Attachment 3A
MEETING SUMMARY
JOINT MEETING OF
DIRECTORS OF UTILITIES COMMITTEE
DIRECTORS OF HEALTH
December 4, 2013
Chesapeake

1. **Summary of the November 6, 2013 Meetings of the H2O – Help to Others – Program Board of Directors and the Directors of Utilities Committee**

   There were no comments on, or revisions to the summary of the November 6, 2013 Committee meeting.

   ACTION: The summary of the November 6, 2012 meeting of the H2O Program Board of Directors and the Directors of Utilities Committee meeting was approved.

2. **Summary of June 5, 2013 Joint Meeting of the Directors of Utilities Committee, Directors of Health, and Emergency Managers**

   There were no comments on, or revisions to the summary of the June 5, 2013 meeting.

   ACTION: The summary of the June 5, 2013 joint meeting of the Directors of Utilities Committee, Directors of Health, and Emergency Managers was approved.

3. **Regulatory Update**

   Mr. Dan Horne, Virginia Department of Health (VDH), Office of Drinking Water (ODW), provided an update on regulatory issues. A copy of Mr. Horne's summary is attached. At the state level, he noted that VDH staff is working with the VDH Waterworks Advisory Committee to develop proposed revisions to the Waterworks Regulations. Following internal review, VDH will convene a regulatory advisory panel to provide input prior to the January 2015 target date for beginning review under the Virginia Administrative Process Act. Waterworks will have the opportunity to comment on the design criteria, as well as other sections of the regulation.

   At the federal level, the final revised Total Coliform Rule becomes effective April 1, 2016. Under the new rule, a level 1 assessment and reporting is prompted by a trigger value and a level 2 assessment and reporting is required for acute MCL violations. This is a change from a public notification rule to a "find the defect and fix" rule. EPA is providing training to states in December 2013 and in February, March, and April 2014. EPA has yet to publish formal guidance, which was due in June 2013. Upon receipt of guidance, VDH will develop an implementation strategy and provide training for waterworks in partnership with Virginia Rural Water, the American Water Works Association, and potentially with Virginia Planning Districts.

Mr. Horne noted the January 4, 2014 effective date of the Reduction of Lead in Drinking Water Act of 2011. The EPA's October 2013 summary document of the law and answers to frequently asked questions is the first agency statement determining that fire hydrants are not exempt from the act and need to meet the new definition of "lead-free." The Committee discussed support of legislation currently moving through Congress to exempt fire hydrants from the new requirements. Local utilities intend to submit letters of support for Senate approval of the Community Fire Safety Act (HR3588).

Mr. Horne asked the Committee to contact him with any member nominations for VDH's Waterworks Advisory Committee.

ACTION: No action.

4. Drinking Water Fluoridation

Mr. Peter Pommerenk, planning and analysis bureau manager for the City of Virginia Beach Department of Public Utilities presented a review of drinking water fluoridation, including common practices and regulations, peer reviewed literature, commonly cited health benefits and concerns, and a summary of other issues related to ethics and risk. A copy of Mr. Pommerenk's presentation and accompanying white paper is attached.

Questions and the Committee's discussions are summarized below:

- VDH Office of Drinking Water noted that the Board of Health does not require, but has encouraged water fluoridation.
- In response to the question of whether any home water filters remove fluoride, Mr. Pommerenk noted that activated carbon cartridges will remove small amounts of fluoride and that home reverse osmosis systems will remove most of the fluoride, however, system effectiveness depends on the membrane used by the manufacturer.
- In response to a question from the Committee, Mr. Tom Leahy explained that the Department of Public Utilities receives relatively few, but persistent calls in opposition to water fluoridation. Citizens against water fluoridation assert that an industrial chemical, which could contain arsenic and trace radioactive material, is being added to the water supply to elicit a medical/public health response without the consent of the public and that water fluoridation is based on recommendations from the 1950s and 1960s that were not well researched.
- The Committee discussed the marginal health benefits of water fluoridation (an estimated one in six individuals benefits from the practice). It was noted that the argument in favor of water fluoridation is that marginal public health benefits

are gained at relatively low cost; this same argument could be used to add other non-treatment related chemicals to water. It was noted that only moderate quality studies have been done to assess the public benefits of water fluoridation, and these studies found that -10% to 60% of the population benefits from the process; the range is too wide to be conclusive and better research is lacking.

- The Committee commented that they appreciate Mr. Pommerenk's research and the information presented. Utilities will continue to comply with regulations governing public water systems and guidance set forth by the Center for Disease Control.

ACTION: No action.

5. Back-up Water Supplies for Jail Facilities

Director Tom Leahy, Virginia Beach Department of Public Utilities, briefed the Committee on a study being conducted in partnership with the City's Sherriff and Public Safety Department to evaluate the feasibility of a back-up water supply for the jail in the event of an emergency. The effort is intended to assist the Sherriff's office in assessing alternatives to support sheltering in place of approximately 1,500 inmates.

The study considers the jail's water demand, including fire flow requirements and heating and cooling, as well as the impact of design storms on jail facilities and provisions for back-up water supplies at other correctional facilities in the state. Preliminary design and cost estimates are being developed for alternatives for discussion with the sheriff. The Department of Public Utilities is not advocating for any particular alternative; the evaluation is being done to ensure that realistic alternatives and costs are considered.

The Committee noted a previous Department of Homeland Security funded effort to provide back-up wells and treatment systems to support heating, cooling, and non-potable uses at hospitals.

The Committee discussed the potential for temporary suspension of certain regulations governing public water systems in the event of an emergency, especially since a significant portion of the population drinks from private wells. It was noted that past government action suspending local health rules sets a precedent for this.

The Committee will revisit this topic at the June 2014 joint meeting with the Health Directors and Emergency Managers.

ACTION: No action.

