Assessment of current treatment works to handle climate change related pollutants and options to make current multi-barrier systems climate change proof – Summary of Prepared Research

Illustration: http://destinationofmarvel.blogspot.no/2011/02/stop-climate-change.html

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Author(s)
Gema Raspati (SINTEF), Jose Menaia (LNEC), Klaasjan Raat (KWR), Maria João Rosa (LNEC), Beatriz De La Loma González (KWR), Edvard Sivertsen (SINTEF)

Quality Assurance
By Bjørnar Eikebrokk (SINTEF)

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Contents

1 OVERVIEW

Studies show that climate change will affect all areas of the water industry, including the quality and availability of water resources, the infrastructures, and the treatments that are required to meet the quality standard. Key questions addressed in this work include identification of the expected source water quality changes, the impact of these quality changes to the water utilities, identification of vulnerabilities of current water treatment schemes, and adaptation/mitigation options to cope with the expected future changes.

A survey (questionnaire) was conducted amongst the water utilities in the partner cities. The questions were based on the identified source water quality challenges and the preparedness of the water utilities in coping with these challenges. Most of the water utilities have already planned for actual measures in coping with the expected climate change impacts. Some of the climate change impacts are only considered as probable threats to the current treatment systems. For these and unforeseen impacts, in general there is a need for supplementary processes and/or redesign of the current treatment systems and operation.

The need for treatment scheme modifications or adaptations was assessed in such a way that the resilience against expected or probable climate change impacts is acquired. The report highlights some of the potential treatment technologies as viable options in restoring the barrier that is potentially compromised owing to the climate change effects. The options to redesign water treatment process that include cutting edge treatment technologies, modification of the conventional treatment, and integration of natural systems as part of treatment processes are presented.

2 FINDINGS

2.1 Impacts of climate change on raw water quality

Climate change will impact water supply systems by altering source water availability and quality, and reducing the reliability of infrastructures. An overview that describes various impacts of climate change on the urban water cycle has been given by Ugarelli et al. (2011), and effects relevant for water treatment have been extracted and made the basis for the survey. These effects comprised the following:

- Increased water temperature
- Increased NOM concentrations
- Increment in turbidity, taste and odour compounds, and problems associated with algae
- Increased microbial loads in source water
- Faster and more severe raw water quality changes
- Increased concentrations of organic and inorganic micropollutants
- Raw water limited availability and scarcity
- Intrusion of saline water into groundwater and surface water

2.2 Adaption and mitigation strategies

Mitigation is defined as an anthropogenic intervention as response to negative consequences or an effort of making the consequences less severe. Adaptation counts for adjustment of a system in response to actual or expected stimuli or their effects, which moderates harm or exploits beneficial opportunities. Following assessment of climate change mitigation by IPCC (2007a and 2007b), current mitigation actions would not prevent climate change from happening in the next few decades, no matter how rigorous and inexorable the mitigations are. Adaptation is therefore inevitable and might be the only option available in the changing environment, despite the facts that there are limits and barriers to effective adaptation.

Adaptation or mitigation strategies will have to take into account (Elliot et al., 2011):

- The reason for deteriorated quality (source of pollution: diffuse or point source, rise of sea level, reduced flow, increased run-off, etc.).
- The type of quality impairment (suspended solid, turbidity, NOM, microbial contamination, micropollutants, inorganic contamination, algal blooms, etc.).
- The vulnerability of the used water source (present state, protective status, etc.).

Adaptation or mitigation strategies may range from managerial to technical solutions. In general adaptation/mitigation of water treatment facilities due to water quality change can be established by taking into account these basic principles (Pronk and Kazner, 2008):

- Flexibility: Considering alternative raw water sources, applying modular treatment processes, upgrading treatment technology and capacity.

- Integration: Integrated water resource management, water saving campaigns, raw water source protection, and catchment monitoring, integration of all stakeholders including NGOs and customers. Restrictions as regards to settlements in catchment areas are by health authorities considered important to reduce risk of contamination (Vevatne et al., 2007).
- Local conditions: Emission monitoring/registering, natural background concentration monitoring, water use restrictions, drought management plant, preference for avoidance or remediation (adaptation vs. mitigation).

