

Bacteria (E. coli) | 2019

Substance Overview

The groundwater standard for bacteria protects people from illness caused by microbial pathogens. These pathogens are small organisms, such as bacteria, viruses, and parasites, that can cause disease.¹ Microbial indicators usually measure a group of bacteria or just one type of bacterium to indicate the possible presence of pathogens. These indicators are used to set the standard because they are more efficient to measure than every single pathogen. Two microbial indicators are used today to protect drinking water:

- **Coliform** are a group of bacteria that are naturally present in the environment.
- **E. coli** (*Escherichia coli*) are a type of coliform bacteria that are found in the environment, food, and gut of people and animals.

This document provides the recommended Public Health Enforcement Standard for E. coli.

Recommendations

Wisconsin does not currently have an NR140 Groundwater Quality Public Health Enforcement Standard for *E. coli*.

DHS recommends an enforcement standard of zero for *E. coli*. The recommended standard is based on EPA's maximum contaminant level (MCL) for *E. coli*.

DHS recommends a NR140 Groundwater Quality Public Health Preventive Action Limit of 0 for *E. coli*.

Current Standards	
Enforcement Standard:	N/A
Preventive Action Limit:	N/A
Recommended Standards	
Enforcement Standard:	0
Preventive Action Limit:	0

Health Effects

Pathogens in water can cause a variety of illnesses.^{1,2} Most common illnesses are acute (short-term) gastrointestinal illnesses causing diarrhea, abdominal discomfort, nausea, and vomiting. Less common illnesses are chronic (long-term) and include kidney failure, hepatitis, and bloody diarrhea.

Infants and young children, the elderly, and people with compromised immune systems are at the highest risk for illness from pathogens in water.¹

Exposure Routes

Pathogens can get into drinking water from human and animal feces. People can be exposed to waterborne pathogens from drinking contaminated water, coming into contact with a contaminated surface, or being in contact with a person who is carrying the pathogen.

Current Standard

Wisconsin does not currently have groundwater standards for *E. coli*.³

Standard Development

Federal Numbers

Maximum Contaminant Level:	0	(2016)
Health Advisory:	N/A	
Drinking Water Concentration (Cancer Risk):	N/A	

State Drinking Water Standard

NR809 Maximum Contaminant Level:	N/A
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Acceptable Daily Intake

EPA Oral Reference Dose:	N/A
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Oncogenic Potential

EPA Cancer Slope Factor:	N/A
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Guidance Values

None available

Literature Search

Search Dates:	2016 – 2019
Total studies evaluated:	None
Key studies found?	No

Federal Numbers

Chapter 160, Wis. Stats., requires that DHS use the most recent federal number as the recommended enforcement standard unless one does not exist or there is significant technical information that was not considered when the federal number was established and that indicates a different number should be used.

Maximum Contaminant Level

In April 2016, EPA made changes to how bacteria are regulated in public water systems as part of the Revised Total Coliform Rule (RTCR).¹ The RTCR replaced the non-acute MCL for total coliform with an acute MCL for *E. coli* (*Escherichia coli*). This change was because more recent studies have shown that *E. coli* is a more specific indicator of contamination from feces and many coliform bacteria detected by total coliform tests are not pathogenic and occur naturally in the environment.

Health Advisory

The EPA has not established a health advisory for *E. coli*.⁴

Drinking Water Concentrations at Specified Cancer Risk Levels

Because *E. coli* are microbial indicators, this evaluation is not appropriate.

State Drinking Water Standard

Chapter 160, Wis. Stats., requires that DHS use a state drinking water standard as the recommended enforcement standard if there are no federal numbers and a state drinking water standard is available.

NR 809 Maximum Contaminant Level

Wisconsin does not have a state drinking water standard for *E. coli*.⁵

Acceptable Daily Intake

If a federal number and a state drinking water standard are not available, ch. 160, Wis. Stats., requires that DHS use an acceptable daily intake (ADI) from the EPA to develop the recommendation. Statute allows DHS to recommend a different value if an ADI from the EPA does not exist or if there is significant technical information that is scientifically valid, was not considered when the federal ADI was set, and indicates a different number should be used. The EPA provides ADIs, termed oral reference doses, as part of a health advisory, human health risk assessment for pesticides, or for use by the Integrated Risk Assessment System (IRIS) program.

EPA Oral Reference Dose

The EPA does not have an oral reference dose for *E. coli*.