6. Roundtable Discussion

During the roundtable portion of the meeting, the VDH Office of Drinking Water clarified recent changes for public notification requirements for localized water main breaks

The roundtable portion of the meeting is summarized below:

- In response to a question from the Committee, VDH Office of Drinking Water clarified recent changes for public notification requirements for localized water main breaks. The VDH Waterworks Advisory Committee discussed the issue and the AWWA toolkit is to be recommended to utilities.

BREAK (5 minutes)
The joint meeting of the Directors of Utilities Committee and Directors of Health concluded. Following the break, the meeting reconvened for discussion of topics pertaining to the Utility Directors.

7. Regional Sanitary Sewer System Asset Consolidation

The Committee discussed the December 3, 2013 draft of the Memorandum of Agreement for HRSD implementation of the regional wet weather capacity improvements. HRSD General Manager Ted Henifin reviewed locality comments and items addressed through revisions to the MOA. The Committee noted issues that require more discussion. A follow-up conference call between the MOA partners is scheduled for December 6, 2013.

ACTION: No action.

8. Staff Reports

Staff Reports are summarized below:

- **2013 Groundwater Permit Summary Map:** An updated groundwater permit map for the Eastern Virginia Groundwater Management Area has been prepared by HRPDC staff. The map is made available on HRPDC's website: http://www.hrpdc.org/news/index/view/id/1606. At the Committee's request, HRPDC staff will inquire with the Department of Environmental Quality about sharing of the agency's groundwater permit database in Microsoft Access format.

- **2014 Committee Meeting Schedule:** The 2014 meeting schedule for the Directors of Utilities Committee was provided as agenda Attachment 7A. HRPDC staff will send electronic meeting invitations to Committee members.

ACTION: No action.

9. Other Business

- **Educational outreach**: : James City Service Authority General Manager Larry Foster noted that the askHRgreen.org "value of water" commercial airing on the local Williamsburg area radio station effectively conveys the message that water services come with a cost and these services are essential to maintaining our quality of life.

- **New EPA Report:** Mr. Dave Morris, Newport News Waterworks, noted the availability of the November 2013 EPA Synthesis Report, "The Importance of Water to the U.S. Economy." The report, as well as information on the EPA's study components, is available on the agency's website: http://water.epa.gov/action/importanceofwater/.

ACTION: No action.

Committee Meeting Sign-In Sheet
December 4, 2013

Attachment 3B

Locality/Agency	Representative	Representative	Representative	Representative
HRSD	Ted Henifin	Phil Hubbard		
Chesapeake	Bill Meyer	Ted Garty		
Franklin				
Gloucester	Martin Schlesinger			
Hampton	Tony Reyes	Jason Mitchell		
Isle of Wight	Frank Haltom			
James City County	Larry Foster			
Newport News	Joe DuRant			
Newport News	Dave Morris			
Newport News	Joyce Heffington			
Norfolk	Kristen Lentz			
Poquoson	Bob Speechley			
Portsmouth	Bryan Foster	Erin Trimyer		
Smithfield				
Southampton				
Suffolk	Al Moor	Craig Ziesemer		
Surry				
Virginia Beach	Tom Leahy	Bob Montague	Peter Pommerenk	
Virginia Beach				
Williamsburg	Ralph Patterson			
Windsor				
York	Brian Woodward			
HRPDC	Julia Hillegass	Katie Cullipher	Rebekah Eastep	
HRPDC	Whitney Katchmark	Tiffany Smith		
New Kent				
DEQ				
EPA				
USGS				
VDH	John Aulbach	Dan Horne	Dan Botdorf	
VDH	Harry Bennett	Clifton D. Horne		
VDH	Nancy Welch			
AECOM				
AquaLaw	Justin Curtis			
Brown & Caldwell	Richard Stahr			
CH2M-Hill				
Christian Barton				
CNA				
HDR				
Hurt & Proffitt, Inc.				
McGuire Woods				
Rice Associates				
REMSA				
Troutman Sanders				
Virginia Fusion Center				
Virginia WARN				
URS				
Wiley Wilson				
Private citizens				

VDH – Office of Drinking Water
Update Items for HRPDC Meeting
4 Dec 2013

1. **Regulations Status Update**
   - **VDH Waterworks Regulations**
     1. ODW internal team made up of CO and FO staff is doing one "final review" of all the regs.
     2. As each part is completed, it is being presented to all staff for review and comment.
     3. The Waterworks Advisory Committee is being updated on progress, as part of their routine meetings.
     4. Once the internal review is complete, VDH will put together a Regulatory Advisory Panel to review and comment on the proposed revisions. RAP will consist of appropriate stakeholders.
     5. ODW internal will review all comments and make any appropriate changes.
     6. Once completed, the proposed revisions to the Regulations will enter the APA process. Hopefully this will be by Jan 2015.
   - **Federal level**
     i. Revised Total Coliform Rule
        1. Final Rule published 13 Feb 2012 - effective date of 1 Apr 2016
        2. Does away with monthly MCL violation (triggers a "level 1" investigation and report) but keeps the acute MCL violation (triggers a "level 2" investigation and report)
        3. Changes from a "public notification" rule to "find the defect and fix" rule
        4. EPA is providing training to States – first training session was in September, rest got delayed due to Federal Government shutdown. Next session next week, other three will be in Feb, Mar, and Apr.
        5. EPA formal guidance to States not yet published – expected to come after trainings have been completed (but will probably be in "draft for comment" format)
        6. VDH team will start meeting following issuance of (draft) guidance to develop VDH implementation strategy

2. **Federal law**
   - **Reduction of Lead in Drinking Water Act of 2011**
     i. Effective date 4 Jan 2014 – as of that date, can't use or introduce into commerce materials in drinking water system that don't meet the new definition of "lead free". There are some specific exemptions to coverage, plus some exclusions to items that only provide non-potable water service.

