Risk Evaluation and Decision Support for Drinking Water Systems

Introduction

The vital importance of a reliable and safe drinking water supply makes efficient risk management necessary for water utilities. Risks must be assessed and possible risk-reduction measures evaluated to provide relevant decision support. The World Health Organization (WHO) emphasises the use of an integrated approach where the entire drinking water system, from source to tap, is considered when assessing and managing risks.

This report provides a background to risk evaluation and decision support for managing risks in water utilities. A special focus is put on cost optimisation, and methods for cost-benefit analysis (CBA), cost-effectiveness analysis (CEA) and multi-criteria decision analysis (MCDA) of risk reduction alternatives are presented.

Results

A dynamic fault tree method is presented that enables quantitative, integrated risk assessment of drinking water systems. It is shown how the method can be used to evaluate uncertainties and provide information on risk levels, failure probabilities, failure rates and downtimes of the entire system and its subsystems. The fault tree method identifies where risk-reduction measures are needed most and different risk-reduction alternatives can be modelled, evaluated and compared. The method is combined with economic analysis to identify the most cost-effective risk-reduction alternative.

Integrated risk assessments of drinking water systems are commonly performed using risk ranking, where the probability and consequence of undesired events are assessed using discretised scales. There is, however, no common, structured way of using risk ranking to prioritise risk-reduction measures. Two alternative models for risk-based, multi-criteria decision analysis (MCDA) for evaluating and comparing risk-reduction measures have therefore been developed. The MCDA models are based on risk ranking, they can consider uncertainty in estimates and include criteria related to, for example, different risk types and economic aspects.

This report provides methods for integrated risk assessment that make it possible to evaluate risks and prioritise risk-reduction measures in an efficient way. This study also provides good examples of applications of these methods in Gothenburg, Sweden, Bergen, Norway and Březnice, Czech Republic.

Based on the practical applications of these methods, it is concluded that the methods provide relevant decision support for efficient risk management in water utilities.

More information

The results of this work are presented in the report "Risk Evaluation and Decision Support for Drinking Water System".

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TKI Categorisation

Classification											
Supply Chain		**Process Chain**		**Process Chain (cont'd)**		**Water Quality**		**Water Quantity (cont'd)**	
Source		**Raw water storage**		**Sludge treatment**		**Legislation/regulation**		- Leakage	
- Catchment		- Supply reservoir		- Settlement		- Raw water (source)		- Recycle	
- Groundwater		- Bankside storage		- Thickening		- Treated water			
- Surface water		**Pretreatment**		- Dewatering		**Chemical**		**Risk Management / Consumers**	
- Spring water		- Screening		- Disposal		- Organic compounds			
- Storm water		- Microstraining		**Chemical dosing**		- Inorganic compounds		**Risk analysis**	
- Brackish/seawater		**Primary treatment**		- pH adjustment		- Disinfection by-products		- Hazard identification	x
- Wastewater		- Sedimentation		- Coagulant		- Corrosion		- Risk estimation	x
Raw water storage		- Rapid filtration		- Polyelectrolyte		- Scaling		**Risk evaluation**	
- Supply reservoir		- Slow sand filtration		- Disinfectant		- Chlorine decay		- Risk tolerability decision	x
- Bankside storage		- Bank filtration		- Lead/plumbosolvency		**Microbiological**		- Analysis of options	x
Water treatment		- Dune infiltration		**Control/instrumentation**		- Viruses		**Risk reduction / control**	
- Pretreatment		**Secondary treatment**		- Flow		- Parasites		- Risk reduction options	x
- Primary treatment		- Coagulation/flocculation		- Pressure		- Bacteria		- Decision making	x
- Secondary treatment		- Sedimentation		- pH		- Fungi		- Implementation	
- Sludge treatment		- Filtration		- Chlorine		**Aesthetic**		- Monitoring	
Treated water storage		- Dissolved air flotation(DAF)		- Dosing		- Hardness / alkalinity		**Risk Communication**	
- Service reservoir		- Ion exchange		- Telemetry		- pH		- Communication strategies	
Distribution		- Membrane treatment		**Analysis**		- Turbidity		- Potential pitfalls	
- Pumps		- Adsorption		- Chemical		- Colour		- Proven techniques	
- Supply pipe / main		- Disinfection		- Microbiological		- Taste		**Trust**	
Tap (Customer)		- Dechlorination		- Physical		- Odour		- In water safety/quality	
- Supply (service) pipe		**Treated water storage**						- In security of supply	
- Internal plumbing		- Service reservoir				**Water Quantity**		- In suppliers	
- Internal storage		**Distribution**						- In regulations and	

								regulators	
		- Disinfection				**Source**		**Willingness-to-pay/acceptance**	
		- Lead/plumbosolvency				- Source management		- For safety	
		- Manganese control				- Alternative source(s)		- For improved taste/odour	
		- Biofilm control				**Management**		- For infrastructure	
		Tap (Customer)				- Water balance		- For security of supply	
		- Point-of-entry (POE)				- Demand/supply trend(s)			
		- Point-of-use (POU)				- Demand reduction			

TKI Categorisation (continued)

Contains		**Constraints**		**Meta data**					
Report	x	Low cost		*Author(s)*					
Database		Simple technology		*Organisation(s)*					
Spreadsheet		No/low skill requirement		*Contact name*					
Model	x	No/low energy requirement		*Contact email*					
Research	x	No/low chemical requirement		*Quality controller name*					
Literature review		No/low sludge production		*Quality controller organisation*					
Trend analysis		Rural location		Source					
Case study / demonstration	x	Developing world location		*Date prepared*					
Financial / organisational				Date submitted (TKI)					
Methodology	x			Date revised (TKI)					
Legislation / regulation									
Benchmarking									