DWI Chief Inspector reports

Present compliance rates with standards, water supply events and prosecutions to the public e.g. Estonia via the Water and Health Information System



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Altia Eesti AS	Altia Eesti AS veevärk	• Laabi küla, Harku vald, Harju	Vastav	26. november 2021

https://vtiav.sm.ee/

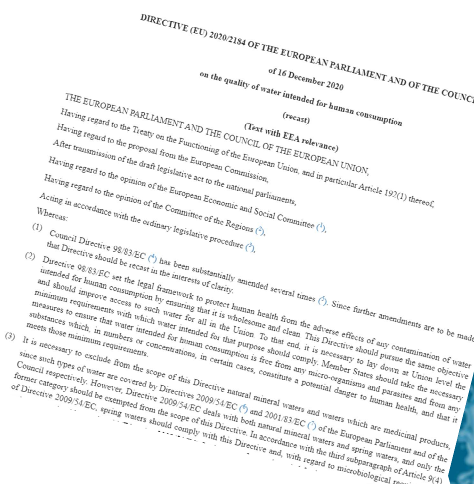
https://dwi-content.s3.eu-west-2.amazonaws.com/wp-content/uploads/2022/08/19153555/E02750078_DWI-Public-water_England_V07.pdf

Application of the EU Drinking Water Directive

- In 2015 the European Union amended the Drinking Water Directive (98/83/EC) to incorporate the risk-based approach.

- Member states must comply with this amendment *to develop monitoring programmes to ensure that the delivered water is safe and meets the quality requirements laid down in Annex I of the Drinking Water Directive (DWD).*

- Monitoring programmes must now include risk management.



DIRECTIVE (EU) 2020/2184 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 16 December 2020

on the quality of water intended for human consumption

(recast)

(Text with EEA relevance)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty on the Functioning of the European Union, and in particular Article 192(1) thereof,

Having regard to the proposal from the European Commission,

After transmission of the draft legislative act to the national parliaments,

Having regard to the opinion of the European Economic and Social Committee (1),

Having regard to the opinion of the Committee of the Regions (2),

Acting in accordance with the ordinary legislative procedure (3),

Whereas:

(1) Council Directive 98/83/EC (4) has been substantially amended several times (5). Since further amendments are to be made, that Directive should be recast in the interests of clarity.

(2) Directive 98/83/EC set the legal framework to protect human health from the adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean. This Directive should pursue the same objective and should improve access to such water for all in the Union. To that end, it is necessary to lay down at Union level the minimum requirements with which water intended for that purpose should comply. Member States should take the necessary measures to ensure that water intended for human consumption is free from any micro-organisms and parasites and from any substances which, in numbers or concentrations, in certain cases, constitute a potential danger to human health, and that it meets those minimum requirements.

(3) It is necessary to exclude from the scope of this Directive natural mineral waters and waters which are medicinal products, since such types of water are covered by Directives 2009/54/EC (6) and 2001/83/EC (7) of the European Parliament and of the Council respectively. However, Directive 2009/54/EC deals with both natural mineral waters and spring waters, and only the former category should be exempted from the scope of this Directive. In accordance with the third subparagraph of Article 9(4) of Directive 2009/54/EC, spring waters should comply with this Directive and, with regard to microbiological requirements,

EU Drinking Water Directive – https://eur-lex.europa.eu/eli/dir/2020/2184/oj

The case of Iceland – challenges

National frameworks should include legal requirements on water protection, surveillance on drinking water quality and performance of the water supply system, and systematic preventive management. Iceland has successfully implemented these requirements into legislation. However, this has not been without challenges.

Iceland has two levels of administration involved in provision of drinking water and sanitation: municipal and central government (4 departments). Although the Icelandic framework for safe water has most of the legal requirements in place, institutional arrangement is complicated on the governmental level with few formal channels for cooperation between the various governmental institutions.

Roles and responsibilities are sometimes unclear and administration is approached from different perspectives, for example in water catchment protection where at least three governmental institutions are involved. Arrangements for collaboration are unclear in legislation which is especially evident in case of incidents and waterborne outbreaks. It is important that the central government has a clear mandate to verify that legal requirements for drinking water are fulfilled.

Municipalities need support, training and guidelines from the governmental institutions as well as adequate resources for surveillance of water utilities, water quality, treatment, status of supply system.

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Activities of surveillance agencies

- Identify and investigate waterborne disease outbreaks
- Analyse trends and the outcomes of WSP audits and sanitary inspections (for small supplies) to inform remedial measures and wider policy
- Check compliance with quality standards and analyse trends in compliance
- Audit WSPs and verify their effectiveness
- Conduct on-site sanitary inspections for small supplies
- Provide advice and support to water suppliers, particularly for small supplies

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Activities of surveillance agencies

Establish
- Legal framework
- Legislative and institutional basis which promotes risk assessment
- Responsibilities which support small systems
- An enabling environment to support exchange of information

Review and update
- National standards

Ensure
- Surveillance covers source to tap
- Adequate reporting and flow of data
- Surveillance data is analysed and used to improve regulations

Provide
- Clear definitions of roles and responsibilities

Promote
- Effective coordination and collaboration

Assess
- Human resource and institutional capacity and identify needs for strengthening

Secure
- Adequate human and financial resources
- Capacity building at different levels

Build and sustain
- An inventory/information system that supports effective surveillance

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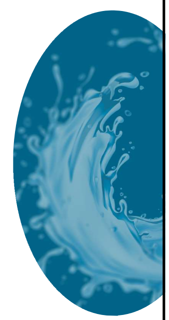
Activities of water suppliers

- Develop a Water Safety Plan
- Ensure treatment is always optimised
- Carry out operational monitoring
- Maintain the distribution system and carry out timely repairs
- Respond promptly to any incidents
- Respond to customer complaints – these may be an indicator of an issue
- Ensure a safe and continuous water supply

16

Discussion

Are there regulations in your country within which the water supplier works? Who is responsible for implementation and enforcement of the regulations? Since the introduction of that legislation, is there evidence that water quality has improved? What changes have occurred?



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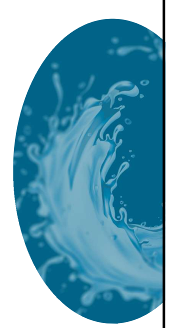
Knowledge test

1. Can you identify the different roles of the following in surveillance:
- Central Government
- Ministry of Health
- Surveillance agents
- Water supplier
- Building owner

2. What challenges might occur when setting up national frameworks for surveillance?

3. What are the key factors for success when setting up a surveillance system?



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Session summary

- Governments must set the framework for drinking-water management through enforceable legislation
- Water suppliers are responsible for ensuring their supplies do not pose a risk to public health
- Regulators and/or Surveillance Agencies ensure that this is the case and may be there to provide advice and support as well as enforcement.
- Penalties for water suppliers should be used as a last resort.

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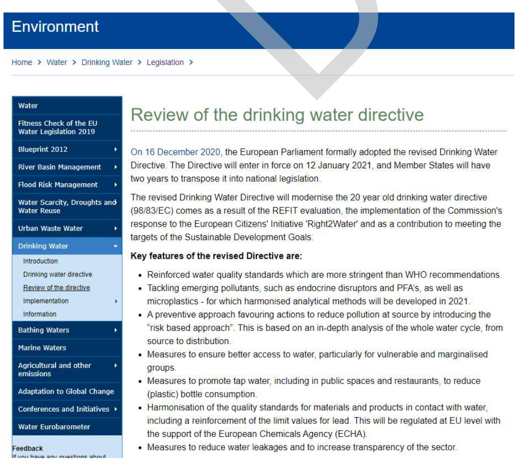
Useful references for further reading


Environment

Home > Water > Drinking Water > Legislation >

Water
Fitness Check of the EU Water Legislation 2019
Blueprint 2012
River Basin Management
Flood Risk Management
Water Scarcity, Droughts and Water Reuse
Urban Waste Water
Drinking Water
Introduction
Drinking water directive
Review of the directive
Implementation
Information
Bathing Waters
Marine Waters
Agricultural and other emissions
Adaptation to Global Change
Conferences and Initiatives
Water Eurobarometer
Feedback

Review of the drinking water directive

On 16 December 2020, the European Parliament formally adopted the revised Drinking Water Directive. The Directive will enter in force on 12 January 2021, and Member States will have two years to transpose it into national legislation.

The revised Drinking Water Directive will modernise the 20 year old drinking water directive (98/83/EC) comes as a result of the REFIT evaluation, the implementation of the Commission's response to the European Citizens' Initiative 'Right2Water' and as a contribution to meeting the targets of the Sustainable Development Goals.

Key features of the revised Directive are:

- Reinforced water quality standards which are more stringent than WHO recommendations.
- Tackling emerging pollutants, such as endocrine disruptors and PFA's, as well as microplastics - for which harmonised analytical methods will be developed in 2021.
- A preventive approach favouring actions to reduce pollution at source by introducing the "risk based approach". This is based on an in-depth analysis of the whole water cycle, from source to distribution.
- Measures to ensure better access to water, particularly for vulnerable and marginalised groups.
- Measures to promote tap water, including in public spaces and restaurants, to reduce (plastic) bottle consumption.
- Harmonisation of the quality standards for materials and products in contact with water, including a reinforcement of the limit values for lead. This will be regulated at EU level with the support of the European Chemicals Agency (ECHA).
- Measures to reduce water leakages and to increase transparency of the sector.

https://ec.europa.eu/environment/water/water-drink/review_en.html

https://www.who.int/publications/i/item/9789241513944

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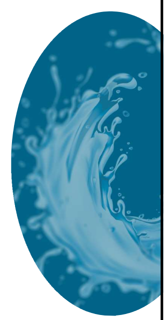
Questions?



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Key Message 3: Risk-based surveillance points at what needs to be looked at

Module 4

PROTOCOL ON WATER AND HEALTH

World Health Organization European Region

UNECE

1

Overview

- Aims of this session
- Risk-based surveillance for hazard identification
- Source pathway receptor model
- Examples of hazardous events
- Role of risk-based surveillance in safe operation of a water supply system
- Pathogens and chemicals
- Prioritising contaminants
- Identifying control measures and a monitoring strategy

2

Aims of this session

1. To understand that risk-based drinking-water quality surveillance is an important part of a proactive approach to identification and control of hazards and risks in drinking-water systems
2. To understand that the identification of hazards and assessment of the risks in the system will provide a rationale for prioritizing strategies and improvement actions to control critical hazards

3

VIDEO PLACEHOLDER

Placeholder for video with DWI discussing the core functions of drinking-water surveillance.

4

Risk-based surveillance for hazard identification

Risk-based drinking-water surveillance identifies the hazards that pose the greatest risks to the population and supports the development of appropriate and efficient monitoring programmes for individual supplies.

When the greatest risks are identified, mitigation must be put in place and monitored by the supplier to ensure effectiveness. Regulators must monitor what the supplier is doing to support their actions.

The identification of hazards and assessment of the risks in the system will provide a rationale for prioritizing strategies and improvement actions to control the hazards (Fawell et al., 2019).

5

Identifying hazards in the drinking-water system

- Assess whole system from source to tap:
  - Catchment, source, abstraction, treatment, storage, distribution
- Ensure a systematic programme of data collection and surveys:
  - These may include water sampling, analysis and sanitary inspection

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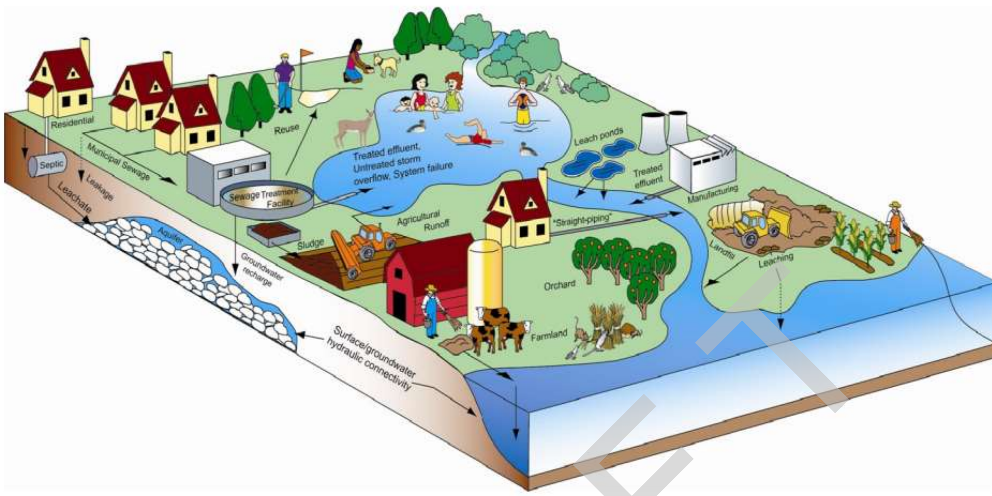
REMINDER!
Sources of pollutants



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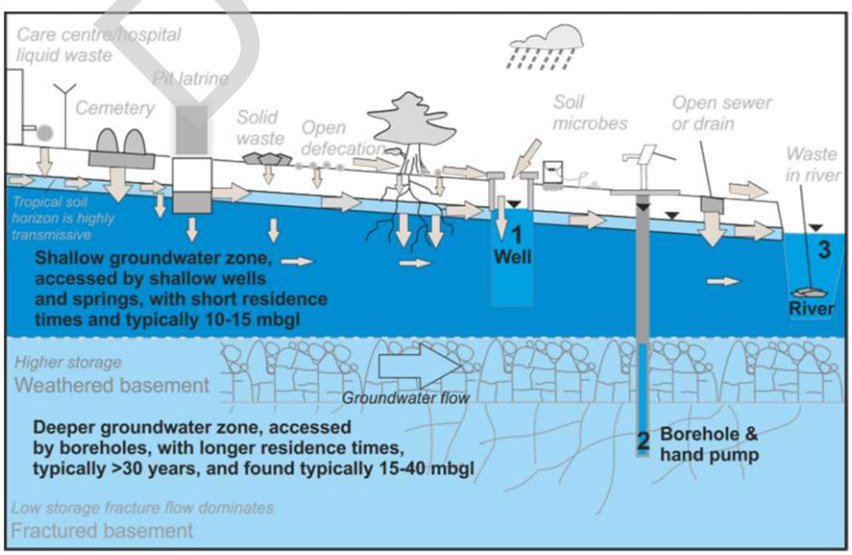
Source pathway receptor model



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Examples of hazardous events

Point of contamination	Hazardous event
Source water (surface or groundwater)	·Runoff of animal and human waste and sewage into source water during wet weather · Ingress of faecal material in karstic groundwater during wet weather · Leakage of faecal matter from on-site sanitation or damaged sewers
Treatment system	· Inundation of filtration beds with contaminated surface water or wastewater during flooding (Add -High turbidity following heavy rainfall) · Failures in coagulation and/or filtration processes or sub-optimal operation · Failure to achieve adequate disinfection (usually chlorination)
Distribution system	· Cracked or eroded pipes or damaged valves facilitating ingress of untreated/contaminated water from the environment, especially during pressure drops · Cross-contamination of drinking-water systems with non-potable systems (such as wastewater, process water and rainwater) Contamination with chemicals or sewage due to backflow from building plumbing into the water-supply distribution systems · Contamination of water due to unhygienic condition of water containers for carrying water from source to home or storage in the home
Storage system	- Faecal contamination of water stored in reservoirs or storage tanks from birds or animals that have entered the storage reservoir or tank – ingress of contaminated water through cracks in the roof of storage reservoirs, particularly after heavy rainfall
Point of use system	· Contamination during household storage due to the use of contaminated, dirty or inadequately covered storage vessels · Insufficient maintenance of home water-treatment devices

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Activity

Spot the hazards!