ii. EPA issued a "Summary of the Act and Frequently Asked Questions" document on 22 Oct 2013 that had some real surprises about what gets covered – water heaters/ice makers/dishwashers are, washing machines aren't

iii. Biggest surprise is EPA's determination that fire hydrants need to meet the new definition. There is significant action being undertaken to challenge this determination.

iv. HR3588 (Community Fire Safety Act of 2013) being considered by Congress right now. Introduced in the House on 21 Nov – passed by House (vote was 384-0, with 47 "no vote") on evening of 2 Dec.

v. EPA webinar on 25 Nov to discuss the issue. 4 questions were discussed:

   a. What is the frequency and duration of potable water uses of fire hydrants?
   b. What are the challenges of converting the existing manufacturing processes and the supply chains to lead free hydrants in the open position?
   c. What are the concerns with utilizing low lead brass on the upper portions of hydrants and the impacts on the reliability of the hydrants for fire protection?
   d. If EPA were to allow a transition period for hydrants to meet the lead-free definition, what length of time would be needed?

3. Waterworks Advisory Committee – recruiting new members. Looking particularly for a Class I licensed operator. Term begins Jan 2014, lasts three years. Must be in good standing with licensure board, involved with the industry, and in communication with operators at other waterworks. Will need support of employer (some travel is needed, for "in person" meetings).

Water Fluoridation

Peter Pommerenk, Ph.D., P.E.
Department of Public Utilities
City of Virginia Beach

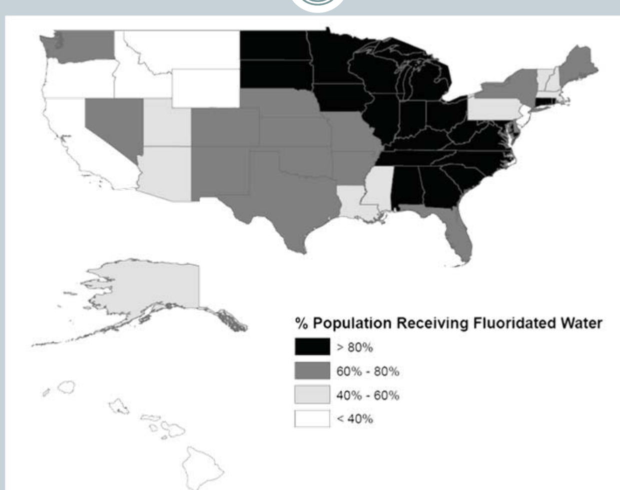
Outline

- National & international perspectives
- Chemistry & application of Fluoride
- Public health benefits and concerns
- Non-health related issues

Water Fluoridation in the United States

- Practiced for the prevention of dental caries
- Hailed as one of the 10 great public health achievements of the 20th century (CDC)
- Widespread support of water fluoridation in the U.S. (American Dental Association's "Fluoridation Facts")

Water Fluoridation in the United States



2006 Data

Water Fluoridation Worldwide

- 378 million people served worldwide with fluoridated water
  - >40% of population: U.S., Australia, Brazil, Brunei, Canada, Chile, Ireland, Israel(?), Malaysia, Singapore
- No water fluoridation in most of Europe and many populous nations
  - High natural fluoride levels?
  - Opposition to water fluoridation

Fluoride in Water Treatment

- Fluoride occurs naturally as F^-
  - Dissolution of fluorine-containing minerals
- Typically added as fluorosilicic acid (H_2SiF_6)
  - Byproduct of phosphate production
  - 73,000 tons produced in 2012 (mostly used for fluoridation)
  - Dissociates in water into F^- and silicic acid $[SiO_x(OH)_{4-2x}]_n$
  - AWWA/ANSI/NSF Standard 60 certified
    - May contribute traces of arsenic to drinking water
- Other fluoride chemicals:
  - Sodium fluoride (NaF)
  - Sodium fluorosilicate (Na_2SiF_6)

Fluoride in Water Treatment

- Interferes by complexation with aluminum
  - Carry-over of Al into the distribution system
  - Increased coagulant (alum) doses
- Other (questionable) synergistic effects:
  - Complexation of lead and hexafluorosilicate ion (SiF_6^{2-}) ???
  - Chloramines ???

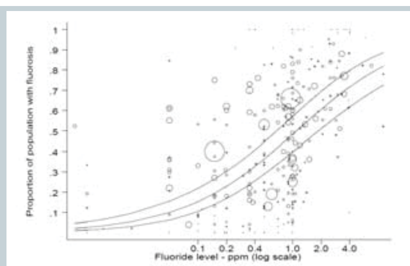
Fluoride Regulations

- National Primary Drinking Water Regulations
- Virginia Waterworks Regulations
- Maximum Contaminant Level (MCL):
  - Primary (enforceable) 4.0 mg/L – increased risk of bone disease and dental fluorosis
  - Secondary (non-enforceable): 2.0 mg/L
  - Guideline for water fluoridation: 0.7 mg/L (DHHS, 2011)
- MCL Goal (4.0 mg/L)
  - Should be lowered to include new data on health risks and total exposure (NRC, 2006)

Public Health Benefits and Concerns

- Dental Caries
  - Dental caries inhibition by fluoride is well understood
    - Significant reduction in the prevalence tooth decay among children is due to various applications of fluoride
  - Role of water fluoridation
    - Fluoridated versus non-fluoridated communities
    - Confounding factors (sugar consumption, bottled water, other fluoride modalities and sources, access to dental care)
    - “Fluoride's actions primarily are topical...” (CDC)
    - Effective for 1 in 6 people (University of York, UK study)
    - “Halo” or “Diffusion” Effect