Further, the possible adaptation/mitigation strategies also comprise:

- Flexibility in water treatment: application of advanced treatment methods particularly in periods of drought or flooding. Flexibility is also required for temperature induced algal blooms resulting in the occurrence of algal toxins in the surface water reservoirs.
- Ban on combined sewer overflows (CSOs) of rainfall events directly after periods of drought or during peak flush events. Low cost options such as use of constructed wetlands to collect, buffer, and treat CSO should always be considered first.
- Flexibility of the treatment facility to treat different raw water resources in order to avoid highly polluted raw water from entering the treatment facility during storm/drought events.

Optimization of existing WTPs should always be the first step towards adaptation of water treatment systems to climate change. The next option may include assessments of the need for supplementary treatment steps. Replacement of the treatment technology should be viewed as the last resort if the above means fail or are inadequate.

2.3 Multi-barrier approach

The best way to make sure drinking water systems are reliable in supplying good quality and safe water is to exercise a preventive risk management approach. The key to ensuring clean, safe and reliable drinking water is to understand the drinking water supply from the source all the way to the consumer's tap. This knowledge includes understanding the general characteristics of the water source and the surrounding catchments, as well as mapping all the real and potential threats to the water quality. These threats can be natural, such as seasonal droughts or flooding, or created by human activity, such as agriculture, industrial practices, or recreational activities in the watershed as discussed previously in this report. Threats can also arise in the treatment plant or distribution system owing to operational failures, breakdowns or aging infrastructure (CCME, 2004 & WHO, 2006).

The multi-barrier approach takes all of these threats into account and makes sure there are sufficient "barriers" in place to either eliminate them or minimize their impacts. Multi-barrier approach includes selecting the best available source (e.g., lake, river, and aquifer) and protecting it from contamination, using effective water treatment, and preventing water quality deterioration in the distribution system. The approach recognizes that while each individual barrier may be not be able to completely remove or prevent contamination, and therefore protect public health, together the barriers work to provide greater assurance that the water will be safe to drink over the long term.

The benefits associated with implementing a multi-barrier approach could include better public health protection, a reduction in healthcare costs, better management of water treatment costs, and, indirectly, increased environmental protection. In tackling climate change impact, this approach is relevant given the scale of potential impacts from climate change that may hamper provision of clean, safe, and reliable drinking water.

In addition to setting drinking water quality objectives or standards, effective drinking water regulatory programs may consist of both abatement and enforcement programs (CCME, 2004). The abatement component involves working co-operatively with system owners/operators to prevent and/or solve drinking water supply or quality problems. On the other hand, the enforcement component involves taking appropriate action when violations of specific requirements occur. Abatement activities by a regulatory agency demonstrate a commitment to actively assist partners in ensuring the provision of safe drinking water by providing technical advice and assistance. Enforcement activities are a necessary demonstration of the importance that a regulatory agency places on the provision of safe drinking water. It indicates that non-compliances with requirements are taken seriously. The intention of enforcement is to ensure appropriate remedial action and monitoring requirements are implemented to protect the quality of drinking water.

Accordingly, the work has put focus on treatment technologies, including different schemes that take advantage of their synergistic combination, then contributing to the implementation of multi-barrier systems. Incorporating natural systems as part of the treatment strategy has also been considered. Advantages and disadvantages of both stand-alone and combinations of technologies have been addressed and discussed. The integration of these technological approaches in more comprehensive managerial/regulatory strategies has also been addressed and acknowledged as important for the establishment of multi-barrier systems.