Oncogenic Potential

Chapter 160, Wis. Stats., requires that DHS evaluate the oncogenic (cancer-causing; carcinogenic) potential of a substance when establishing the groundwater standard. If we determine that something is carcinogenic and there is no federal number or ADI from the EPA, DHS must set the standard at a level that would result in a cancer risk equivalent to 1 case of cancer in 1,000,000 people. DHS must also set the standard at this level if the EPA has an ADI but using it to set the groundwater standard would result in a cancer risk that is greater than 1 in 1,000,000.

Because *E. coli* are microbial indicators, this evaluation is not appropriate.

Additional Technical Information

Chapter 160, Wis. Stats., allows DHS to recommend a value other than a federal number or ADI from the EPA if there is significant technical information that was not considered when the value was established and indicates a different value is more appropriate.

To ensure the recommended groundwater standards are based on the most appropriate scientific information, we search for relevant health-based guidance values from national and international agencies and for relevant data from the scientific literature.

Guidance Values

For *E. coli*, we searched for values that been published since 2016 when RTCR was published. We did not find any relevant guidance values from the EPA, Agency for Toxic Substances and Disease Registry (ATSDR), World Health Organization (WHO), or Health Canada.

Literature Search

The latest research indicates that *E. coli* is a very strong indicator of fecal contamination in drinking water because it thrives in the gastrointestinal tract of warm-blooded animals.^{1,6-8}

Standard Selection

DHS recommends an enforcement standard of 0 for *E. coli*.

The EPA has an MCL of 0 for *E. coli*. State statute requires that DHS recommend a federal number (including MCL) if one is available and there is no significant technical information that was not considered when the federal number was set that demonstrates another number is more appropriate. Available scientific information indicates that *E. coli* is an appropriate pathogen indicator for the protection of groundwater.

Basis for Enforcement Standard

- Federal Number
- Cancer Potential
- EPA Acceptable Daily Intake
- Technical information

DHS recommends a preventive action limit of 0 for *E. coli*.

Because DHS recommends an enforcement standard of zero for *E. coli*, the recommended preventive action limit is also zero.

Prepared by Sarah Yang, Ph.D.

Wisconsin Department of Health Services

References

1. USEPA. National Primary Drinking Water Regulations: Revisions to the Total Coliform Rule, Final Rule. In: Register F, ed. *Vol. 78 No. 30*2013:10270-10365.
2. Payment P, Locas A. Pathogens in water: value and limits of correlation with microbial indicators. *Ground water*. 2011;49(1):4-11.
3. WIDNR. Groundwater Quality. In: Resources WDoN, ed. *Chapter NR 140*2017.
4. USEPA. Drinking Water Contaminant Human Health Effects Information. 2019; <https://www.epa.gov/dwstandardsregulations/drinking-water-contaminant-human-health-effects-information#hh1>.
5. WIDNR. Safe Drinking Water In: Resources WDoN, ed. *Chapter NR 809*2018.
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Bacteria (Total Coliform) | 2019

Substance Overview

The groundwater standard for bacteria protects people from illness caused by microbial pathogens. These pathogens are small organisms, such as bacteria, viruses, and parasites, that can cause disease.¹ Microbial indicators usually measure a group of bacteria or just one type of bacterium to indicate the possible presence of pathogens. These indicators are used to set the standard because they are more efficient to measure than every single pathogen. Two microbial indicators are used today to protect drinking water:

- **Coliform** are a group of bacteria that are naturally present in the environment.
- ***E. coli* (Escherichia coli)** are a type of coliform bacteria that are found in the environment, food, and gut of people and animals.

This document provides the recommended Public Health Enforcement Standard for Total Coliform.

Recommendations

The current NR140 Groundwater Quality Public Health Enforcement Standard of zero for total coliform is based on EPA's MCL from the 1980s.

DHS recommends no change to the enforcement standard. The recommended standard for total coliform is based on EPA's treatment technique requirements for total coliform.

DHS recommends an NR140 Groundwater Quality Public Health Preventive Action Limit of zero for total coliform.

Current Standards	
Enforcement Standard:	0
Preventive Action Limit:	0
Year:	1985

Recommended Standards	
Enforcement Standard:	0
Preventive Action Limit:	0

Health Effects

Pathogens in water can cause a variety of illnesses.^{1,2} Most common illnesses are acute (short-term) gastrointestinal illnesses causing diarrhea, abdominal discomfort, nausea, and vomiting. Less common illnesses are chronic (long-term) and include kidney failure, hepatitis, and bloody diarrhea.