Public Health Benefits and Concerns



- Dental Fluorosis
  - Clear association with fluoride levels in drinking water
  - Cosmetic defect (ADA)
  - Due to “higher than optimal” fluoride intake
    - ADA: “inappropriate use of fluoride-containing dental products” because “fluoride intake from food and beverages has remained constant over time.”
  - CDC: Use low-fluoride bottled water to prepare infant formula to reduce risk of fluorosis

Public Health Benefits and Concerns

- Epidemiological studies found no clear associations between water fluoridation and cancer, bone fractures, Alzheimer's Disease, low I.Q., birth rates, Down syndrome, …
  - Adverse outcomes are associated with high fluoride levels and are not due to water fluoridation
  - However, more high-quality research / dose-response studies needed
  - Sources: University of York (2000), NRC (2006)

Other Issues/Ethics/Risk

- Only 1% of treated water consumed is actually ingested
  - Wasteful use of fluoride chemicals?
  - Dispersal of fluoride in the environment?
- Fluoride is unlike other water treatment chemicals
  - It does not inhibit, remove or otherwise inactivate harmful or nuisance substances
  - Drinking water serves as delivery vehicle for a nutritional supplement
  - Can be viewed as mass medication without consent

Other Issues/Ethics/Risk

- Fluoride dose received by individuals cannot be controlled:
  - Infants
  - Persons with impaired kidney function
  - Heavy tea drinkers
  - MSM consumers
- Precautionary Principle?
  - Some persons have to expect a net harm
  - Cost-effective alternatives to caries prevention are available

Questions?

Review of Water Fluoridation

Prepared by
Peter Pommerenk, Ph.D., P.E.
City of Virginia Beach
Department of Public Utilities
September 27, 2013

Introduction

Since its first implementation in 1945 in Grand Rapids, Michigan, the fluoridation of public water supplies has been widely applied in the United States as a public health measure to prevent tooth decay. Based on 2006 data, nearly 70 percent of the U.S. Population receives water from a fluoridated supply (Centers for Disease Control and Prevention (CDC), 2008). The CDC hail water fluoridation as one of the 10 great public health achievements of the 20th century.

Despite the fact that water fluoridation is endorsed by numerous national organizations, there remain concerns regarding the safety and effectiveness of this measure. Because of these concerns, we have performed the following:

- Review current State and Federal regulations, applicable design and operation standards as well as common practices regarding the addition of fluoride to public water supplies.
- Gather data from internet and news media sources on the positions of professional and governmental organizations regarding water fluoridation as well as on current fluoridation regulations and/or practices in other developed nations.
- Based on a review of the peer-reviewed literature, provide a synopsis of the aqueous chemistry of fluoride with particular focus on synergistic effects with other water constituents and the potential impacts on plumbing materials and compliance with water quality goals.
- Based on a search of the recent peer-reviewed literature, list the most commonly cited public health concerns or benefits. Review and summarize applicable meta-studies.

Background

The City of Virginia Beach obtains treated water from the City of Norfolk's Moore's Bridges water treatment plant. Fluoride is added by the plant operator as fluorosilicic acid, which is the most widely used chemical applied for water fluoridation. The chemical, also called hydrofluosilicic acid or hexafluorosilicic acid (chemical formula H_2SiF_6), is a byproduct of phosphoric acid and phosphate fertilizer production. It is made by scrubbing silicon tetrafluoride and hydrogen fluoride gases that evolve during the extraction of phosphate from the minerals using sulfuric acid (American Water Works Association, 2006). It is estimated that in 2012, 73,000 tons of fluorosilicic acid was recovered from U.S. phosphoric acid plants, most of which was used in water fluoridation (U.S. Geological Survey, 2013).

Supplied typically as a 20 to 30 percent (as H_2SiF_6) solution, fluorosilicic acid is a highly corrosive and toxic, straw-colored liquid with a pungent odor. Like all drinking water additives, according to Virginia Law, fluorosilicic acid must meet the standards set forth by the American National Standards Institute (ANSI) and the National Sanitation Foundation International (NSF) (Virginia Administrative Code 12VAC5-590-860). ANSI/NSF Standard 60 certified chemicals are deemed suitable for contact with potable water and must meet minimum requirements for impurities such as suspended matter, heavy metals and radionuclides (American Water Works Association, 2006). NSF International (2013) states that there is no contamination of drinking water from the fluoridation products that the NSF has tested and certified. However, Hirzy *et al* (2013) question this view and recommend the use of pharmaceutical-grade sodium fluoride in lieu of fluorosilicic acid due to its lower arsenic content.

Application of water fluoridation in Virginia is governed by 12VAC5-590-930. The regulation establishes permitting requirements and applicable standards for fluoride chemicals, their storage and feed installations. The Virginia Water Works Regulations also require daily monitoring of chemical consumption and measuring the fluoride residual in finished water to ensure compliance with the National Primary and Secondary Drinking Water Regulations that the Commonwealth of Virginia has adopted. These regulations specify primary and secondary maximum contaminant limits (MCLs and SMCLs) for various inorganic and organic chemicals. In addition, the U.S. Environmental Protection Agency (EPA) establishes maximum contaminant level goals (MCLGs) as exposure guidelines to prevent adverse health effects in the general population. The goal of the SMCL is to reduce the occurrence of adverse cosmetic effects from exposure to fluoride. The regulatory, enforceable standard is the MCL which is set as close as possible to the MCLG.

Federal and state regulations stipulate a MCL for fluoride equal to the MCLG of 4.0 mg/L due to increased risk of bone disease and dental fluorosis (mottling of teeth) after long-term exposure at levels above the MCL. A secondary MCL was established at 2.0 mg/L.

In 2006, the National Research Council (NRC, 2006) presented a scientific review of EPA's standards for fluoride in drinking water. Based on this review, the committee concluded unanimously that the MCLG for fluoride of 4.0 mg/L should be lowered and recommended that EPA update the risk assessment on fluoride to include new data on health risks and better estimates of total exposure.