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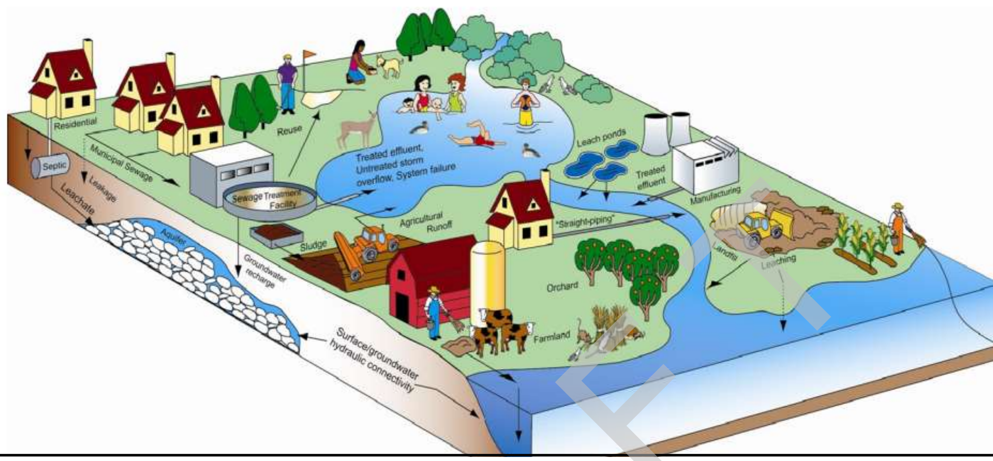
Activity

Spot the hazards!



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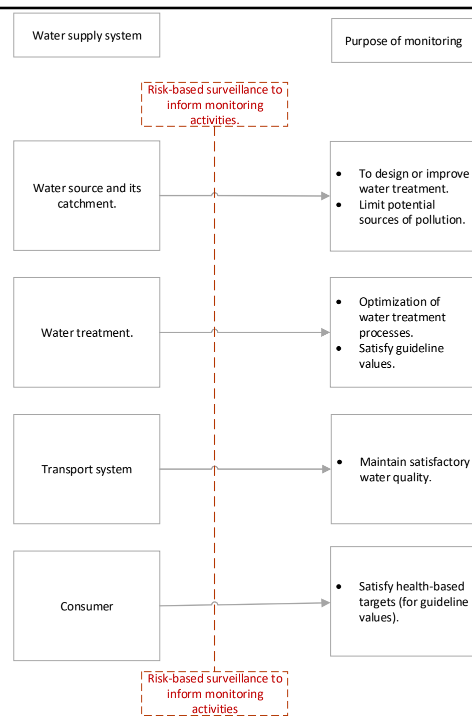
Role of risk-based surveillance in safe operation of a water supply system

The safe and effective operation of a water supply system requires a full understanding of the system. This understanding develops with the implementation of a water safety plan and is refined by risk-based water quality surveillance.



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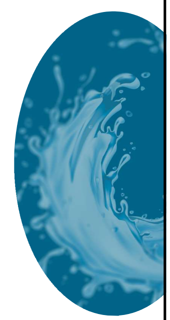
Pathogens and chemicals

Pathogens - priority	Chemicals
Illness/death after single exposure	Cause disease through long-term exposure. Some aren't necessarily harmful to health but can cause user acceptability issues
Sources include human and animal faecal matter including bacteria, viruses and parasites. A few can come from growth in distribution systems including in buildings e.g. Legionella	Can be natural in source waters or from agriculture, industry or sewage discharge. May come from treatment or from distribution
Ingress into distribution or growth in distribution or in buildings	Surface water is generally at greater risk than groundwater, although groundwater can become contaminated.



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Prioritising contaminants

- Water Safety Plans are used to identify hazards throughout the water supply system to the tap starting in the catchment/source water
- The risk associated with each hazard is assessed based on the likelihood or frequency of the hazard occurring, the numbers or concentration and the severity or consequence of the occurrence including exceeding standards. This should take into account hazardous events.
- Risks should then be prioritised

The importance of the Risk = Likelihood x Severity

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Consequence					
Likelihood	Insignificant (1)	Short term or localised, not health related non compliance or aesthetic. Minor (2)	Widespread aesthetic issues or long term non compliance, not health related. Moderate (3)	Potential long term health effects. Major (4)	Potential illness. Catastrophic (5)
Has occurred in past and likely to happen again (5)	5	10	15	20	25
Has occurred in past and has potential to happen again (4)	4	8	12	16	20
Is possible under certain circumstances (3)	3	6	9	12	15
Is possible and cannot be ruled out completely (2)	2	4	6	8	10
Most unlikely (1)	1	2	3	4	5 15

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Example of assessment of risk

- **Hazard:** Microbial contamination of a service reservoir from birds
- **Cause:** Birds' faeces enter through open inspection hatches

Consequence					
Likelihood	Insignificant (1)	Short term or localised, not health related non compliance or aesthetic. Minor (2)	Widespread aesthetic issues or long term non compliance, not health related. Moderate (3)	Potential long term health effects. Major (4)	Potential illness. Catastrophic (5)
Has occurred in past and likely to happen again (5)	5	10	15	20	25
Has occurred in past and has potential to happen again (4)	4	8	12	16	20
Is possible under certain circumstances (3)	3	6	9	12	15
Is possible and cannot be ruled out completely (2)	2	4	6	8	10
Most unlikely (1)	1	2	3	4	5

- **Risk:** Major *(5 x 4)* Has occurred in past and likely to happen again (5); Potential health impact (4)

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Activity

For each hazard decide whether the risk type is microbial or chemical. Once you have assigned the risk type, prioritize the hazards as high/medium or low risk.

Where	Hazard	Risk type Microbial or chemical?	Prioritization
Source	Cattle defaecation close to unfenced wellhead		
Source	Pesticides from agriculture		
Distribution	Leaks on trunk main and distribution system		
Distribution	Lead pipes in distribution		

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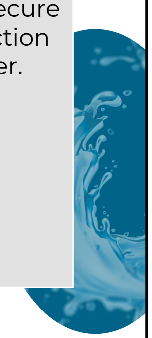
Identifying control measures and a monitoring strategy

Hazard	Control	Action	Monitoring required	Frequency	By whom	Corrective action
Cattle or sheep defaecation close to unfenced wellhead	Fencing and secure inspection covers.	Install control measures	Regular checks on the integrity of fence and that gate is closed. Inspection covers securely in place	Preferably daily	Operating staff	Mend fence, lock gate, secure inspection cover.



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Activity

For the hazard below complete the table below.

Hazard	Cause	Corrective Action	Monitoring required?	Future actions	By who	Anything else?
Ingress of faecal-contaminated water from the wastewater system to the drinking water system in a building	Poor plumbing design, and insufficient supervision of plumbers					

Legionella in Cologne, Germany

Impact: 9 buildings which had had Legionella spp. occurrences of >100 CFU/100 mL within the last 12 months

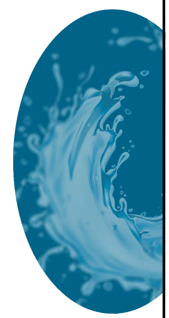
Surveillance investigation: Collection of 807 drinking water samples from the 9 buildings with Legionella spp. Samples tested for Legionella spp., L. pneumophila, HPC 20 °C and 36 °C (culture-based). Each building was sampled for 6 months under standard operating conditions in the drinking-water plumbing systems. Occurrences were significantly correlated with temperature, pipe length measures, and stagnation

Source: Völker et al., 2016

Waterborne outbreak, Prague, Czech Republic

What happened? Prague experienced its largest waterborne outbreak since the 1950s caused by cross contamination from breakages of water and sewerage pipes,

Impact: 5,150 people with acute gastric illness from this area sought official medical treatment. It was estimated there were about 11,000 to 12,000 cases of norovirus infection in this outbreak



Lessons learned: Understanding the distribution system with its vulnerabilities would have provided an opportunity for preventive maintenance and an indication of the need to be aware of the dangers of leaking sewer systems. Need to design to ensure water pipes are above sewers if possible.

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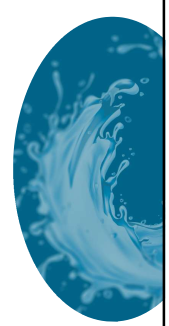
Pro-active approach, Lithuania

Concern: Protect infants from methemoglobinemia due to elevated concentrations of nitrate or nitrite in drinking-water from private wells

What they did: National Public Health Centre (PHC) under the Ministry of Health organizes a chemical test of the well to determine the concentration of nitrate and nitrite in the drinking-water



Outcome: PHC informs individuals and municipalities in which pregnant women or infants reside about the results and risks to support short and long-term planning, prevention measures and safe preparation of infant formula.

Source: Fawell et al., 2019

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Session summary

1. Risk-based surveillance forms part of a proactive approach to the identification of hazards and control measures in a water supply system.
2. Understanding the distribution system allows preventative actions to be implemented, hopefully avoiding public health incidents.
3. A risk matrix can be used to prioritise contaminants and identify appropriate control measures.

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Questions?

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Key Message 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

Module 5

PROTOCOL ON WATER AND HEALTH

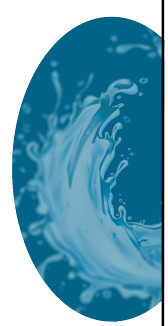
World Health Organization European Region

UNECE

1

Overview

- Aims of this session
- Why prioritise microorganisms?
- Breaking the deadly cycle
- Indicator bacteria – what are they
- Common indicator bacteria used
- Indicator bacteria - limitations
- Where do pathogens occur in drinking water supply networks?
- Tools to support with risk assessment
- Operational, compliance and other types of monitoring



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Aims of this session

1) To understand the importance of microbiological contamination in relation to infectious gastrointestinal disease.
2) To understand the role of faecal indicators and their limitations.
3) To understand the different types of monitoring and how they are used to minimize the risk from microbiological pathogens.

3

VIDEO PLACEHOLDER

Placeholder for video with Harold van den Berg, Netherlands National Institute for Public Health and the Environment

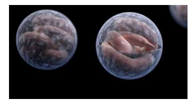
4

Why prioritise microorganisms?

Definition: A microorganism which can cause illness

Bacteria
e.g. *E.coli*

Viruses
e.g. *Norovirus*



Protozoa
e.g. *Cryptosporidium*
Source: CDC

"The potential health consequences of microbial contamination are such that its control must always be of paramount importance and must never be compromised."

WHO Guidelines for drinking-water quality 4th edition

"Every year, on a global basis, billions of cases of illness result from ingestion of (pathogenic) microorganisms in drinking-water."

Yates, 2019

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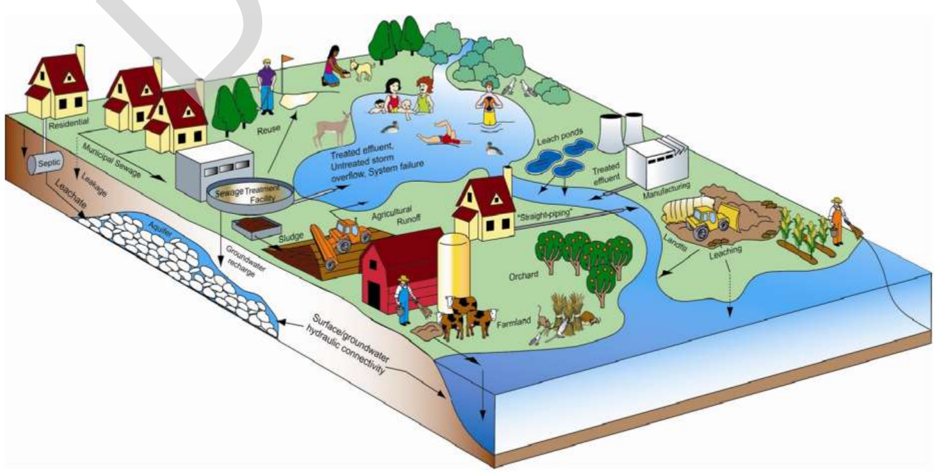
REMINDER!
Sources of pollutants



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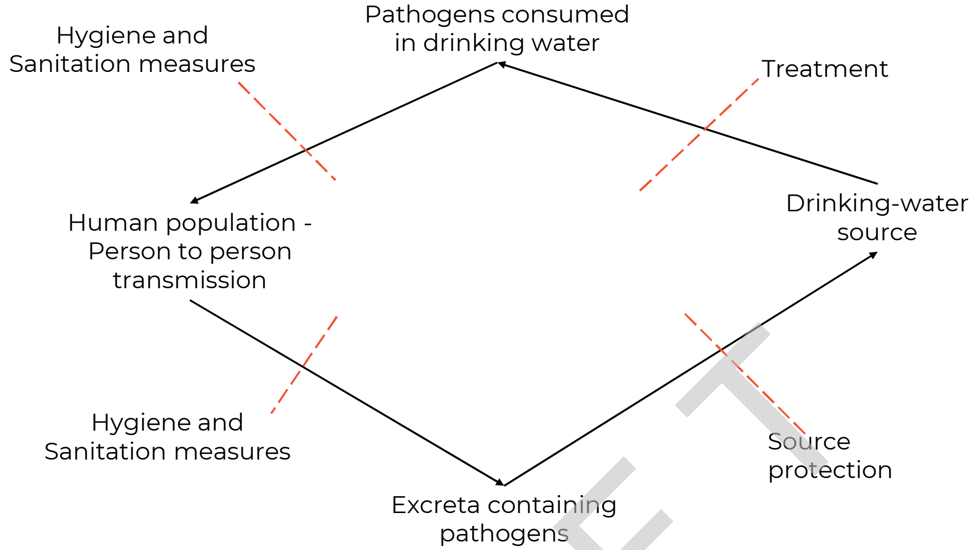
Breaking the deadly cycle



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Discussion

What pathogens can you think of and what diseases do they cause?
What are their links to water?