Infants and young children, the elderly, and people with compromised immune systems are at the highest risk for illness from pathogens in water.¹

Exposure Routes

Pathogens can get into drinking water from human and animal feces. People can be exposed to waterborne pathogens from drinking contaminated water, coming into contact with a contaminated surface, or being in contact with a person who is carrying the pathogen.

Current Standard

The current NR140 Groundwater Quality Public Health Enforcement Standard of zero for total coliform was established in 1985.³ This standard is based on the EPA's 1989 maximum contaminant level for total coliform.⁴ The current NR140 Groundwater Quality Public Health Preventive Action Limit for total coliform is also zero.

Standard Development

Federal Numbers

Maximum Contaminant Level:	See below
Health Advisory:	N/A
Drinking Water Concentration (Cancer Risk):	N/A

State Drinking Water Standard

NR809 Maximum Contaminant Level:	N/A
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Acceptable Daily Intake

EPA Oral Reference Dose:	N/A
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Oncogenic Potential

EPA Cancer Slope Factor:	N/A
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Guidance Values

None available

Literature Search

Search Dates:	2000 – 2019
Total studies evaluated:	Approximately 5,600
Key studies found?	Yes

Federal Numbers

Chapter 160, Wis. Stats., requires that DHS use the most recent federal number as the recommended enforcement standard unless one does not exist or there is significant technical information that was not considered when the federal number was established and that indicates a different number should be used.

Maximum Contaminant Level

In April 2016, EPA made changes to how bacteria are regulated in public water systems as part of the Revised Total Coliform Rule (RTCR).¹ The RTCR replaced the non-acute MCL for total coliform with an acute MCL for *E. coli* (*Escherichia coli*).¹ Instead of having an MCL for total coliform in the RTCR, the EPA

uses a treatment technique for total coliform in public water systems. For total coliform, the treatment technique is set at zero meaning that if total coliform are detected in a public water system, the system must conduct follow-up assessments and correct sanitary defects. More specifically, public water systems that collect 40 or more bacteria samples per month are required to take additional actions if more than 5.0% of those samples have total coliform. For systems that collect fewer than 40 samples per month, follow-up action is required if more than one sample has total coliform.

Health Advisory

The EPA has not established a health advisory for total coliform.⁵

Drinking Water Concentrations at Specified Cancer Risk Levels

Because total coliform bacteria are microbial indicators, this evaluation is not appropriate.

State Drinking Water Standard

Chapter 160, Wis. Stats., requires that DHS use a state drinking water standard as the recommended enforcement standard if there are no federal numbers and a state drinking water standard is available.

NR 809 Maximum Contaminant Level

Wisconsin does not have a state drinking water standard for total coliform.⁶

Acceptable Daily Intake

If a federal number and a state drinking water standard are not available, ch. 160, Wis. Stats., requires that DHS use an acceptable daily intake (ADI) from the EPA to develop the recommendation. Statute allows DHS to recommend a different value if an ADI from the EPA does not exist or if there is significant technical information that is scientifically valid, was not considered when the federal ADI was set, and indicates a different number should be used. The EPA provides ADIs, termed oral reference doses, as part of a health advisory, human health risk assessment for pesticides, or for use by the Integrated Risk Assessment System (IRIS) program.

EPA Oral Reference Dose

The EPA does not have an oral reference dose for total coliform.

Oncogenic Potential

Chapter 160, Wis. Stats., requires that DHS evaluate the oncogenic (cancer-causing; carcinogenic) potential of a substance when establishing the groundwater standard. If we determine that something is carcinogenic and there is no federal number or ADI from the EPA, DHS must set the standard at a level that would result in a cancer risk equivalent to 1 case of cancer in 1,000,000 people. DHS must also set the standard at this level if the EPA has an ADI but using it to set the groundwater standard would result in a cancer risk that is greater than 1 in 1,000,000.

Because total coliform bacteria are microbial indicators, this evaluation is not appropriate.

Additional Technical Information

Chapter 160, Wis. Stats., allows DHS to recommend a value other than a federal number or ADI from the EPA if there is significant technical information that was not considered when the value was established and indicates a different value is more appropriate.

To ensure the recommended groundwater standards are based on the most appropriate scientific information, we search for relevant health-based guidance values from national and international agencies and for relevant data from the scientific literature.

Guidance Values

For total coliform, we searched for values that have been published since 2016 when the RTCR was published. We did not find any relevant guidance values from the EPA, Agency for Toxic Substances and Disease Registry (ATSDR), World Health Organization (WHO), or Health Canada.

Literature Search

We conducted a search for studies that evaluated the applicability of total coliform as an indicator for microbial pathogens in drinking water and groundwater.