National and International Perspectives on Water Fluoridation

Figure 1 was prepared from CDC data (CDC, 2008) and it illustrates the percentage of the population in each state that receives fluoridated drinking water.

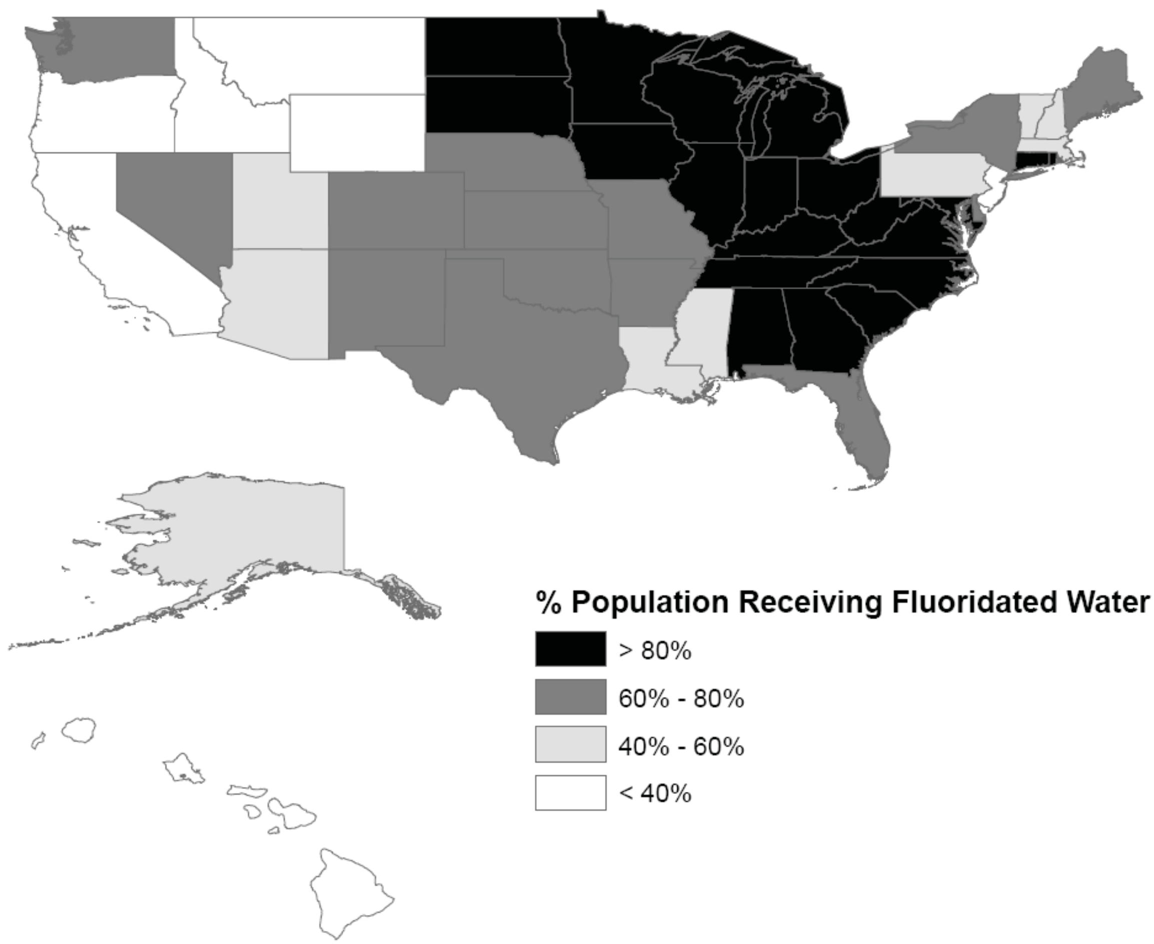


Figure 1: Fluoridation Status in the United States in 2006

These data show that in most states more than 60% of the population receives fluoridated water with the exception of a few western states and Hawaii. California however, has adopted mandatory fluoridation of all public water supplies and therefore, the numbers represented by Figure 1 are likely to increase significantly. A mandatory fluoridation bill was also introduced in New Jersey, which has not yet passed the full assembly as of September 2013. The sponsors of these bills usually cite the CDC's position of overwhelming evidence of the effectiveness of water fluoridation in preventing dental caries.

The widespread support of water fluoridation in the Unites States is documented by the American Dental Association's (ADA) "Fluoridation Facts," which list over 100 mostly national organizations that recognize the public health benefits of community water fluoridation for preventing dental decay (ADA, 2005a). The list includes most notable national organizations involved in public health and medicine, pediatrics, dentistry and oral hygiene, the American Water Works Association as well as the U.S. Public Health Service, the Department of Defense, the Department of Veterans Affairs, and the World Health Organization (WHO). It is worth noting that based on a cursory review of statements found on their web sites, only few of the organizations listed in the "Fluoridation Facts" have performed an independent review of the literature. In many cases, where a public statement or policy was found on the web site, the CDC's position is referenced.

The international perspective on water fluoridation can be surmised based on data compiled by The British Fluoridation Society (2012). This source indicates that 378 million people receive artificially fluoridated water worldwide, half of which reside in the United States. Countries where more than 40% of the population receives fluoridated water include the U.S., Australia, Brazil, Brunei, Canada, Chile, Ireland, Israel[1], Malaysia and Singapore. Water fluoridation is not practiced in Europe, with the exception of parts of the United Kingdom, Ireland, Spain and Serbia. Many other populous nations do not apply fluoride in water treatment, including China, Japan, Mexico, Nigeria, South Africa, Taiwan and Venezuela.