2.4 Findings from the water treatment survey of partner cities

The contributions received from the water utilities may be summarized as follows:

- The utilities have in common the majority of the challenges listed:
  - most WTPs indicated expected or probable increase in water temperature, NOM concentration, turbidity, T&O compounds, (micro)algae and/or cyanobacteria, microbial load, biofilm formation potential
  - many of the WTPs indicated expected or probable faster and more severe raw water quality changes in surface water and increased concentration of nutrients and organic micropollutants

- Two water utilities (Oasen and Barcelona) reported sea water intrusion as the main future challenge, which was also mentioned for catchments in the Algarve region Multimunicipal System in drought scenarios. Shortage of raw water source was reported also by two utilities (Oslo and Simferopol), but for different reasons. Raw water shortage in Simferopol is directly related to climate change (effect of drought), whereas in Oslo is merely due to population growth.

- Most of the water utilities have already planned for actual measures in coping with the expected climate change impacts. Some of the climate change impacts are foreseen, but only considered as probable threats to the current treatment systems. More focus must be put in coping with foreseen/unforeseen problems that may compromise the water supply safeguard.

- The utilities rely predominantly on conventional surface water treatment assisted by ozonation and PAC (or GAC in the case of Seattle) adsorption to handle these challenges. Adjustment of chemicals' (particularly the oxidants ozone and chlorine, and the coagulant) and PAC dosing, sludge wasting and filtration cycles (filtration rates, filtration time, and backwashing) are key-measures for adapting the water treatment to the climate change impacts encountered.

- Neither physical (e.g. nanofiltration (NF) or reverse osmosis (RO)) nor biological (e.g. slow sand filtration (SSF) , biologically active granular activated carbon (BAC) biofiltration) or hybrid (fine-PAC adsorption/membrane (bio)reactor) barriers were reported, so small and hydrophilic organics may not be effectively removed by the drinking water treatment (Rosa et al. 2009, WHO 2011). This may decrease bio stability and poses a threat to the distribution system with respect to the risk of microbial regrowth. The threat would be greater to water utilities that do not exercise residual disinfectant in their distribution system.

- The control of micropollutants might be particularly challenging in drought scenarios and also in high precipitation events when the raw water becomes (suddenly in intense rainfall events) highly turbid, NOM and microbiologically load which strongly hinder the performance of the oxidation, coagulation and adsorption processes. Special care must be taken to ensure a safe disinfection while minimizing the DBP formation, e.g. bromate and THMs. Strong variations in water background inorganic matrices driven by water scarcity and rain events may also severely impact the treatment effectiveness and efficiency. Bromate formation may become an issue in water scarcity scenarios, when the inlet bromide concentration increases due to saline intrusion in groundwater and surface waters used for drinking water production (USEPA 2005, Rosa et al. 2009, WHO 2011).

- Apart from technological approach, adaptation and mitigation measures can be supported by effective implementation of relevant regulations e.g. source protection, water reuse and saving initiatives and other managerial aspects of water resource.

Accordingly, this context suggests some specific needs for supplementary processes and redesign of the current treatment systems and operation. Likewise, the survey reveals the need of regulatory measures to protect and improve raw water quality and minimize the degradation of distribution network water (e.g., due biofilm development and intrusions), thus alleviating challenges posed to WTP and complementing multicarrier systems enabling for the consumers safety.

3 CONCLUSIONS AND RECOMMENDATIONS

This report concludes that adaptation or mitigation strategies will have to take into account the reason for deteriorated quality, the type of quality impairment and the vulnerability of the used water source. Adaptation or mitigation strategies may range from managerial to technical solution. In general adaptation/mitigation of water treatment facility due to raw water quality change can be established by taking into account three basic principles: flexibility, integration, and understanding of local conditions. Information presented in this report may be useful to other water utilities experiencing similar problems. This report may serve as a guideline in which the other water utilities may learn from the experiences and actions taken by the water utilities in partner cities in coping with specific water quality issues due to climate change.

Apart from technological approach, this report also underlines that, in order to fully ensure the establishment of multi-barrier systems, adaptation and mitigation measures need to be supported by effective implementation of relevant regulations e.g. source protection, water reuse and saving initiatives and other managerial aspects of water resource that add resilience to water treatment systems against climate change.

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