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ENVIRONMENTAL IMPACTS OF CHANGE IN SUPPLY WATER QUALITY ON DISTRIBUTION OF POTABLE WATER: A TECHNICAL REVIEW

KEY WORDS: Water quality, drinking water, and treatment

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ABSTRACT

BACKGROUND: Driven by the development of water purification technologies and water quality regulations, the use of better source water and/or upgraded water treatment processes to improve drinking water quality have become common practices worldwide.

OBJECTIVE AND METHODOLOGY: The objective of this paper is to review past years' studies and evaluate the environmental impacts of change in water supply quality on distribution of potable water.

RESULT: The destabilized and mobilized distribution network-harbored material may be retained in the distribution networks as loose deposits instead of flowing out at customers' taps if the generated particulate matter has a weight that can balance the hydraulic force.

CONCLUSIONS: There is a need for a framework comprising a system assessment, management plans and operational monitoring as a means of evaluating the potential environmental impacts before changing the supply-water quality.

INTRODUCTION:

Drinking water treatment makes water potable by removing contaminants present in the source water. Depending on the contaminants present, different technologies and their combinations can be used for drinking water production [1]. In both developing and industrialized countries, a growing number of contaminants are entering water supplies due to human activity: heavy metals, pharmaceuticals, endocrine disruptors, pre-fluorinated compounds, flame retardants or biocides. Public health and environmental concerns drive efforts to tighten water quality regulations and further treat waters previously considered clean. These efforts have greatly promoted the development of water treatment science and technology and the upgrading of treatment plants over several decades [2,3].

The treated drinking water is delivered to individual dwellings, communal buildings and other customers' through pressurized distribution networks (Dns), including drinking water distribution systems (DWDSs) and premises plumbing. Those DNs - consisting of pipes, pumps, valves, storage tanks, reservoirs, meters, fittings, and other hydraulic appurtenances transport the drinking water from a centralized treatment plant or well to customers' taps. For the drinking water provision, distribution is as important as production, because the quality of tap water can only be as good as the condition of the pipes it flows through [4,5].

OBJECTIVE AND METHODLOGY:

The objective of this paper is to review past years' studies and evaluate the environmental impacts of change in water supply quality on distribution of potable water.

DISCUSSION:

Water Quality Stability and Retrogression during Distribution

There is a broad consensus that the goal of drinking water supply should be seen as providing good quality at the customer's tap rather than only at the point it leaves the treatment plant. The treated drinking water enters the distribution system containing physical loads (particles), microbial loads (cells) and nutrient loads (organic and inorganic nutrients) [6, 7]. Given the occurrence the long retention times (also referred as "water age") especially at the dead-end nodes and in premises plumbing the simultaneously impact of physiochemical and microbiological processes can result in the deterioration of the quality of the water that reaches customer's tap compared to the original water produced at the treatment plant. Such water quality deterioration has been observed and reported worldwide: for example, higher turbidity and particle counts.

Uneven Supply-water Quality Changes and Effects

The tightening of water quality regulations, the development of water purification technologies, and the awareness of the deterioration of water quality have led to the upgrading of treatments at water utilities and thus to a better quality treated water at treatment plants worldwide. This upgraded treatment constitutes a cause of irregular changes in supply-water quality; other causes are the use of alternative source water and variations in disinfectant strategies [8, 9]. Uneven changes therefore refer to situations that are qualitatively different from the regular operation of a DWDS. Accordingly, the accompanying transition effects refer to the often-dramatic impact of these changes in the networks, and particularly on distribution network-harbored material (DNHM) [10].

Supply-water quality is of course subject to regular fluctuations related to daily variations in source-water quality and treatment performance. In addition, there may also be periodic changes, such as operationally related changes (filter backwash), seasonal changes of surface-water quality, annual switching of water sources, and changes in the mixing ratio of multiple water sources [12]. All of these periodic changes in supply-water quality fall under the rubric of regular changes and are part of the environment in which the DNHM has developed and stabilized in the distribution system (biofilm, pipe scales and biofilm matrix).

Chemical Destabilization

Chemical destabilization is mostly caused by the differences of pH, redox potential, and ion composition in the supply water. This is especially relevant in the remobilization of contaminants bound by pipe scales on metal pipes via desorption and/or dissolution. For example, large amounts of Fe rich particulates (>300 mg/l) were released after a change was made from no disinfection to chlorination (Equation (2)); and in another study, the switch in source water caused Fe concentration peaks (>10 mg/l) in the first month because of the presence of high SO_4^2 concentration (Equations (3) and (4)). Moreover, the replacement of chlorine for monochloramine caused the release of up to 4800 mg/l Pb (Equation (5)

$CaCO_3 + CO_2 + H_2O4 \rightarrow Ca2^+ + 2HCO^-_3$	(1)
$Fe(OH)_3 + 3HCl \leftrightarrow 4FeCl_3 + 3H_2O$	(2)
$FeOOH + So_4^{2-} \leftrightarrow (FeO)_2SO_4 + 2OH^-$	(3)
$(FeO)_2SO_4 + 2H_2O \leftrightarrow 2Fe^{3+} + SO_4^{2-} + 4OH^-$	(4)
$Pb_3\,(CO3)_2(OH)_2 + 2H^+ \leftrightarrow 3Pb^{2+} + 2CO_3^{2-} + 2H2O$	(5)

Environmental Impacts

Old Pipes

Old pipes are vulnerable to the intrusion of contaminants because of the increased number of pipe breaks and negative pressure events. In the case of transition effects caused by physiochemical and microbiological destabilization, the corrosion, pipe material leaching, and pipe scale release caused by the irregular changes in supply-water composition, may accelerate the pipe damaging process [8, 11, 14, 16, 18].

Potable Water Quality and Safety

Physically, the release of DNHM can cause problems, such as blue water (high copper concentration) and red water (high iron concentration) and in some cases water meter clogging which leads to pressure loss at the taps. Chemically, the release of heavy metals (Pb, As, Cu, Fe, Mn) may pose health risks to customers [17]. Microbiologically, the detachment of biofilm and the release of cells may lead to high cell densities in the water column. As (opportunistic) pathogenic microorganisms have been frequently detected in biofilms and loose deposits in DNs and their release into water column can, in principle, constitute a pathogen mobilization process and pose health risks to consumers [16, 18, 19].

Water Distribution Process

The destabilized and mobilized DNHM may be retained in the DNs as loose deposits instead of flowing out at customers' taps if the generated particulate matter has a weight that can balance the hydraulic force. In this situation, the organic components, which were previously protected by pipe scales and biofilm matrix from contacting disinfectant residuals in the water column will, when release, cause faster decay of disinfectant residuals and form disinfection by-products (DBP) in the system where the disinfectant residuals maintained during distribution [12,19]. The mobilized but retained particulate matter also offers more surface area and available nutrients for bacterial growth [19].

CONCLUSIONS:

It can be concluded that not much information has been available on the environmental impacts of change in water supply quality on distribution of potable water, nor are there any proper guidelines for the avoidance of potential esthetic and health risks. Based on this technical review and as per the WHO's outlined Water Safety Plans, there is a need for a framework comprising a system assessment, management plans and operational monitoring as a means of evaluating the potential environmental impacts before changing the supply-water quality.

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