These statistics from other developed nations contrast the widespread fluoridation practice in the United States. It might be that naturally occurring fluoride does not necessitate the addition of fluoride to drinking water in certain parts of the world or that the implementation is too costly in countries with many small water systems. In Europe however, it appears that the vast majority of people simply oppose water fluoridation (Griffin, 2008) resulting in a tendency to remove existing fluoridation

[1] Various internet sources report that the Israel will cease water fluoridation in 2014 (Even, 2012).

schemes, which is the opposite trend to the U.S. Whether the lack of water fluoridation has affected dental health in European countries is discussed in a subsequent section.

Chemistry of Fluoride in Water Treatment and Distribution

In most natural waters, fluoride occurs in its “free” ionic form due to the dissolution of fluorine-containing minerals such as fluorite (commonly: fluorspar), fluoroapatite and cryolite. Thus, the concentration of fluoride in natural waters is dependent on the occurrence of fluoride-bearing minerals within the watershed.

When fluorosilicic acid is added to water, the chemical dissociates into silicate ions and fluoride ions (Urbansky, 2002). Fluoride is then present in treated water in the same form as in natural water or as if it were added using sodium fluoride or sodium silicofluoride, the two other chemicals commonly used for artificial water fluoridation.

Fluoride is known to interfere in water treatment where aluminum-based coagulants are used (Pommerenk, 2002). With high levels of fluoride in the raw water or where fluoride is added concurrently with the coagulant[2], particle and organic matter removal might be impaired. This is due to fluoride's affinity to form dissolved compounds with aluminum and therefore reduce the formation of hydroxo-aluminum complexes which facilitate the coagulation of particulate and natural organic matter in water treatment.

Fluoride-aluminum interactions are confined to the acidic pH region in which most conventional water treatment plants are operated. Due to more stringent regulations aimed at enhancing removal of natural organic matter, many conventional treatment plants operate at pH values below the pH of minimum solubility of aluminum. This practice can result in increased carryover of aluminum through the filtration stage. Thus, even if fluoride is added at a point where it cannot directly interfere with the coagulation and filtration process, fluoride can still complex aluminum and prevent it from precipitating after final pH adjustment.

Driscoll and Letterman (1988) found that nearly 20% of the aluminum transported in a water distribution system was present as aluminum-fluoride complexes. Aluminum can also be present in distribution systems due to post-precipitation (Costello, 1984) and could therefore be mobilized when

[2] Where applicable, Virginia Waterworks Regulations actually require addition of fluoride to the raw water, but due to the known interference, this stipulation is rarely followed.

fluoride is introduced. Berend and Trouwborst (1999) also identified cement-mortar pipes as significant sources of aluminum. These authors did not specifically investigate the effect of fluoride, even though chemical interactions are possible near neutral pH values. Reiber *et al* (1995), who discussed the bioavailability of aluminum in drinking water, also acknowledged the importance of fluoride in governing the solubility of aluminum.

Even though interactions between fluoride and other metal ions in drinking water are thermodynamically possible, these effects are usually minor in comparison to aluminum. There has been considerable debate about the effect of silicate that is contained in fluorosilicic acid. Masters et al. (1999, 2000) postulated that the hexafluorosilicate ion (SiF_6^{2-}) does not fully dissociate and remains in solution at an appreciable concentration. They further asserted that the hexafluorosilicate ion can cause leaching of lead from plumbing appurtenances. This hypothesis was refuted by Urbansky and Schock (2000). Urbansky (2002) later acknowledged that further study is required to understand the chemistry of the hexafluorosilicate ion. However, he disputed the suggestion the hexafluorosilicate ion can form stable complexes with lead (and thus can cause leaching of the toxic metal from plumbing materials). The controversy about the effects of fluorosilicic acid on leaching of lead has not been resolved. Maas et al. (2007) published experimental data that suggests a synergistic effect of the disinfectant chloramines and hydrofluosilicic acid on lead mobilization. However, to date, these findings have not been corroborated by other independent researchers.

Public Health Benefits and Concerns

This section provides a summary and discussion of the public health benefits and concerns of community water fluoridation.

Dental Caries

The mode of dental caries inhibition by fluoride seems to be well understood (Jones *et al*, 2005). Fluoride is believed to help re-mineralize early damage to the tooth enamel caused by acid produced by the breakdown of sugar by plaque bacteria. It is also thought to make teeth more resistant to acid attack by altering the chemical structure and to inhibit the enzyme activity of the plaque bacteria that produce acid.

There is general agreement that a significant reduction in the prevalence tooth decay has occurred among children in most of the developed countries in recent decades (Petersson, 1996), and many researchers believe that the use of fluoride in various forms (toothpaste, water and salt fluoridation, etc.) has contributed most to the decline in dental caries prevalence.

In the U.S., community water fluoridation, being promoted “an extremely effective and inexpensive means of obtaining the fluoride necessary for optimal prevention of tooth decay” (ADA, 2005b), is most often credited with the observed reduction in dental caries. However, this claim is problematic because a dramatic decline in the occurrence of dental caries has also occurred in areas that do not receive artificially fluoridated water. This was pointed out as early as 1986 by Diesendorf (1986) in the prestigious journal Nature and has since been supported by numerous studies in developed countries.

As an example, based on the index for decayed, missing or filled teeth (DMFT index), dental caries among 12-year olds is no more prevalent in Germany than either Australia or the United States (World Health Organization Collaborating Centre, 2013). This is observed despite the fact that over 60% of the population of each Australia and the U.S. receive naturally or artificially fluoridated water (The British Fluoridation Society, 2012), whereas no water fluoridation is practiced in Germany, where natural fluoride levels are below 0.3 mg/L in more than 90% of delivered drinking water (Bundesinstitut für Risikobewertung, 2005).