8

Indicator bacteria – what are they?

Microbiological water quality sampling generally samples for indicator bacteria.

Faecal indicator bacteria are not necessarily the disease causing bacteria themselves but are bacteria used to assess the microbiological quality of drinking-water

- Although these bacteria are not typically disease causing, they are present in large numbers in faeces and indicate that faecal contamination and the possible presence of waterborne pathogens is probable.
- E. *coli* and Enterococci are the classic indicators of human and animal faecal contami in source water and in drinking water. Sometimes thermotolerant coliforms may be u but these are not such good indicators.
- The standard is 0 (zero) colony forming organisms in 100ml water.
- Any detection must be investigated and where possible a repeat sample analysed. No detection should be ignored.

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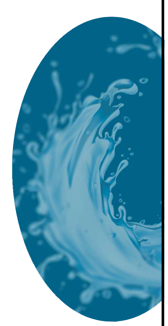
Indicator bacteria – what are they?

- Found in faeces of humans and other animals
- Act as a warning that human pathogens may be present • SURROGATES for pathogenic micro-organisms • NOT pathogens • Provide no information about source of contamination
- Presence of faecal indicators in water does not **guarantee** the presence or absence of pathogens
- The sample size of water taken to analyse for faecal indicators is small in relation to the volume of water supplied
- Numbers of pathogens vary in time and are not evenly dispersed in water supplies
- Viruses and protozoa are often more resistant in the environment and to disinfection than faecal indicator bacteria
- Spot checks may miss critical contamination events, such as wet-weather events that affect source-water quality and can overwhelm treatment and impact drinking-water quality



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Common Indicator bacteria used

***Escherichia coli* (E.*coli*):** Large numbers in human faeces usual indicator

Enterococci (faecal streptococci): Large numbers in human faeces. Enterococci may survive better in the environment but also may grow in the environment.

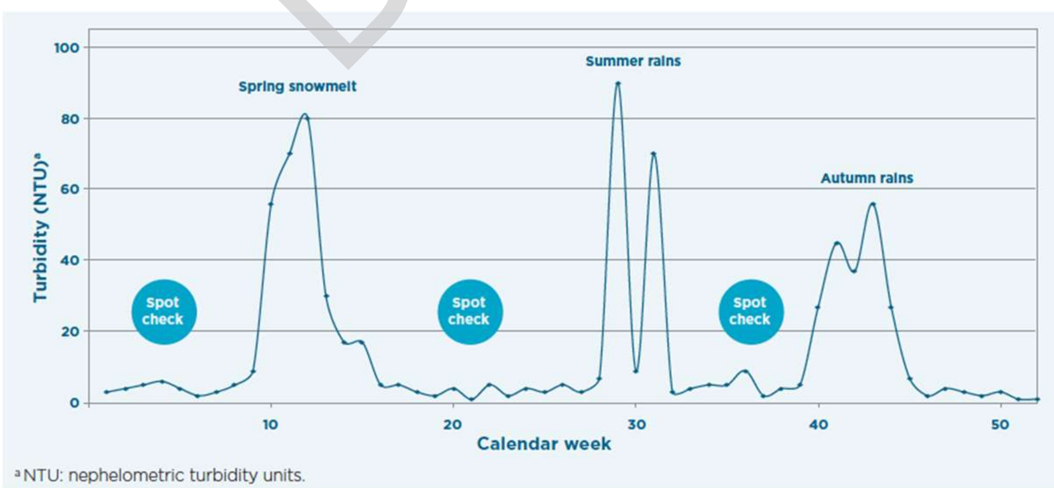
Total viable count (Heterotrophic plate count): indicator of change in distribution system water quality – not a health indicator.

Total coliform bacteria: grow naturally in the environment so not a good health indicator but good indicator of leakage into distribution.

Thermotolerant coliform bacteria: high numbers in human faeces.. Can be used as a health indicator but not as reliable as E. *coli.*

11

REMINDER!
Limitations of relying on sampling data for water quality management



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REMINDER!
Limitations of relying on sampling data for water quality management

- Not all of the water is sampled, sample size in relation to the volume of water supplied is low.
- Sample numbers of pathogens vary in time and are not evenly dispersed.
- Critical contamination events may be missed, such as wet-weather events that affect source-water quality and subsequently drinking-water quality by overwhelming treatment.
- Results are retrospective and the water has probably already been drunk.

13

Indicator bacteria – limitations

- Viruses and protozoa are often more resistant in the environment and to disinfection than faecal indicator bacteria (there are several examples of outbreaks where disinfection has killed the indicator but not the pathogen

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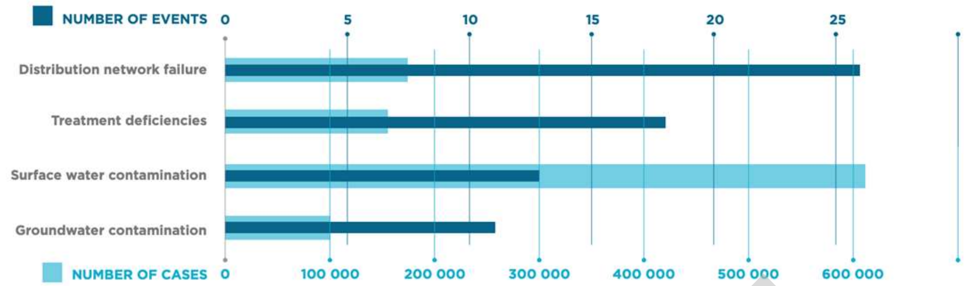
Where do pathogens occur in drinking water supply networks?



- Deficiencies in drinking water distribution networks, such as cross-connections, or ingress of contaminated water may lead to contamination of the supply when and where monitoring is difficult
- Cross-connections and backflows are considered among the most severe public health risks in distribution networks.
- Leaking service reservoirs can lead to contamination following rainfall events in which external contaminated water enters.

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Cryptosporidium in Milwaukee, USA

- **Impact:** An estimated 403,000 cases of diarrhoea
- **Cause of outbreak and outcomes:** Rates of isolation of other enteric pathogens remained stable, but there was more than a 100-fold increase in the rate of isolation of cryptosporidium. Cryptosporidium oocysts passed through the filtration system of one of the city's water-treatment plants. Chlorine killed the indicator bacteria and the water supplier was unaware of the risk at the treatment works. There was a long delay before the source was identified and remediation took place.

Source: Mac Kenzie et al., 1994

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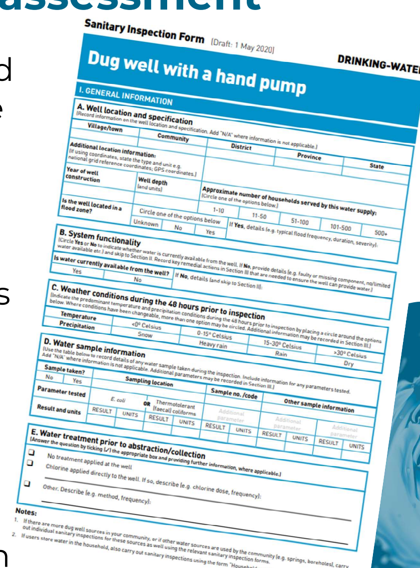
Knowledge Test

Has there been a recent significant microbiological waterborne outbreak in your country? What caused it? What lessons were learned from the outbreak?

17

Tools to support with risk assessment

- Low-cost, robust and easy to use tools exist and can help identify local risks to the water source and support Water Safety Plans.
- Examples include sanitary inspection forms from WHO, predefined risk assessment tools as used by the Drinking Water Inspectorate of England and Wales for small supplies, or risk priority tools as used in Serbia.
- Used in conjunction with microbiological monitoring to identify causes of contamination and control measures.



Sanitary Inspection Form (Draft: 1 May 2020)

DRINKING-WATER

Dug well with a hand pump

I. GENERAL INFORMATION

A. Well location and specification
(Record information on the well location and specification. Add "N/A" where information is not applicable.)

Village/town	Community	District	Province	State

Additional location information: (If using coordinates, state the type and unit e.g. national grid reference coordinates; GPS coordinates.)

Year of well construction | Well depth (and units) | Approximate number of households served by this water supply: (Circle one of the options below.) 1-10 | 11-50 | 51-100 | 101-500 | 500+

Is the well located in a flood zone? Circle one of the options below: Unknown | No | Yes | If Yes, details (e.g. typical flood frequency, duration, severity):

B. System functionality
(Circle Yes or No to indicate whether water is currently available from the well. If No, provide details (e.g. faulty or missing component, no/limited water available etc.) and skip to Section II. Record key remedial actions in Section III that are needed to ensure the well can provide water.)

Is water currently available from the well? Yes | No | If No, details (and skip to Section II):

C. Weather conditions during the 48 hours prior to inspection
(Indicate the predominant temperature and precipitation conditions during the 48 hours prior to inspection by placing a circle around the options below. Where conditions have been changeable, more than one option may be circled. Additional information may be recorded in Section III.)

Temperature	<0° Celsius	0-15° Celsius	15-30° Celsius	>30° Celsius
Precipitation	Snow	Heavy rain	Rain	Dry

D. Water sample information
(Use the table below to record details of any water sample taken during the inspection. Include information for any parameters tested. Add "N/A" where information is not applicable. Additional parameters may be recorded in Section III.)

Sample taken? No | Yes — Sampling location — Sample no. /code — Other sample information

Parameter tested: E. coli OR Thermotolerant (faecal) coliforms | Additional parameter | Additional parameter | Additional parameter

Result and units: RESULT | UNITS | RESULT | UNITS | RESULT | UNITS | RESULT | UNITS | RESULT | UNITS

E. Water treatment prior to abstraction/collection
(Answer the question by ticking (✓) the appropriate box and providing further information, where applicable.)

- ❑ No treatment applied at the well
- ❑ Chlorine applied directly to the well. If so, describe (e.g. chlorine dose, frequency):
- ❑ Other. Describe (e.g. method, frequency):

Notes:
1. If there are more dug well sources in your community, or if other water sources are used by the community (e.g. springs, boreholes), carry out individual sanitary inspections for these sources as well using the relevant sanitary inspection forms.
2. If users store water in the household, also carry out sanitary inspections using the form "Household practices".

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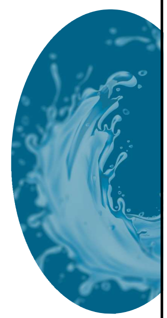
Operational monitoring

- Simple observations and tests to rapidly confirm control measures work. Often done by continuous monitoring at larger works e.g. turbidity, chlorine residual.
- Limits are set for control measures, monitors against those limits and corrective action in response to a detected deviation before the water becomes unsafe
- The frequency of operational monitoring varies with the nature of the specific control measure

Source: WHO, 2017



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Designing operational monitoring

It is better to have a complete record of reliable data concerning water quality at a few sampling stations than to have a lot of unreliable data from many sampling stations. – If reported data are not credible, the programme and its staff will loose credibility.

e.g.

- Rainfall in catchments and turbidity in source waters to track possible contamination events;
- Dosage of chemicals used in treatment, such as coagulants;
- Turbidity measured post-filtration, preferably on each filter;
- Chlorine residual measured after chlorination and at critical points throughout the distribution system, including in dead-end sections and low-flow zones;
- Temperature in warm- and cold-water plumbing systems in buildings as an integral part of preventing and controlling Legionella growth;
- Inspection of protective infrastructures, such as wellheads, fences or service reservoirs..

Operational monitoring is not the same as Compliance monitoring

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Compliance monitoring

- Drinking-water quality monitoring.
- Verification of performance of Water Safety Plans
- Determined by regulations
- Risk-based monitoring allows reduced monitoring for chemicals that are present at concentrations that are well below the standard.
- Does not apply to microbiological parameters.

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Other types of monitoring

Investigative monitoring is part of hazard assessment

Verification monitoring confirms the ability of treatment barriers to achieve what they are designed for.

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Campylobacteriosis, New Zealand

- **Location:** Havelock North, New Zealand
- **Impact:** An estimated 5500 campylobacteriosis cases, 45 hospitalisations and three deaths
- **Cause of outbreak and outcomes:** Very heavy rainfall resulting in overflow of surface water bodies into boreholes. Post-contamination surveillance identified the serving aquifer to be vulnerable to surface water intrusion. Poor relationships between stakeholders were identified. Events such as extreme weather noted as being important warning signs of potential contamination.

Source: Gilpin et al., 2020

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Knowledge test

1. Why is microbiological drinking-water contamination of such concern?
2. Is microbiological drinking-water contamination region-specific. Yes or No?
3. Chemical concentrations in drinking-water are typically prioritized over microbiological concentrations for monitoring . True or False?
4. Microbiological drinking-water contamination never occurs after treatment. True or False?
5. Can you name the most common faecal indicator bacteria? What are their limitations?
6. What is the difference between operational monitoring and compliance monitoring?