To conduct our literature review, we searched the National Institutes of Health's PubMed database for articles published from January 2000 to January 2019 related to groundwater or drinking water contamination that evaluated the applicability of total coliform as an indicator for microbial pathogens.^a Approximately 5,600 studies were returned by the search engine. We excluded studies that focused on pathogens that do not present a potential human health risk, studies of laboratory methods, and studies that evaluated water treatment technologies. We focused on studies that assessed correlations between coliform bacteria and the occurrence of microbial pathogens in water, such as enteric viruses, protozoa, and certain pathogenic bacteria.

While not a direct indicator of health risk, there are coliform bacteria that can cause disease in humans, particularly in infants, people with weakened immune systems, and people undergoing treatment in healthcare settings. These include species in the *Klebsiella*, *Citrobacter*, and *Enterobacter* genera.

- *Klebsiella* species can be found in feces or the environment.⁷ *Klebsiella pneumoniae* is an opportunistic pathogen (one that only affects people under rare circumstances – usually when someone has a weakened immune system) and a frequent cause of hospital-borne infections. It predominately causes urinary tract infections and respiratory infections.
- *Citrobacter* species can be found primarily in feces.⁸ *Citrobacter* can cause sepsis and meningitis in infants and may cause pneumonia in immunocompromised people or infants.

^a The following search terms were used in the literature review:
Title/abstract: (coliforms OR microbial) AND (groundwater OR "drinking water")
Language: English

- *Enterobacter* species can be found in feces or the environment.⁹ *Enterobacter* are opportunistic pathogens and the cause of many hospital-borne infections. They can cause brain abscesses, pneumonia, meningitis, and septicemia (blood infection).

A handful of studies have examined the correlation between total coliform, *E. coli*, and pathogens in groundwater. Locas et al. evaluated the occurrence of pathogen indicators (enterococci, *E. coli*, total coliforms, coliphages) and pathogenic viruses (human enteric viruses and norovirus) in groundwater samples from 12 sites in Canada in two studies.^{10,11} They detected human enteric viruses in two samples in which total coliforms were present but *E. coli* was absent. While this scenario is likely rare, it suggests that the absence of *E. coli* is not a conclusive indication that the water is pathogen free. In fact, Locas et al found that total coliforms were the only microorganism always present simultaneously with culturable viruses. In another study, Abbaszadegan et al. looked at the correlation between total coliform and *E. coli* and pathogenic viruses in groundwater.¹² They found that total coliform is a slightly more sensitive test for the occurrence of viruses than *E. coli*.

Our literature search has shown that members of the total coliform family can be pathogenic and that total coliforms can be valuable indicators for the presence (or absence) of pathogens in drinking water and groundwater.

Standard Selection

DHS recommends an enforcement standard of 0 for total coliform.

Chapter 160 of State Statute requires that DHS recommend adoption of a federal number unless there is new information not considered by the EPA when this level was adopted. Federal numbers include maximum contaminant levels or drinking water standards from the EPA. For total coliform, EPA replaced the maximum

contaminant level with a treatment technique. For some systems, this technique is triggered when total coliform is present (levels are more than zero). DHS considers this trigger as a federal number.

While total coliforms are not a direct indicator of fecal contamination and not all coliform bacteria are pathogenic, they can be used to evaluate the potential for infection associated with a water supply. The detection of total coliform in a well indicates that the well is compromised in some way and vulnerable to contamination by pathogens until the sanitary defect is identified and repaired.

Wisconsin's groundwater is used as a drinking water source in private wells and many public water systems. Unlike public systems, private well owners are not required to have their wells inspected and repaired following detection of total coliform, making them more at risk for the potential health effects described above. Furthermore, private well users include many sensitive subpopulations, including pregnant women, infants, and immunocompromised individuals. Therefore, DHS recommends an enforcement standard of zero for total coliform.

Basis for Enforcement Standard

- Federal Number
- Cancer Potential
- EPA Acceptable Daily Intake
- Technical information

DHS recommends a preventive action limit of 0 for total coliform.

Because DHS recommends an enforcement standard of zero for total coliform, the recommended preventive action limit is also zero.

Prepared by Sarah Yang, Ph.D.

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References

1. USEPA. National Primary Drinking Water Regulations: Revisions to the Total Coliform Rule, Final Rule. In: Register F, ed. *Vol. 78 No. 30*2013:10270-10365.
2. Payment P, Locas A. Pathogens in water: value and limits of correlation with microbial indicators. *Ground water*. 2011;49(1):4-11.
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