Miyazaki (1996) noted that dental caries in Japanese children has declined with very limited fluoride usage, and the researcher suggested that a reduction in sugar consumption was responsible for the decline. Based on a questionnaire mailed to experts in the field, Brathall (1996) found that there was clear agreement on the use of fluoridated toothpaste as a main reason for reduced tooth decay. In Germany, Splieth (1996) observed an association between the introduction of fluoridated toothpaste and the decline in tooth decay. Seppä *et al* (1998, 2000) found in two studies in Finland that the discontinuation of water fluoridation did not result in a discernible increase in caries prevalence. Brofitt et al. (2007) concluded that bottled water users had significantly lower fluoride intakes, but found no evidence of an association with increased caries. Even though these studies are just a subset of the vast research literature on this topic (and there are many with contrasting conclusions), they call into question the assertion that water fluoridation is necessary for dental caries prevention. Interestingly, even the CDC has admitted that fluoride's “actions primarily are topical for both adults and children,”(CDC, 1999) which essentially means that fluoride has to be in contact with the tooth enamel and therefore, ingestion through drinking water is not required.

In a systematic review of public water fluoridation by the NHS Centre for Reviews and Dissemination, University of York (U.K.), researchers concluded that fluoridation of drinking water supplies does reduce caries prevalence but that the degree to which dental caries is reduced was not clear from the available data and that the effect could be biased due to confounding factors (McDonagh, 2000). The median difference in the proportion of caries-free children between fluoridated and non-fluoridated areas was only 15%. Therefore, six people need to receive fluoridated water for one extra person to be caries-free. This does not appear to be "an extremely effective means for optimal prevention of tooth decay."

The lack of an unambiguous positive association between fluoridated water use and dental caries reduction has been attributed to the "diffusion" or "halo"-effect of fluoride use in neighboring communities through the export of foods and beverages processed with fluoridated water (ADA, 2005a). Griffin (2001) asserts that "failure to account for the diffusion effect may result in an underestimation of the total benefit of water fluoridation …" This might be applicable in the United States, but the "halo" effect is unlikely to be a factor in countries without naturally or artificially fluoridated water that have experienced the same or greater decline in tooth decay. In addition, if fluoride intake from sources other than drinking water has indeed increased, then the recommended fluoride levels in drinking water should be reduced as Tickner and Coffin (2006) point out: "The ADA maintains that fluoride levels administered in water are closely monitored to ensure the safe, optimal level of fluoride to prevent decay. However this claim is problematic since it does not consider cumulative exposures from many other sources (toothpaste, pesticide residues on foods, mechanically deboned meat, and many processed foods and beverages made with fluoridated water). The result is a total exposure level that can, in some cases, equal this optimal fluoridation level without ever consuming treated water. Despite these additional sources of fluoride exposure, the amount added to drinking water continues at the same level as was established in the 1940s." As a consequence, fluoride intake for some people might exceed levels that are safe, e.g., heavy black tea drinkers (Cao, 2004) or consumers of mechanically deboned meat. Fein and Cerklewski (2001) found that a single serving of chicken sticks alone would provide about half of a child's upper limit of safety for fluoride.

In summary, it is evident that fluoride plays an important role in caries prevention. However, there is doubt whether the delivery of fluoride through drinking water is necessary or effective.

Dental Fluorosis

Dental fluorosis has been shown to be associated with fluoride levels in water (McDonagh, 2000) and it is the only detrimental effect of water fluoridation that is acknowledged by the CDC and other fluoridation proponents. According to the ADA, "Dental fluorosis is caused by a disruption in enamel formation which occurs during tooth development in early childhood related to a higher than optimal intake of fluoride" (ADA, 2005a). The ADA regards dental fluorosis merely as a cosmetic defect and blames its increasing prevalence over the past 60 years on the "inappropriate use of fluoride-containing dental products" because "fluoride intake from food and beverages has remained constant over time." This argument seems to contradict the ADA's assertion that non-fluoridated communities benefit from water fluoridation through the "halo"-effect.

A recent study on fluorosis and dental caries outcomes found that the "optimal" fluoride intake for tooth decay prevention may not be optimal for preventing fluorosis (Warren et al., 2009) and therefore, recommending an "optimal" fluoride intake is problematic. Even the CDC (2013) now recommends that infant formula should be prepared with low-fluoride water to lessen the risk of enamel fluorosis. The CDC makes no mention where young mothers could obtain low-fluoride water at an affordable cost; bottled water meets less stringent quality standards and costs several thousand times more than tap water. In its support for water fluoridation, the CDC seems to expect adolescents to incur the risk of enamel fluorosis for the benefit of caries prevention. However, good dental health with a minimum of dental fluorosis can also be achieved by adequately administering fluoride to children and young people without water fluoridation. This was concluded by the authors of a study performed in Germany (Momeni *et al*, 2007).

Bone Fractures

Adverse effects on bone health, namely an increase in hip fractures, are frequently cited by fluoridation opponents as a reason to cease community water fluoridation. Even though there were studies that indicated a higher incidence of hip fractures in fluoridated communities, McDonagh's comprehensive review (2000) did not identify a clear association of hip fracture with water fluoridation. Based on a search of the recent literature, this finding appears still valid.

Cancer

The effects of fluoride on various cancers have been examined extensively through epidemiological and animal studies. The meta-study conducted by the University of York (McDonagh, 2000) concluded that "the findings of cancer studies were mixed, with small variations on either side of no effect. Individual cancers examined were bone cancers and thyroid cancer, where once again no clear pattern of association was seen. Overall, from the research evidence presented no association was detected between water fluoridation and mortality from any cancer, or from bone or thyroid cancers specifically." Since 2000, additional work on osteosarcoma, a form of bone cancer, has been conducted. Bassin et al.

(2006) found a positive association between fluoride exposure from drinking water during childhood and the incidence of osteosarcoma among males. However, the authors cautioned about generalizing the results of the study. The NRC (2006) considers the results from cancer case-control studies ambiguous and stated that additional research is required to support lowering the MCL for fluoride in drinking water based on osteosarcoma risk.