24

Session summary

1. Microbiological quality of drinking-water is of principle concern to public health due to the acute effects it causes.
2. Monitoring indicator bacteria provides an indication of the microbiological quality of the sample however there are limitations.
3. Risk assessment complimented with verification monitoring is the most effective way to safeguard drinking-water supplies and in turn public health.

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Questions?

26

Key Message 5: Only monitor what is necessary

Module 6

1

Overview

- Aims of this session
- Why not monitor for all parameters in the Guidelines?
- Chemicals in drinking-water – sources of chemical contaminants
- Chemicals in drinking-water – core parameters to monitor
- Developing national standards
- Monitoring frequencies for chemical contaminants
- Selecting sampling points
- New and emerging substances
- Exceeding standards

2

Aims of this session

1) To understand why it is necessary to prioritize core parameters for monitoring

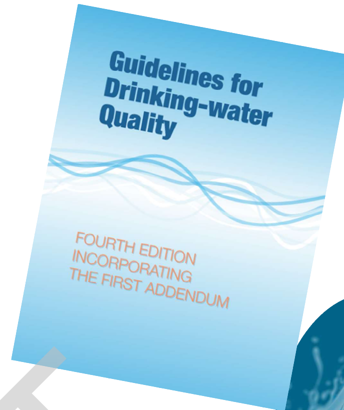
2) To be able to select those parameters that are of public health significance and system performance

3

VIDEO – John Fawell

4

Why not just monitor for all parameters in the Guidelines?



- 90+ chemicals in GDWQ
- But not all are present in all drinking-water
- Sampling and analysis carry a cost, sometimes very significant cost
- Must focus resources for greatest benefit
- More resource efficient and cost effective
- Surveillance authorities should support to prioritize monitoring (See EU Directive case study)

Monitoring of chemicals needs to be selective. Risk-based drinking-water surveillance directs water-quality monitoring towards the most important, relevant parameters for system performance and public health protection.

(WHO, 2017)

5

Chemicals in drinking-water – sources of chemical contaminants

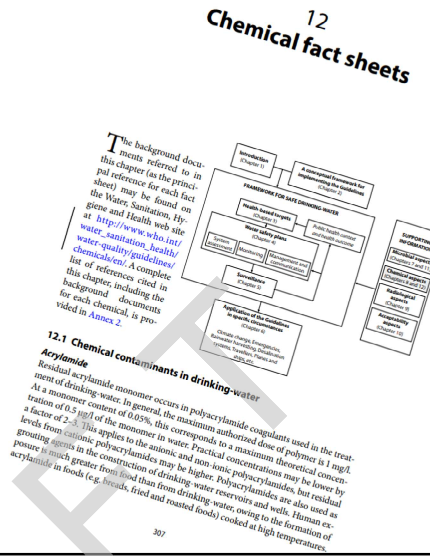
- **Natural:** from rocks, in still or slow-flowing waters -algal toxins, industrial activities - manufacturing, processing and mining. Agricultural activities – nitrate, pesticides, oils and fuels. Human settlements - sewage, waste disposal, urban runoff and fuel leakage. Poorly sited sanitation - nitrate
- **Drinking-water treatment:** aluminium, iron, acrylamide (from coagulation), contaminants from other process chemicals, disinfection by-products, including chlorate from breakdown of hypochlorite.
- **Distribution:** Contact with materials during distribution e.g. storage tanks, pipes, plumbing in buildings, including domestic.

6

Chemicals in drinking-water – core parameters to monitor

"Most chemicals arising in drinking-water are of health concern only after extended exposure of years, rather than months, with the principal exception of nitrates."

(WHO, 2017)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Chemical fact sheets

The background documents referred to in this chapter (as the principal reference for each fact sheet) may be found on the Water, Sanitation, Hygiene and Health web site at http://www.who.int/water_sanitation_health/water-quality/guidelines/chemicals/en/. A complete list of references cited in this chapter, including the background documents for each chemical, is provided in Annex 2.

12.1 Chemical contaminants in drinking-water

Acrylamide

Residual acrylamide monomer occurs in polyacrylamide coagulants used in the treatment of drinking-water. In general, the maximum authorized dose of polymer is 1 mg/l. At a monomer content of 0.05%, this corresponds to a maximum theoretical concentration of 0.5 µg/l of the monomer in water. Practical concentrations may be lower by a factor of 2–3. This applies to the anionic and non-ionic polyacrylamides, but residual levels from cationic polyacrylamides may be higher. Polyacrylamides are also used as grouting agents in the construction of drinking-water reservoirs and wells. Human exposure is much greater from food than from drinking-water, owing to the formation of acrylamide in foods (e.g. breads, fried and roasted foods) cooked at high temperatures.

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7

Discussion

What chemical parameters are particularly of concern in your country/region and why?

8

Detecting chemicals in Germany

- A large volume of drinking-water data screened for human-derived chemicals
- 700 detected compounds identified which were linked to one or multiple potential sources
- From over 5200 chemicals, 174 were prioritized for their health relevance for drinking-water
- The prioritized suspects are relevant for more detailed risk assessment
- The relatively fast approach shows to be complementary to currently used target-based approaches, however this usually involves advanced analytical techniques

Source: Sjerps et al., 2016

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Developing national standards

- National standards should be set to reflect the most important chemicals for the country. Values need to reflect the particular circumstances, including achievability and affordability.
- Standards should be reviewed and reassessed at intervals to be kept up to date.
- Where standards cannot be met straight away they can be modified at intervals to support incremental improvement and allow time for infrastructure improvements, e.g. lead in EU.
- Flexible regulations should provide a clear criteria for decision making including justification and documentation, e.g. reduced monitoring frequency, deviations and derogations where it will be difficult for a supply to meet a standard but there is no unacceptable risk to health

10

Developing national standards

What chemicals are/are likely to be present in the country/region?

What concentrations are they and are the concentrations increasing (or decreasing)?

Are the concentrations of concern for public health? Consider WHO guideline values

What is the likelihood that the parameter will affect user acceptability?

It is not necessary to cover everything at once. Might be better to get evidence of a need for a standard for a particular chemical first.

It is important not to change standards too frequently if they are to be taken seriously and there are implications for infrastructure and operations.

11

Monitoring frequencies for chemical contaminants

- Consider whether the concentration in drinking water is variable or stable and the trend of the concentration.
- Consider seasonal variation or lack of seasonal variations.
- Frequency of monitoring should reflect the risk of a breach of a standard or guideline value (i.e. a health target).
- Monitor on the basis of what you need to know not what would be nice to know.

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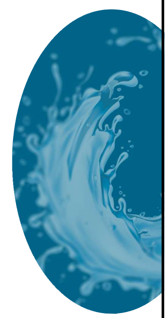
Introducing risk-based monitoring in Jersey

- Primary water source is surface water
- Greatest source water contamination risks identified as from agriculture and septic tanks (microbiological, nitrate and a range of pesticides)
- Most results of extensive chemical monitoring to meet the requirements of the drinking-water regulations resulted in non-detects or very low levels of chemicals
- A risk-based approach to monitoring introduced, which reduced the number of determinations and the cost of carrying out drinking-water compliance monitoring by over 50%
- Raw water contamination with pesticides remained
- The reduction in cost of the monitoring programme released funds to increase the monitoring of raw water
- Better quality management of historic contamination by pesticides
- Data used for persuading the agricultural industry to adopt better catchment practices to prevent or minimize contamination.

Source: Fawell et al., 2019



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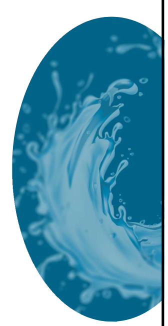
Selecting sampling points

- Generally based on the source and substance characteristics. If it is from raw water then unless it is likely to change in distribution sample post-treatment.
- If it changes in distribution, e.g. trihalomethanes, need to sample at the tap or close to the end of distribution (requires more samples).
- Service connections or plumbing derived chemicals monitor at the tap. May be responsibility of building owner or local surveillance authority. May need different approach as concentration can depend on contact time of the water with the source, e.g. lead



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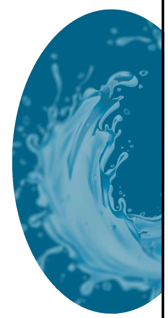
Discussion

Does the legislation in your country promote flexibility of monitoring based on risk (occurrence and concentration) for chemical parameters?



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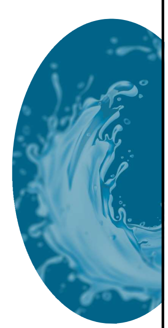
New and emerging substances

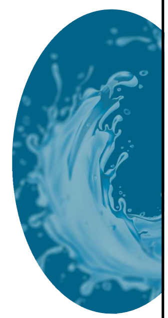
- Examples:
  - Pharmaceuticals and personal care products
  - Perfluorinated substances (PFAS)
  - Microplastics and nanoplastics
- Must ensure that there is a scientific body of evidence indicating their impact to human health through drinking-water. Beware of the impact of the media!
- Do not let these detract from other monitoring but they may be of importance locally, e.g. PFAS in groundwater near airfields..
- Monitoring may be very difficult and expensive. Treatment may be even more so.



16

Discussion

Are emerging substances raising any concerns in your country/region? If so, which substances are you concerned about an why?



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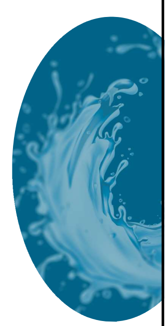
Exceeding standards

- Does not automatically mean a threat to health
- Need clear procedures in advance.
- Consider:
  - Extent of the exceedance, small or large, how does it relate to the margin of safety in the standard? Check the reliability of the analysis, i.e. resample. Is it causing an acceptability problem, e.g. taste, odour or appearance?
  - Duration of the exceedance, hours, days, months or years?
  - The parameter itself and who the high risk user groups are for that parameter, e.g. Nitrate and bottle-fed infants. Vulnerable industries.
  - The actions that might be needed to reassure consumers. Without disrupting supplies.



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Knowledge test

1. Why is it not necessary to monitor all parameters in the WHO Guidelines?
2. Why are microbiological parameters prioritized over chemical parameters?
3. What factors should be considered in selecting the parameters to monitor?

19

Session summary

- To make best use of resources and for most effective surveillance standards should reflect the priorities for water quality and public health
- Standards should be tailored and periodically reviewed to prioritize national risks.
- Monitoring of compliance with standards is vital but needs to be flexible, resource effective and concentrate on important risks to public health, and to be undertaken at a sensible frequency for a particular supply. Is it simply compliance or to show whether whether the hazards and risks are under proper and continuing control.

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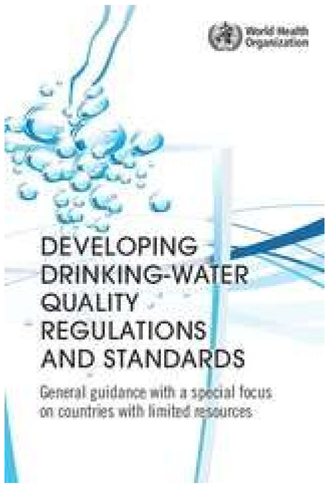
Useful references for further reading



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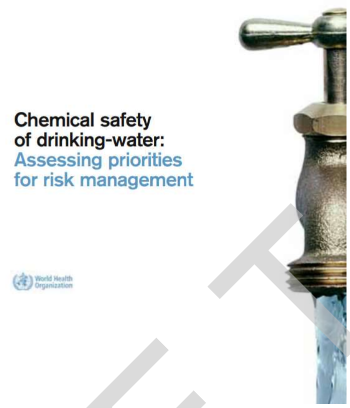

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Questions?

22

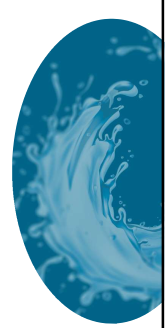
Key Message 6: Risk-based surveillance aids forward-thinking and anticipation of change

Module 7

1

Overview

- Aims of this session
- Examples of long-term changes
- Climate change: potential impacts on drinking-water supplies
- Climate change: benefits of risk-based surveillance
- Role of agencies in long term planning



2

Aims of this session

1) To identify emerging sources of drinking-water quality risks
2) To understand the role of governments and surveillance agencies in preparing for and responding to long-term change

3

VIDEO PLACEHOLDER

Placeholder for video discussing the core functions of drinking-water surveillance.

4

Examples of long-term changes

- **Man-made** – increased development, changes in industry or agriculture, increased demand, pharmaceuticals. Reduced groundwater resources due to over-abstraction.
- **Environmental** – drought, flooding, other extreme weather events which may affect water quality i.e. landslides.
- **Climate-related** - “Increases in some extreme weather events and storm surges will increase the risk that infrastructure for drinking water, wastewater, and stormwater will fail due to either damage or exceedance of system capacity, especially in areas with aging infrastructure”(US Global Change Research Program, 2018)

Increase in trihalomethanes in Scotland

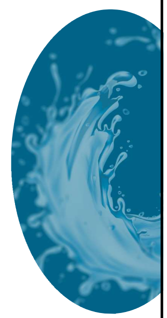
- Monitoring data from 5 drinking-water treatment plants (DWTPs) showed significant correlations between trihalomethane (THMs) levels, water temperature and dissolved organic carbon (DOC). The strong seasonality of these parameters demonstrated how climate can influence THM formation.
- Laboratory experiments quantified the sensitivity of THM formation to changes in water temperature and DOC concentration, reproducing real-world THM formation in the DWTPs .
- Validated relationships were combined with literature about future trends in summer temperatures and surface water DOC in the British Isles, to estimate future global warming impacts on THMs formation in DWTPs that use chlorine for disinfection.
- An increase in mean summer temperatures will likely increase THM formation, with a 1.8°C temperature increase and 39% THM increase by 2050 representing a mid-range scenario
- Projected increases have major implications to potable water globally, either as changes in health risks or water treatment costs to maintain an equivalent quality potable supply

Source: Valdivia-Garcia et al., 2019

Discussion

Can you think of examples of manmade and non-manmade changes which may impact the water supplies in your country or region in the future?