The American Cancer Society (2013) also supports earlier findings that there is no strong evidence of a link between water fluoridation and cancer; however, they recommend further high-quality studies are required to address this topic.

Elevated Lead Exposure

Several studies were conducted examining exposure to lead and water fluoridation using fluorosilicate chemicals (as opposed to sodium fluoride) with different outcomes (Masters et al. 1999, 2000; Macek et al., 2006; Coplan, 2007). This issue has been controversial with respect to the statistical data analysis and mechanistic interpretation. That is, Coplan (2007) found an association in the same data in which Macek et al. (2006) did not detect a statistically significant effect. As previously discussed, from a chemical standpoint, it is unlikely that fluorosilicic acid would behave differently than sodium fluoride (Urbansky, 2002). The CDC maintains that there is no risk of lead exposure due to fluoridation chemicals.

Other Health Effects

Numerous studies have attempted to link water fluoridation to Alzheimer's Disease, low I.Q., birth rates, Down syndrome and various other negative outcomes. McDonagh (2000) considered the quality of the research on these topics generally low and concluded that the studies provide insufficient evidence on any particular outcome to reach conclusions. Recently, a study by Harvard researchers on the effects of fluoride on children's neurodevelopment has received wide-spread media attention (Choi *et al*, 2012). These researchers recommend further study of the potential risks of low-level fluoride exposure.

Non-Health Related Effects of Water Fluoridation

The EPA estimates the median per capita ingestion of community water at approximately 0.9 liters per day (U.S. Environmental Protection Agency, 2004). Ingestion from all water sources is approximately 2 liter per day. Using an average daily per capita water use of approximately 250 liters, more than 99% of the fluoride added at the water treatment plant is not used for caries prevention. Rather, due to domestic water use for sanitary purposes, laundry, car washing and irrigation as well as industrial use, fluoride is dispersed in the environment. This appears a wasteful use of the chemical, but based on current commodity prices for fluorosilicic acid, the per capita cost of water fluoridation is below $1.00 annually (Hirzy *et al*, 2013), which is considerably below the cost of other fluoride modalities (CDC, 2001). However, it is the utility that is burdened with the cost of this public health measure.

Ethics and Risk

Unlike other chemicals used in water treatment, fluoride is added to drinking water for the specific purpose of providing a health benefit upon ingestion by the receiving population. Therefore, drinking water is merely a delivery vehicle for a nutritional supplement. Fluoridation opponents view this practice as mass medication without consent.

Other chemicals used in water treatment, such as oxidants, coagulants, disinfectants, acids, bases and corrosion inhibitors are applied to remove, inhibit or otherwise inactivate harmful chemicals and microorganisms. The benefits as well as the risks from the application of these chemicals are usually well understood and non-controversial. For example, it is well known that the benefits of water chlorination vastly outweigh the risks from exposure to disinfection byproducts.

In order to maintain potable water free from harmful substances and ensure public health, water utility operators have no choice but to add these chemicals in the treatment process. In addition, the public water supply is for most of the population the only economically feasible alternative to obtain safe drinking water. Fluoride is distinct from other chemicals used in water treatment because withdrawing this chemical will have no impact on public health because other sources of fluoride for caries prophylaxis are available. If low cost alone were a sufficient rationale for water fluoridation, this argument could also be used to justify the addition of other essential nutrients to drinking water.

Another problem with water fluoridation is that it is not possible to control the dose an individual receives. Thus, parts of the population can be exposed to higher than safe fluoride levels, e.g., heavy tea drinkers, infants fed with formula or persons with impaired kidney function who do not undergo dialysis. Rippe (2009) states that "Regarding fluoridation, even in the best risk-chance scenario, some persons have to expect a net harm. Therefore, the reasoning in favor of fluoridation has to have a specific purpose. The proclaimed reasoning is that fluoridation will benefit the worst off and is therefore a demand of justice. But this argument fails as there are other options to benefit the worst off. "

Given the uncertainty in risk as well as questionable benefits, a precautionary approach to water fluoridation might be warranted. Tickner and Coffin (2006) state that "A precautionary approach to fluoridation would consider all the available evidence on efficacy, safety, and alternatives. Given the temporal (throughout a lifetime) and spatial (broad population exposure) exposure to fluoride in drinking water, a more detailed analysis of potential impacts, including population variability and identification of potentially vulnerable populations would be prudent under a precautionary framework. Given the potential magnitude and scale of impacts, if they were real, one might accept a lower level of proof before taking preventive actions. Such actions could include a detailed analysis of whether cost-effective alternatives to achieve the function of fluoride exist (reducing cavities)." Therefore, because cost-effective alternatives to caries prevention are available through fluoridated toothpastes and other topical applications, the precautionary principle can be interpreted to support a moratorium on public water fluoridation.

Conclusions

Based on a review of peer-reviewed scientific studies and publications by various professional and governmental organizations, the following can be concluded:

- Water fluoridation is endorsed by numerous, well-respected organizations.
- It has been well established that the topical application of fluoride reduces dental caries. Aside from enamel fluorosis, epidemiological data provide no evidence of adverse health effects due to water fluoridation.
- Water fluoridation is widely implemented in the U.S. In contrast, people in most of Europe, Japan and many other populous countries do not receive fluoridated water. These developed nations have experienced the same decline in dental caries prevalence as the U.S. because other fluoride modalities are available.
- Because the amount of fluoride that an individual receives cannot be carefully controlled through water fluoridation, vulnerable sub-populations may be exposed to higher than safe fluoride levels. Under a precautionary framework, in the face of uncertain risks and given that there are existing, effective alternatives to prevent dental caries, it can be justified to cease water fluoridation.

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