Can you think of ways in which surveillance agencies may be able to plan to mitigate the impacts of these?



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Climate change: potential impacts to drinking-water supplies

"Climate change is disrupting weather patterns, leading to extreme weather events, unpredictable water availability, exacerbating water scarcity and contaminating water supplies. Such impacts can drastically affect the quantity and quality of water..."

(UNICEF, 2022)

These impacts will be exacerbated by increasing demand for domestic and industrial use and irrigation. The effects of extreme rainfall will be exacerbated by increasing non-porous surfaces in towns and cities.

8

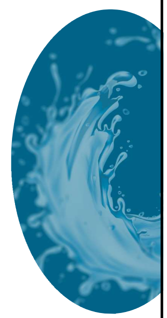
Climate change: potential impacts to drinking-water supplies

Increased temperatures
- Higher water demand
- Pathogen proliferation and new pathogens in distribution
- Reduced stability of chlorine residual
- Algal toxins from cyanobacterial blooms

Drought
- Lower water availability
- Increased concentration of pollutants
- Release of contaminants from sediments

Sea-level rise
- Saline intrusion of coastal aquifers
- Flooding of infrastructure

Precipitation and flooding
- Flooding of infrastructure
- Increasing pathogens
- Overwhelming processes



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Climate change: benefits of risk-based surveillance

Risk-based surveillance can:

- Support with predicting the location and scale of the risk to water quality
- Identify long-term changes and associated risks
- Track risk and changes needed to adapt
- Bring financial and socioeconomic benefits – forewarned buys time to adapt

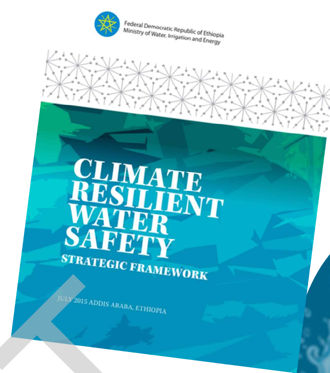
Both mitigation and adaptation strategies will be required to manage drinking-water resources in future in response to the effects of climate change.

10

Climate-resilient WSPs in Ethiopia

Surveillance approach: Climate-resilient WSPs implemented in the water supplies of Addis Ababa and Adama, which supply 5 million and 500,000 people, respectively. Based on the risks identified, water quality monitoring can be optimized by prioritizing parameters and events which pose a higher risk for contaminating the drinking-water

Surveillance outcomes: Water quality monitoring improved at both drinking-water utilities to provide relevant data used as input for climate-resilient water safety planning. By continuously linking water quality monitoring and climate-resilient water safety planning, utilization of information was optimized



https://wsportal.org/wp-content/uploads/sites/3/2018/07/Climate-Resilient-Water-Safety-Plan-Strategic-Framework.pdf

Source: van den Berg et al., 2019

11

Role of agencies in long-term planning

- Advocate and proactively participate in long-term planning processes to:
  - ensure continuing access to freshwater sources for drinking-water purposes;
  - manage water demand among competing needs
  - review the resilience of supply systems
  - implement control measures to maintain water quality
- Promote consideration of the hazards and health risks resulting from long-term changes in the local WSPs of water suppliers
- Engage with other sectors and agencies (including environment, water resource management, meteorology and agriculture) and supporting collation and analysis of data over time to:
  - identify possible new hazards, trends and peaks in concentrations, and
  - inform water suppliers accordingly (other sectors may already have data available that the water-supply sector can access);
- Advise policy-makers and regulators if regulations and water-quality standards merit updates in response to observed changes in terms of, for example, additional parameters or changes to parametric values in the light of new knowledge.

Source: Fawell et al., 2019

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Discussion

Can you think of an example of proactive surveillance from your country or region or how proactive surveillance there may be applied?

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Knowledge test

1. How might climate change impact on water resources?
2. In addition to climate change, what other factors may affect water supply in the future?
3. Can you name the roles surveillance agencies play in long term planning for water supply systems?
4. What other long-term changes may pose a risk to drinking-water supplies?

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Session summary

- Emerging man-made and natural risks can pose a threat to drinking-water quality.
- Climate change is of particular concern due to impacts to water quality and drinking-water infrastructure.
- Surveillance can aid proactive planning to anticipate future pressures (human, climate and environmental) on water systems.

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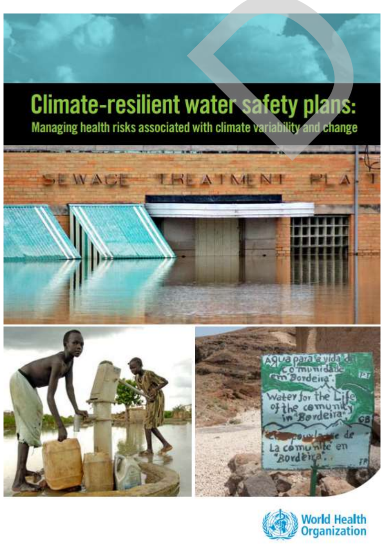
Useful references for further reading



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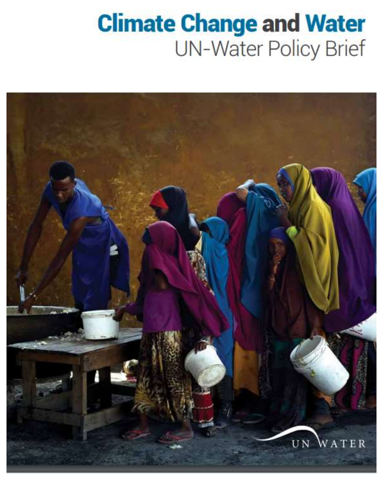

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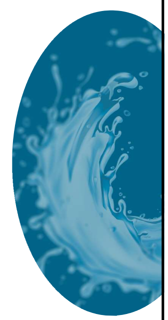
Questions?



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Strengthening drinking-water surveillance training package Case Study

Facilitator Handbook

PROTOCOL ON WATER AND HEALTH

World Health Organization
European Region

UNECE

Contents

Objectives

The objective of this exercise is to support participants with the understanding of the importance of risk-based surveillance and to give them experience of considering factors which should be included when developing risk-based surveillance plans.

Structure of the exercise

During this case study you will take participants through a series of exercises that will mirror the 6 key messages of strengthening drinking-water surveillance. These are guide activities. They may be adapted as required. Anticipate spending 30 minutes per exercise, however this is only a guide.

Scenario

You work in the national public health authority (NPHA) in country Xanadu. The country has areas where there are various industries and agriculture, they each predominate in different areas. There are three large cities and many villages with a range of large, well-resourced supplies and many small to very small supplies that generally have limited resources. There is a central analytical laboratory and the potential to establish smaller regional laboratories. You are required to identify what steps are required by government and regional authorities to improve the quality of drinking water and reduce the level of waterborne disease in the population. There is uncertainty about disease levels and causes in some regions that are largely rural. There are occasional outbreaks which appear to be waterborne. You have been tasked with implementing a risk-based surveillance approach to drinking-water management, but ministers are unsure what this entails and are looking for firm recommendations. The country has limited health surveillance at this time, but this is steadily improving. There is a health ministry with overall responsibility for health and a new department tasked with understanding the health situation, this could become the national health surveillance agency. There is an environment ministry responsible for environmental protection, but nobody has overall responsibility for drinking water quality at this stage.

As part of a national task group you have been given the responsibility for suggesting the way forward for drinking-water and waterborne diseases, what is required and how it should fit in the overall structure.

Exercise 1 (to reflect Key Message 1 – Surveillance is a core public health function)

1. Public health surveillance provides and interprets data to facilitate the prevention and control of disease. To achieve this, surveillance should have clear objectives including how the data is collected, analysed and disseminated. Based on the limited information given above, what objectives should be set to improve the health of the population of Xanadu with respect to waterborne diseases?
2. As a group, identify what monitoring requirements should be in place for public health in general, and drinking water. Who should be responsible for collecting public health data? what are the planned uses of the surveillance data? should happen to the data once it is collected? What are your recommendations to government?

Exercise 2 (to reflect Key Message 2 - Risk-based surveillance is a governmental responsibility)

Stakeholders are the persons and organizations who contribute to, use, and benefit from surveillance. Stakeholders should be identified not because they contribute to or use surveillance results, and also should contribute to periodic evaluation of the established risk-based surveillance.

1. As a group, identify the key stakeholders who may be responsible or accountable for drinking water surveillance in Xanadu. Consider the different types of supplies in Xanadu (i.e. urban/rural, large/small) and how these may require various types of support.

2. Develop a responsibility matrix for the identified stakeholders.

Stakeholder	Responsibility	Frequency of activity

3. Sketch a flow chart to show how surveillance may be conducted including the stakeholders involved and their roles.

Exercise 3 (to reflect Key Message 3 - Risk-based surveillance points at what needs to be looked at)

In Xanadu there large engineering and manufacturing companies in the large towns. One aspect of manufacturing is generic pharmaceuticals. The large towns have a centralised sewage collection and treatment system with two-stage treatment (settlement and activated sludge) and one discharges to sea while the other two discharge to rivers that are used as drinking water sources. There are groundwater sources near the coast and inland in some of the rural areas. There are surface water supplies in rural areas including one lake source. Upon visiting the towns, you are able to identify a number of sources of hazards and possible hazardous events:

In the rural areas the primary activity is agriculture with a mix of animal husbandry and arable farming. Sewage is mostly down to local arrangements including septic tanks, which may not be well managed. Some of the rural catchments are in hilly areas.

Some of the infrastructure in the towns is old and there are frequent pipe bursts.

Some of the buildings are also old, some with lead plumbing. There is a reliance on storage reservoirs in the larger piped supplies. Suppliers are now establishing Water Safety Plans.

1. Consider various different catchments/locations e.g. urban, industrial, agricultural, domestic, rural. For each of these catchments, list the potential hazards which may impact the quality of the drinking-water in that location.

Catchment location	Hazard/hazardous event	Type of contamination (chemical/microbiological)
Domestic	Sewage	e.g. Microbiology, nitrates
Urban		
Industrial		
Agricultural		
Rural (non-agricultural)		

2. Develop a risk matrix to identify the hazards of greatest concern to drinking-water.

3. Prioritise the hazards in order of level of concern. Which supplies should be given immediate attention?

4. What is the role of (a) the surveillance agency and (b) the water supplier to ensure the risks are well managed?

Exercise 4 (to reflect Key Message 4 - Microbiological drinking-water quality is a key focus of risk-based surveillance)

There are many bacteria, viruses and protozoans which may contaminate drinking water and cause acute disease in the population. In this scenario, surveillance has identified a number of cases of waterborne disease in Xanadu of unknown origin. Considering the different scenarios below (e.g. rural and urban, small or large supplies, piped or non-piped).

1. For each of these scenarios (and others that you might want to consider), discuss and identify at each stage how and where any microbiological contamination might occur.
2. How and why might monitoring of the different scenarios differ? Take into account the locations as well as the type of supply.

	Scenario 1 e.g. rural, small non piped supply eg well	**Scenario 2 e.g. urban piped supply**
Catchment		
Treatment		
Storage		
Distribution		

3. Develop a surveillance strategy to identify the risk mitigation steps that a supply operator might suggest including any water quality sampling you may wish to carry out and what operational monitoring you might expect to see.
4. Are there areas that you feel would be difficult to deal with?

Exercise 5 (to reflect Key Message 5 – only monitor what is necessary)

Faced with authorising a proposal for reduced monitoring from a municipal water supplier consider the following chemical data in conjunction with the hazards you have already identified.

1. Discuss your decisions on which chemicals you would approve for monitoring, which you wouldn't and decide whether there would be any requirement for more information. Consider a substance's risk (i.e. occurrence in the area, significance for public health and acceptability). Discuss what information/data you would want to see if you were setting up a regulatory framework for this.
2. Discuss approaches for responding to exceedances to microbial and chemical parameters; Highlight any overlapping activities; for example, treatment option for a chemical can be beneficial for microbial water quality.

Source	**Parameter**	**Average concentration**	**Standard**	**Number of samples per year**	**Number of years data**	**Stability**
Groundwater	Nitrate	40 mg/L	50 mg/L	12	5	Small increase
Surface water	Total THMs	90 µg/L	100 µg/L	4	4	Varies with season
Surface	Barium	0.5 mg/l	1.3 mg/L	4	2	Stable
Groundwater	Chromium	25 µg/L	50 µg/L	1	3	Stable
Groundwater	Chromium	30 µg/L	50 µg/L	1	3	Small increase
Surface water	Manganese	60 µg/L	80 µg/L	12	5	Discolouration?

Exercise 6 (to reflect Key Message 6 - Risk-based surveillance aids forward-thinking and anticipation of change)

A flood occurs in Xanadu. Consider the following:

1. What are the primary risks to the water supplies in each catchment of Xanadu – rural and urban. What are the consequences to human health and social factors?

2. Develop a risk matrix to reflect and prioritise the risks.

3. Identify potential control measures for each risk you have identified.

4. What actions should the stakeholders take? Start from the top level, i.e. central Government, local government, water companies. Design a matrix to show the responsibilities of each and how each interact with each other.

5. Climate predictions show that hazardous events such as floods are likely to occur more frequently in the future. What actions should stakeholders take to future-proof the drinking water supplies and public health of Xanadu?

6. How might the surveillance system be adapted to deal with future risks?

7. What legislation/regulation would be useful to start implementing or having in place including enforcement.

8. Reflect on future scenarios if a risk-based surveillance system was not in place Imagine the event/incident actually happens, consider the consequences if the above hadn't been planned or implemented.

Strengthening drinking-water surveillance training package

Case Study Handbook

PROTOCOL ON WATER AND HEALTH

World Health Organization
European Region

UNECE

Contents

Introduction

This booklet contains 13 case studies which illustrate different aspects of surveillance highlighted in the training pack. Use these to discuss different challenges and lessons learned in the appropriate context.

Walkerton, USA (KM1)

An estimated 2,300 people became seriously ill and seven died from exposure to microbially contaminated drinking water in the town of Walkerton, Ontario, Canada in May 2000. The severity of this drinking water disaster resulted in the Government of Ontario calling a public inquiry to address the cause of the outbreak, the role of government policies in contributing to this outbreak and, ultimately, the implications of this experience on the safety of drinking water across the Province of Ontario and across the Globe.

Walkerton is a rural agricultural area. Between 8 May and 12 May 2000, heavy rainfall (134 mm) resulted in surface runoff containing *E. coli* O157 and *Campylobacter jejuni* entering a well supplying drinking water. Although the well was chlorinated, the amount of chlorine used was routinely less than the amount required, and bacteria and organic matter overwhelmed the system. The chlorine residual level should have been monitored manually; however, for over 20 years, employees made false entries in their daily operating sheets. On 15 May, samples were taken with false labelling. Another town well was knowingly being run without a chlorinator. While the onset of most of the Walkerton, Ontario, Escherichia coli O157:H7 and Campylobacter outbreak occurred several days after a heavy rainfall on May 12, the accumulated 5-d rainfall amounts from 8-12 May were particularly significant. These 5-d accumulations could, on average, only be expected once every 60 yr or more in Walkerton and once every 100 yr or so in the heaviest rainfall area to the south of Walkerton. It is known that contamination events may increase following high rainfall.

However, in addition to the rainfall events and absence of sufficient treatment other risk factors are also highlighted. There were management failures in terms of experience of the utility managers including a lack of awareness of the Ontario Drinking Water objectives and the lack of knowledge about the risks posed by contaminated drinking water to human health. Other risk factors included a failure to record test results and equipment failures resulting in prolonged stopping of chlorination in the town's main well. It has been reported that the utility knew that the water was contaminated by E. *coli* but did not communicate this to either the Ministry of the Environment (MOE) or the Medical Officer of Health. The MOE noted significant concerns 2 years before the outbreak; however, no action was taken the guidelines governing water safety were not mandatory. The MOE lacked a computerized information system to make critical historic information accessible to those responsible for monitoring.

This case resulted from a lack of oversight, a lack of foresight and poor operating practice. As climate change increases extreme weather events, including heavy rainfall it also demonstrates the need for forward planning to ensure resilience of water supplies.

Lessons learned

Prevention requires a risk management approach that is focused on prevention, as evidenced by:

- Informed vigilance is actively promoted and rewarded.
- Operators and managers should understand the entire water system, as required by a Water Safety Plan approach. This approach should be promoted and actively maintained.

- Effective, real-time treatment process control is a routine operating approach.
- Fail-safe multi-barriers are identified and maintained at a level appropriate to the challenges facing the system.
- Near misses are documented and used to train staff about how the system responded under stress and to identify what control measures are needed in future.
- Operators, supervisors, lab personnel and management all understand that they are entrusted with protecting the public's health and are committed to that responsibility.
- Operational personnel receive the status, training, and remuneration comparable with their responsibilities as guardians of the public's health.
- Response capability and communication are enhanced.
- Continuous improvement is an objective of the organisation (Hrudey and Hrudey, 2004).
- Operators must develop guidance limits for monitoring parameters that are able to detect abnormal conditions, based on understanding the system.
- Operators must recognize and act on (together with management) signals for abnormal conditions (i.e., increase in turbidity or chlorine demand and drop of chlorine residual).
- Operators must recognize when they are facing a problem that is beyond their understanding or training and call for assistance.
- Operators' should be able to recognise any vulnerability in the system that needs improvement to reduce contamination risks.
- Operators must take ownership of problems and inform their managers so they fully understand the existence of problems.

References:

This case study and lessons learned has been adapted from the following references:

Hrudey, S.E. et al., 2003. A fatal waterborne disease epidemic in Walkerton, Ontario: comparison with other waterborne outbreaks in the developed world. Water Science and Technology, 47(3), pp.7–14. Available at: http://www.ncbi.nlm.nih.gov/pubmed/12638998; https://www.ncbi.nlm.nih.gov/books/NBK28459/

Salvadori, MI et al., (2009). Factors that led to the Walkerton tragedy. Kidney International, 75(112), S33-S34. ISSN 0085-2538. Available at https://doi.org/10.1038/ki.2008.616.

https://www.ncbi.nlm.nih.gov/books/NBK28459/

Norway – campylobacter outbreak (KM1)

On 6 June 2019, the Norwegian Institute of Public Health was notified of more than 50 cases of gastroenteritis in Askøy. A reservoir in a water supply system was suspected as the source of the outbreak because of the acute onset and geographical distribution of cases. The Institute investigated the outbreak to confirm the source, extent of the outbreak and effect of control measures. Pilot interviews, a telephone survey and an SMS-based cohort study of residents served by WSS A was undertaken. System information of WSS-A was collected. Among 6,108 individuals, 1,573 fulfilled the case definition. Residents served by the reservoir had a 4.6× higher risk of illness than others. *Campylobacter jejuni* isolated from cases (n = 24) and water samples (n = 4) had identical core genome MLST profiles. Contamination through cracks in the reservoir most probably occurred during heavy rainfall. Water supply systems are susceptible to contamination, particularly to certain weather conditions.
Health surveillance identified an outbreak of disease and subsequently this was identified as a probable waterborne outbreak. Problems with infrastructure were identified after the event.

Lessons learned

This case study highlights the importance of water safety planning, ensuring that infrastructure is resilient and risk-based surveillance is undertaken to mitigate risks.

Reference: https://pubmed.ncbi.nlm.nih.gov/32885779/

Hungary: Early warning systems in outbreak prevention – case example of a drinking water outbreak in Miskolc following an extreme precipitation event (KM1)

Relevant principle: Risk-based surveillance increases the resilience of water supply systems.

Background to the case study:

Miskolc is a city of approximately 80000 inhabitants located in North-Eastern Hungary. It relies on karstic water for its drinking water supply. Following an extreme precipitation event, it experienced a multi-etiological drinking water outbreak affecting over 3500 people.

The water of the karstic spring is generally delivered without treatment, except for safety chlorination. The water supply was monitored regularly according to the frequency defined in the drinking water legislation. Samples were tested routinely for turbidity, microbiological and chemical parameters. During a week of extreme precipitation, increased turbidity was observed, but as faecal indicators were not detected, normal operation was continued. Following the 3-day Pentecost holiday, the water supply was resampled, but by the time the results arrived (two days later), general practitioners already reported increased incidence of gastrointestinal illness. Boil water advice was given and the consumption of water restricted. The advice was upheld until the operation of the water supply returned to normal, and the whole system was disinfected. Epidemiological investigation confirmed the consumption of tap water as the source of infection.

This case demonstrates the need to look at all the indicators of a problem and the importance of not assuming that if faecal indicators are not present, in spite of pointers from other indicators, there is no problem.

Lessons learned:

The cause of the outbreak was the extreme precipitation that changed the underground current in the karst and washed contamination into the water source. Routine testing for fecal indicators was insufficient in preventing the outbreak. Turbidity was found to be indicative of events leading to the deterioration of water quality. Online turbidity monitors were installed, and a control value was assigned to the measurements as an early warning of potential contaminations. A rapid method for E*. coli* testing was also introduced.

Supply operators should introduce simple operational control points for early detection and water incidents and appropriate interventions.

Author: Márta Vargha

Implementation of risk-based approach into national sanitary-epidemiological legislation in Belarus (KM1)

The Ministry of Health of the Republic of Belarus implemented procedures for conducting health risk analysis in the form of a set of criteria for classification of drinking water entities (large scale and small scale drinking water suppliers) with regards to risk.

In the field of sanitary-epidemiological welfare of the population, Belarussian legislation contained elements of health risk analysis but no obligations for implementation of the whole risk assessment scheme into practice. Traditional surveillance system was based on compliance with standards and sanitary norms. At national level however there was a strong understanding of the necessity and benefits of risk-based approach into all areas of human being, including drinking water supply.

In 2016 the Law of the Republic of Belarus of January 7, 2012 "On Sanitary and Epidemiological Welfare of the Population" was amended. It set the basis for the application of risk analysis in order to take measures to prevent and minimize these risks (risk management), as well as to inform in accordance with the established procedure of stakeholders. A number of bylaws had been developed and were still in the process of development. The resolution of Council of Ministers № 43 of 22.01.2018 set the methodology of formation of system risk assessment". The resolution of the Ministry of Health of the Republic of Belarus of 20 January 2017 N 8 approved the guideline on procedures for conducting health risk analysis.

Since then all entities which constitute a hazard to health should undergo the procedures of risk analysis. A set of criteria for classification of drinking water entities for both large and small- drinking water supplies, with regards of risk to consumer, were developed. These criteria cover all stages of drinking water cycle, taking into account monitoring data. Such risk assessment allows the most susceptible stages of the system (target points) to be identified and prioritized and remedial measures actioned. This set a base for correction of drinking water monitoring program to specific system and real situation in the system, as well as help to justify supervisory-control activity (inspections) of responsible bodies.

Risk assessment of the DWSs and the methodology of chemicals risk assessment is widely used in the country to inform decisions for priority investments in the sector, development and implementation of state (regional) programs for drinking water and sanitation.

All waterworks should undergo the procedure of risk assessment within 3 years.

This case demonstrates the importance and benefits of introducing a legislative requirement for WSPs and the risk-based approach.

Lessons learned

The approach address real situation in the drinking water systems, helps better understanding of drinking-water systems, especially small-scale water suppliers. Quantitative criteria allows comparison of a situation in the systems before and after measures undertaken, pros and cons of different water treatment technologies for specific drinking-water supplies based on health impact.

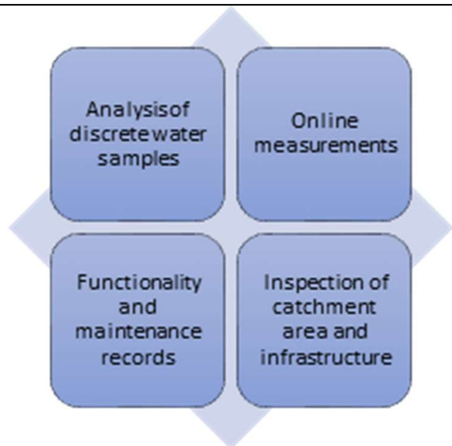
Incorporation of the risk-based surveillance into legislation – an example of the European Drinking Water Directive (KM2)

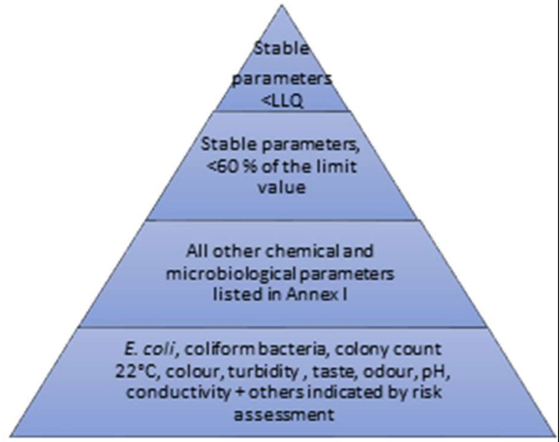
EU member states are required to develop monitoring programmes to ensure that the delivered water is safe and meets the quality requirements laid down in Annex I of the Drinking Water Directive (DWD). In 2015, the European Union amended the DWD to incorporate the risk-based approach.

The EU Commission has amended the Annexes II and III of the EU Drinking Water Directive98/83/EC. Annex II lays down the requirement of drinking water quality monitoring, including parameters to be monitored, monitoring frequency, and the point of sampling. The amendment replaced the previous rigid monitoring scheme by a more flexible, risk-based monitoring programme. The amendment requires the EU member states to develop monitoring programmes to ensure that the delivered water is safe and meets the quality requirements laid down in Annex I of DWD. The monitoring programmes do not rely solely on end product testing, but may also include elements of operational monitoring and sanitary inspections. The minimum frequency of water testing is set based on the volume of supplied water. Basic bacterial indicators, organoleptic properties and a limited number of other parameters (depending on the applied water treatment or the outcome of the risk assessment) are monitored with high frequency, while the “long list parameters” only with a lower frequency. Sample numbers may be reduced further (even to zero) for those parameters which were not detected in previous measurements, or only present in low concentration, and the risk assessment indicates that the breach of compliance is unlikely. Though the point of compliance is the consumers’ tap, samples may be taken at other points in the water supply system if it is demonstrated to be equivalent.

Transition from end-product testing to risk-based surveillance should be gradual. Basic water quality testing should be maintained (simple, cost-effective measurements of high indicative value), while the frequency and scope of more sophisticated analysis should be determined by risk assessment.

Elements of monitoring programmes	Monitoring frequency of various parameters





The amendment requires the EU member states to develop monitoring programmes to ensure that the delivered water is safe and meets the quality requirements laid down in Annex I of DWD. The monitoring programmes do not rely solely on end product testing, but may also include elements of operational monitoring and sanitary inspections (Fig. 1). The minimum frequency of water testing is set based on the volume of supplied water. Basic bacterial indicators, organoleptic properties and a limited number of other parameters (depending on the applied water treatment or the outcome of the risk assessment) are monitored with high frequency, while the "long list parameters" only with a lower frequency (Fig. 2). Sample numbers may be reduced further (even to zero) for those parameters which were not detected in previous measurements, or only present in low concentration, and the risk assessment indicates that the breach of compliance is unlikely. Though the point of compliance is the consumers' tap, samples may be taken at other points in the water supply system if it is demonstrated to be equivalent.

This case demonstrates that it is important to maximise the benefits of risk-based monitoring in order to focus on the hazards that are of greatest importance.

Lessons Learned

Incorporation of important elements of risk-based approach can accelerate the uptake of risk-based supply operation as well as risk-based surveillance.

References: EU Commission Directive 2015/1787 amending the 98/83/EC directive

Introduction of New risk-based Norwegian Drinking Water Regulation (KM2)

The previous Norwegian Drinking Water Regulation from December 2001 based on Council Directive 98/83/EC, did not have a risk-based approach. The annexes from the EU Drinking Water Directive were copied into the Norwegian Regulations as a minimum set of parameters to be tested at minimum frequencies.

The previous Norwegian Drinking Water Regulation, from December 2001, were based on Council Directive 98/83/EC and did not have a risk-based approach. Following the revision of the DWD (2015/1787), the annexes from the EU Drinking Water Directive were copied into the Regulation as a minimum set of parameters to be tested at minimum frequencies.

Waterworks are required to map potential hazards from catchment to consumer and systematically manage the risks. This is a main article (Article 6) of the regulation and many of the following articles are based on this article. Article 19 requires sampling plans to be developed and analysis based on the mapping of potential hazards. Still there are minimum requirements according to the Directive, but the main effort is to ensure that potential risks are managed and monitored. The possibility to reduce the sampling frequency or remove a parameter from the list, is implemented according to Directive 2015/1787.

In addition, several other articles are based on the main principle of risk-based approach(Art. 6). E.g. Art.12 requiring safeguards measures to protect the catchment area and Art. 13 requiring proper methods for water treatment.

The water suppliers are responsible for monitoring the quality of the water and to notify the Norwegian Food Safety Authority (NFSA) if there are any irregularities. NFSA received yearly reports from the water suppliers and perform risk-based inspections and audits.

This case reaffirms the EU approach.

Lesson learned

Regulatory requirements should be simple and distinct in national law to ensure a risk-based approach.

Legionella (KM3)

Legionnaires' disease is a respiratory infection with an overall notification rate in 2019 for the EU/EEA of 2.2 cases per 100 000 population. Four countries (France, Germany, Italy, and Spain) accounted for 71% of all notified cases in 2019.

Surveillance data is collected through different schemes:

• annual retrospective data collection of Legionnaires' disease (LD) cases reported in EU Member States, Iceland and Norway;

• annual retrospective data collection of outbreak events detected and reported in EU Member States, Iceland and Norway.

• near-real-time reporting of travel-associated cases of Legionnaires' disease (TALD) through the European Legionnaires' disease surveillance network (ELDSNet), including reports from countries outside the EU/EEA. This scheme aims primarily to identify clusters of cases that may otherwise not be detected at national level, in order to quickly investigate them and take control measures at the implicated tourist accommodation sites to prevent further infections. Legionnaires' disease cases should be reported to these surveillance schemes in accordance with the 2018 EU/EEA case definition for confirmed cases or probable cases, which includes at least one positive laboratory test.

WHO (2022) reported on the analysis of data by The WHO Collaborating Centre for Health Promoting Water Management & Risk Communication at the University of Bonn, Germany, from mandatory routine monitoring for Legionella in public buildings to determine whether the temperature of domestic hot water is a good indicator of the presence of Legionella spp. in building water systems. Nearly 300 000 datasets were available for 2012–2017 in which Legionella spp. concentrations in the supply flow, return flow and periphery were analysed. Little exceedance of the German technical action value was seen in the supply and return flows. Generally, the concentration of Legionella spp. decreased with increasing temperature, the relation being strong close to the source of heat and weak in the periphery; however, the variation in Legionella spp. concentrations cannot be explained only by water temperature. It was noted that 56 and 53°C are the thermal tipping points for standard installation systems.

Lessons learned

This case illustrates the importance of surveillance in building management as a preventive measure for the most frequent known cause of waterborne (by inhalation of droplets) disease in high income countries.

Building owners should ensure the safety of tap water and suppliers of cold water are responsible for safe operation of the network.

Regular checks for the presence of Legionella bacteria and appropriate control measures applied to engineered water systems may prevent cases of Legionnaires' disease at tourist accommodation sites and in hospitals, long-term healthcare facilities or other settings where higher-risk populations can be exposed.

Legislative and regulatory frameworks should be strengthened to improve surveillance, reporting and outbreak management, with targeted capacity-building programmes and cooperation with the water sector. It is essential to establish multidisciplinary water safety plan development and implementation; ensure water safety through corporate governance, good design, installation,

commissioning and regular operation and maintenance; and effective supervision, training and education.

References:

European Centre for Disease Prevention and Control. Legionnaires' disease. In: ECDC. Annual epidemiological report for 2019. Stockholm: ECDC; 2021.

World Health Organization 2022. Expert meeting on prevention and control of legionellosis in the pan-European region. World Health Organisation.

https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2015.20.46.30064

Rapid assessment of drinking water quality and prevailing sanitary conditions in small scale water supply systems in rural areas of Serbia (KM3)

One third of all water samples taken from SSWSs in rural areas were found to be microbiologically contaminated, correlating with identified sanitary risks and unsolved ownership of the large number of small-scale water supply systems. A national-level systematic survey was conducted in rural areas of Serbia in 2016 based on a rapid assessment methodology developed by WHO.

Drinking-water quality monitoring in rural areas in Serbia is an integral part of the national "Programme on the Protection of the Population Against Infectious Diseases". It is being conducted by the network of the institutes of public health under the Ministry of Health. The drinking water quality parameters and sampling frequency are regulated by the Rule on Hygienic Correctness of Drinking-water ("Official Gazette of SRJ", no. 42/98) for the water supplies that serve more than 20 people (or 5 households). However, the enforcement is weak in rural areas, which resulted in a lack of data on water quality and prevailing sanitary conditions in small-scale water supply systems (SSWSs). Existing challenges such as unregulated ownership of the numbers of rural small water supplies, the lack of responsibility for maintenance and monitoring of facilities, as well as for testing the quality of drinking water hamper the drinking-water quality surveillance.

Absence of a legal entity in managing these water supply systems prevents operation of the sanitary inspection. Maintenance is not supported by the necessary attention, double connections in some households and various illegal connections increase the risk of water contamination, which pose potential risk to health of rural population.

The Republic of Serbia has used the target setting framework under the Protocol on Water and Health to address SSWSs challenges and close the knowledge gaps risk-based drinking-water quality monitoring. Serbia's national targets set under the Protocol include a specific target on undertaking a systematic assessment of drinking-water quality and prevailing conditions in rural water supplies in order to improve the evidence base on rural water supply and enable informed decision-making.

Two types of water supply technologies were investigated: (i) small piped systems serving up to 10 000 people; and (ii) individual supplies which, according to national standards, comprise systems serving less than five households or 20 inhabitants. In total, 1318 small-scale water supply systems were inspected (1136 piped systems and 182 individual supplies) and 1350 drinking-water samples were taken and analyzed for one microbiological parameter (i.e. *Escherichia coli – E.coli*) and 10 physico-chemical parameters (i.e. ammonia, arsenic, chlorine residual, colour, electrical conductivity, hydrogen ions – pH, manganese, nitrate, odour and turbidity). (Fig.1).

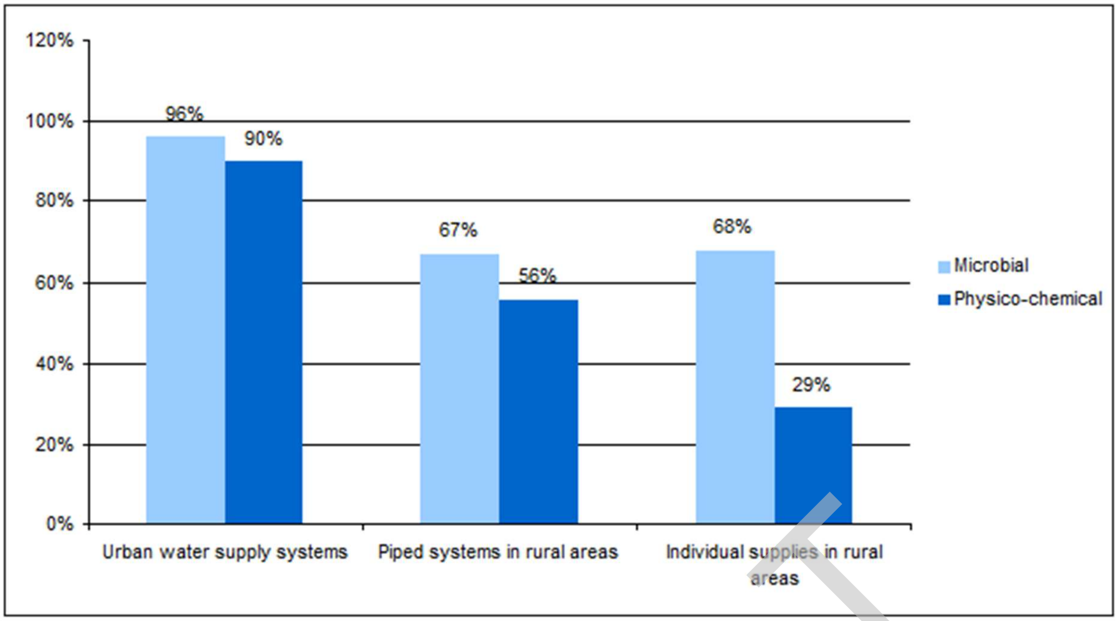


Fig. 1. Microbial and physico-chemical compliance with national water quality standards in rural and urban water supplies in Serbia

The survey findings clearly show a significant water-quality gap between urban and rural areas.

One third of all water samples taken from SSWSs in rural areas were found to be microbiologically contaminated, correlating with identified sanitary risks and unsolved ownership of the large number of small-scale water supply systems. The dominant sanitary risks revealed by sanitary inspection were: absence of regular chlorination, non-established and unmanaged sanitary protection zones, sources of pollution (latrines, sewers, animal breeding, cultivation, roads, industry, rubbish and other sources) placed nearby and unsatisfactory technical conditions.

In many countries, drinking-water quality monitoring in rural areas is lacking and enforcement weak. This results in a lack of data on water quality and prevailing sanitary conditions in small-scale water supply systems (SSWSs). Challenges such as unregulated ownership of rural small water supplies, the lack of responsibility for maintenance and monitoring facilities for testing the quality of drinking water hamper drinking-water quality surveillance, as well as absence of a legal entity in managing these water supply systems. Maintenance is often not supported, double connections in some households and various illegal connections increase the risk of water contamination, which pose potential risk to health of rural population.

The Republic of Serbia has used the target setting framework under the Protocol on Water and Health to address SSWSs challenges and close the knowledge gaps risk-based drinking-water quality monitoring. Serbia's national targets set under the Protocol include a specific target on undertaking a systematic assessment of drinking-water quality and prevailing conditions in rural water supplies in order to improve the evidence base on rural water supply and enable informed decision-making.

This case study illustrates the difficulties in dealing with small rural water supplies and the need for a different but thorough approach.

Lessons learned:

Rapid assessment methodology enabled the identification of the most important causes of contamination and prioritization for the improvement. It served the public health authorities to identify systems that required increased attention and guidance.

- This survey has helped the public health institutes to establish systematic baseline information on small-scale systems in their area of responsibility, increase attention to the challenges related to such systems, and leverage local action towards their improvement.
- It provided useful baseline information on drinking water quality in local or national context, that can be utilized for national target setting and revising or for prioritizing surveillance efforts.
- In the absence of national inventory of small-scale systems in rural areas, the data obtained through the rapid assessment, including development of study design, can complement the national data needed for investment and financial planning the implementation of Water Framework Directive, particularly EU Drinking Water Directive.
- The survey has induced policy actions and measures for the improvement of rural water supplies. These are directed at amendment and enforcement of existing legislation and programmes, as well as development of new regulations.

  The survey makes a strong contribution for designing further education programmes in hygiene and sanitation.

The survey results point to the need for: (i) integration of the Water Safety Planning (WSP) approach in a regulation and its implementation to ensure safe drinking water from source to tap; (ii) increased enforcement of the regulation on foundation and ownership of water supply systems; (iii) development of national and local action plans for improving small-scale systems serving rural populations, and (iv) establishment of a national inventory of small-scale systems that would provide a systematic overview of water supplies in rural areas and effectively support programming of improvement interventions.

References: Jovanović DD, Paunović KZ, Schmoll O, Shinee E, Rančić M, Ristanović-Ponjavić I, the National Expert Group. Rapid assessment of drinking water quality in rural Serbia: overcoming the knowledge gaps and identifying the prevailing challenges. Public Health Panorama. 2017; 3(2):141-356.

Rapid assessment of drinking-water quality: a handbook for implementation. Geneva: World Health Organization; 2012

Jovanovic D, Veljkovic N (eds.). Implementation of the Protocol on Water and Health in the Republic of Serbia – situation analysis. Water and Sanitary Technology. 2015;2:5-10.

Cryptosporidium outbreak in England (KM4)

In 1997 an outbreak of Cryptosporidiosis in Hertfordshire in England affected 300,000 households. The source was chalk groundwater liable to increases in turbidity following heavy rain but there was no *E. coli* detected. The suspected source was previously abandoned small boreholes that the water supplier was unaware of. The source was chlorinated but not filtered. The indicator was killed by the chlorine but the resistant pathogen remained. The first indication of a problem was the detection of cases of Cryptosporidiosis.

Lessons learned

This case illustrates why Water Safety Plans are so important and why consideration of the impact of heavy rainfall is a key part of risk assessment. Reliance on the faecal indicator and chlorination alone is not sufficient.

Milwaukee, USA (KM4)

In the spring of 1993, a very large outbreak of Cryptosporidium occurred in Milwaukee, Wisconsin, USA in which an estimated 400,000 people became ill. The cause of the outbreak was traced to the water supply. Several explanations have been put forward to explain the origin of these oocysts. A widely accepted explanation of the origin of the oocysts was firstly, increased water flows into Lake Michigan because of a late spring thaw, coupled with greater-than-normal winds, resulted in increased flows into the drinking-water inlet. Second, a treatment plant failure on March 23 occurred.

An Environmental Protection Agency (EPA) water engineer inspected both Milwaukee water treatment plants and found them to meet existing state and federal water quality standards at the time of the outbreak. However, at the southern plant the water quality data showed a definite increase in turbidity, which reflected poor filtration. The turbidity was measured every eight hours—the minimum amount required by authorities for routine monitoring.

The EPA inspector also found that, to reduce costs of chemicals used in water treatment, the Milwaukee plants recycled water used to backflush and clean their sand filters. This backflushed water (backwash) containing whatever was caught by the sand filter was added to source water coming into the plant rather than being discharged into a sewer. Over time, the concentration of any contaminant in the water being treated by the plant increases and the risk that the sand filters may not effectively remove the contaminant also rises (Mac Kenzie et al., 1994b).

Weather conditions before the outbreak were also very unusual (Mac Kenzie et al., 1994b). An extremely high winter snowpack had melted rapidly while the frostline remained high, resulting in high runoff containing greater-than-usual levels of organic material. There was also extremely (over 30% more than usual) heavy rainfall during March and April.

At the time of the outbreak, during periods of heavy rain, Milwaukee's storm sewers frequently overflowed. During these periods, sewage was chemically disinfected but otherwise bypassed full sewage treatment. Thus, during periods of high flow, the storm sewer and sanitary sewer water that bypassed treatment then emptied into an area within a breakfront on Lake Michigan, just north of the intake for the south water plant

At the same time, high and frequent northeasterly winds probably accentuated the southerly flow of water out of the breakfront and toward the intake for the southern water plant. The winds also forced the water within the breakfront closer to the lakeshore, accentuating plumes of storm water and treated sewage that flowed through gaps in the breakfront toward the nearby south plant intake grid (Addiss et al., 1995).

At the southern water plant, personnel lacked experience with dosing the new coagulant in response to spikes in finished water turbidity. By the time the decision was made, on April 2, to continue the use of alum as the coagulant, treated water was already significantly contaminated with *Cryptosporidium* oocysts.

In early 1993, a university in central Milwaukee was constructing new soccer fields. The drainage from these fields was directed into a small storm sewer that had to be connected to a larger main sewer. When construction workers cut into the main sewer to make this connection, they discovered a large impaction of bovine entrails and other waste from a large meatpacking plant located nearby. Ensuing investigation and inspection by city officials revealed a cross connection of a sewer from the abattoir kill floor with the storm sewer. This cross-connection existed for years, and these wastes accumulated over a prolonged time. Following correction of the cross-connection, removal of the impacted wastes and hauling the wastes away occurred in early March. Potentially some of these disrupted wastes could have been discharged through the storm sewer directly into the Menomonee River or directly reach the sewage treatment facility following correction of the cross connection. While it is not clear whether the existence and correction of the cross-connection and clean-up of the sewer influenced this outbreak, it was an issue that was addressed during the investigation.

This case illustrates the importance of risk-based approaches in identifying weaknesses in a supply system and the need for avoiding complacency.

Among the many lessons learned from the 1993 Milwaukee *Cryptosporidium* outbreak, the following lessons and needs stand out:

1. *Consistent application of stringent water quality standards.* At the time of the outbreak, drinking water was regulated either by the EPA or by individual states, as was the case in Wisconsin, and the MWW water treatment and quality testing results were in compliance with all state and federal standards. Existing state and federal standards for treated water were insufficient to prevent this outbreak (Mac Kenzie et al., 1994b).

2. Measures of turbidity in treated water is a good indicator of potential contamination rather than viewing turbidity as an aesthetic measure of clarity. Improving monitoring and the quality of water filtration is a powerful lesson from this incident.

3. *Testing of source and finished water for Cryptosporidium*. This was needed to detect risk for an outbreak and to determine when the water was safe to drink afterward. At the time of the outbreak, the sampling process for such testing was difficult and lengthy, and it was not standardized. Improved means of sampling and testing source and finished water for Cryptosporidium were needed.

4. *Surveillance*. Cryptosporidium infection was not a reportable public health condition at the time of the outbreak. Watery diarrhoea proved to be a good case definition for Cryptosporidium infection in an outbreak setting; a more refined clinical case definition was necessary to detect sporadic cases. It would have been useful to have a surveillance system

in place to analyze consumer complaints to the water authority before the outbreak as this spike in complaints to the MMW occurred (Proctor et al., 1998).

5. *Communication.* Targeted public health messages shared with other health departments is useful. This requires guidelines for governmental response to findings of oocysts, increased turbidity of finished water, and elevated particle counts in finished water. Interagency coordination is vital. Electronic and print media in local languages are essential to communicating risk and delivering other important public health messages during the outbreak.

References

https://doi.org/10.1093/aje/kwi005

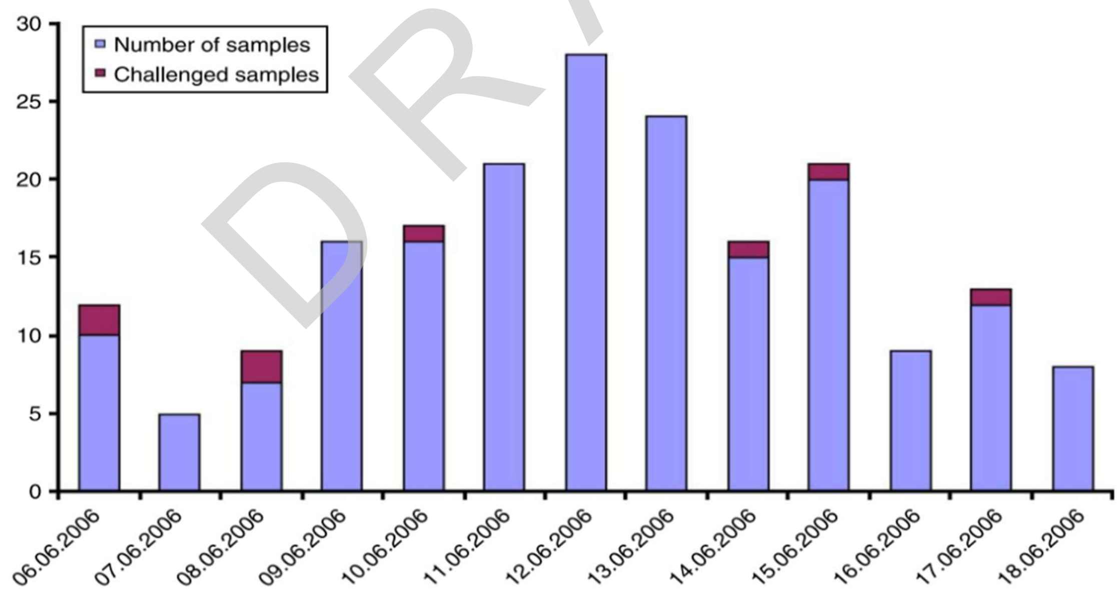
https://www.ncbi.nlm.nih.gov/books/NBK28459/

Early warning systems in outbreak prevention in Hungary (KM4)

Microbiological sampling was carried out following an extreme precipitation event. This case study highlights the risk of relying on routine testing for faecal indicators and how this is insufficient for preventing outbreaks of waterbourne illness.

Miskolc is a city, located in North-Eastern Hungary, of approximately 80000 inhabitants. The city relies on karstic groundwater for its drinking water supply. Following an extreme precipitation event, it experienced a multi-etiological drinking water outbreak affecting over 3500 people.

The water of the karstic spring is generally delivered without treatment, except for safety chlorination. The water supply was monitored regularly according to the frequency defined in the drinking water legislation. Samples were tested routinely for turbidity, microbiological and chemical parameters. During a week of extreme precipitation, increased turbidity was observed, but as faecal indicators were not detected, normal operation was continued. Following the 3-day Pentecost holiday, the water supply was resampled, but by the time the results arrived (two days later), general practitioners already reported increased incidence of gastrointestinal illness. Boil water advice was given and the consumption of water restricted. The advice was upheld until the operation of the water supply returned to normal, and the whole system was disinfected. Epidemiological investigation confirmed the consumption of tap water as the source of infection.



Bacteriological samples in mains and number of non-compliant samples, 6–18 June 2006.

This case study illustrates why operational monitoring is a vital component of risk-based surveillance.

Lessons learned

The cause of the outbreak was the extreme precipitation that changed the underground current in the karst and washed contamination into the water source. Routine testing for faecal indicators was insufficient in preventing the outbreak. Turbidity was found to be indicative of events leading to the deterioration of water quality. Online turbidity monitors were installed, and a control value was assigned to the measurements as an early warning of potential contaminations. A rapid method for *E.coli* testing was also introduced. It was recommended that supply operators should introduce simple operational control points for early detection and water incidents and appropriate intervention.

Operational monitoring for untreated water is vital. Water Safety Plans would have helped to have prevent this outbreak.

Cryptosporidium and water safety plans, England (KM4)

In 1997 an outbreak of Cryptosporidiosis in Hertfordshire in England affected 300,000 households. The source was chalk groundwater liable to increases in turbidity following heavy rain but there was no *E. coli* detected. The suspected source was previously abandoned small boreholes that the water supplier was unaware of. The source was chlorinated but not filtered. The indicator was killed by the chlorine but the resistant pathogen remained. The first indication of a problem was the detection of cases of Cryptosporidiosis.

Lessons learned

This case illustrates why Water Safety Plans are so important and why consideration of the impact of heavy rainfall is a key part of risk assessment. Reliance on the faecal indicator and chlorination alone is not sufficient.

Risk-based sampling for chemistry in Jersey (KM5)

Extensive chemical monitoring is expensive and not necessary following a risk assessment.

Jersey is an island in the Channel. It primarily uses surface water as groundwater sources on the Island are very limited and there is a fluctuating population with a higher population during the summer holiday months when tourist numbers increase. The Island has limited heavy or manufacturing industry but does have an extensive agriculture, including dairy based around the famous Jersey cows and a significant distinctive early potato growing industry (Jersey Royals). The problems of raw water contamination relate to microbiological contamination from agriculture and also septic tanks and chemical contamination with nitrate and a range of pesticides. Most of the results of extensive chemical monitoring to meet the requirements of the UK Drinking Water Regulations adopted in Jersey Law resulted in non-detects or very low levels of chemicals, but the cost of monitoring was significant.

A risk-based approach to monitoring was introduced, which reduced the number of determinations and the cost of carrying out that monitoring by over 50%. However, the problem of raw water recontamination with pesticides remained and the reduction in cost of the monitoring programme released funds to increase the monitoring of raw water which allowed better management of quality by changing streams from which water was abstracted into reservoirs and also identification and management of historic contamination by pesticides that were no longer used. The data were also pivotal in persuading the agricultural industry to adopt better catchment practices to prevent or minimise contamination.

This case study illustrates that the introduction of risk-based monitoring allows the direction of scarce resources to where they can do most good. Jersey introduced risk-based monitoring which reduced the number of determinations by over 50% as measuring many zeros. This freed resources for more raw water monitoring of pesticides which were a problem on the island and pressurising agriculture to improve practice. This case study shows the practical application of risk-based monitoring for chemicals.

Risk assessment of private water supply, England

Reference: https://www.dwi.gov.uk/case-studies/general/water-safety-plan-approach-to-improving-the-safety-of-a-private-supply/

This case study concerns a private water supply serving a large estate where the original outbuildings and stables had been converted into 34 domestic dwellings. The source of the supply was two spring collection chambers from which water is piped for 2km into a large brick-built Victorian underground reservoir ($20m^3$).At this point water was treated (UV treatment and pH correction) before being distributed to the properties.

The local authority carried out a risk assessment and found a risk of contamination from slurry spreading around the springs. In response, a 50m exclusion zone was created around the springs as a risk mitigation measure. In the following spring several of the householders contacted the local authority reporting discoloured water, with a smell of manure. On investigation slurry spreading

outside the 50m exclusion zone was noted and the exclusion zone was extended to include the entire hill slope above the spring to its crest.

In the following September, the farmer spread slurry on an area outside the exclusion zone (the hill slope on the opposite side to the spring) taking care first to check the forecast was for dry weather. However, within hours, consumers were once again contacting the local authority to report problems with the water supply. The owner of the supply issued boil water advice to all the properties and commenced an investigation.

The owner found that only one spring was affected and immediately put the emergency plan in place. This involved diverting the spring to waste (through the overflow) and blocking off the pipework to the reservoir to prevent any more contaminated water entering the supply. However, the water in the reservoir was already contaminated. The local authority attended the site and permitted the owner's alternative supply arrangement. It was felt that the spring that was unaffected could still be used if the reservoir was bypassed. The reservoir was isolated and flow from the uncontaminated spring (chamber) diverted into a temporary reservoir (two water tanks). The tanks were then connected to existing downstream pipework to the properties. This allowed the reservoir to be drained to waste.

At the time of the site visit the local authority formalised the boil water advice in a Regulation 18 Notice. The potential risk to health was verified subsequently by the detection of *E.coli* in samples. The Notice also set out the need for the treatment system to be checked and, if necessary, improved by a competent person, together with cleaning out the reservoir, widening the exclusion zone to above the contour line of both spring sources and development of a water safety plan.

A specialist water contractor improved the treatment system so that it was capable of dealing with the raw water quality challenges of high colour and turbidity due to natural organic matter. A sand filter was installed as additional pre-treatment and the owner arranged for annual inspections to be carried out. The reservoir was cleaned out by jet spray and then disinfected and flushed, likewise the downstream pipework. While these works were taking place, the owner checked the location and condition of the existing pipework and replaced a section in poor condition. A bypass valve was installed after each spring chamber to facilitate running to waste, enabling timely and effective action in any future event and to improve resilience generally (enabling each source to be operated independently of the other).

A water safety plan was completed and detailed weekly checks, annual servicing, alternative supply arrangements and instructions on how to use new diversion valves to isolate a source from the reservoir, as and when required.

Lessons Learned

This case study highlights how the safety of a private supply relies on a comprehensive risk management plan based on the specific risks of the supply. The Inspectorate's risk assessment tool is based on the WHO safety plan approach and its outputs are designed to identify what can be done to develop a comprehensive risk management plan. Specifically the tool is designed to produce action plans that local authorities should be passing on to owners so that water safety planning knowledge is transferred to those who are responsible for the safety of the supply. The Inspectorate recommends that when carrying out the required five-year review of a risk assessment, local authorities utilise the action plan component of the risk assessment tool.

https://www.dwi.gov.uk/case-studies/general/water-safety-plan-approach-to-improving-the-safety-of-a-private-supply/

https://www.dwi.gov.uk/case-studies/general/lack-of-risk-assessment-on-an-historic-regulation-9-supply/