Contamination of Water
Part B: Natural/geogenic chemical pollutants

The material presented here has been prepared by Samuel Addison in April 2021, with input from Dr. Laura Richards and Prof. David Polya of the Department of Earth & Environmental Sciences, The University of Manchester, and other sources as acknowledged. The associated video recordings have been made by Samuel Addison.

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Introduction

This lesson will provide an overview of key natural/geogenic contaminants.

This lesson will build on the knowledge learnt in lesson “Contamination of Water - Part A: What is contamination?”.

Objectives

- Describe how contaminants can naturally contaminate drinking water

- To be able to discuss selected geogenic pollutants that can naturally occur in water supplies.

NATURALLY OCCURRING CHEMICALS

Naturally occurring chemicals

- Naturally occurring chemicals are of particular concern since the area of contamination can be quite extensive, and because contamination can go unnoticed in the absence of a testing program [1].

- WHO has established guideline values for compounds that can occur naturally in water [1].

[1] Pg. 21, UNICEF (2008).

Chemical Fact sheets

- The WHO provides information for each of these naturally occurring chemicals using chemical fact sheets (see [1]).
- Providing information such as guideline values and the chemical's occurrence.
- The following slides will highlight several of these chemicals prioritized by WHO – but importantly there are many other contaminants.

[1] Chapter 12 of World Health Organization, 2011. *Guidelines for drinking-water quality*. Fourth edition. World Health Organization.

Arsenic (As) GV 0.01 mg/L

- Arsenic in drinking water is a global threat to health, considered by some researchers to have more serious health repercussions than any other environmental contaminant [1]
- Arsenic occurs naturally in soils and rocks and in certain conditions can mobilise and contaminate water [1].
- Global prediction maps attempt to predict where arsenic contamination may be [2]
- See lesson “Arsenic pollution” for more information.

[1] Pg. 21, UNICEF (2008), [2] Podgorski and Berg (2020)

Fluoride (F) GV 1.5 mg/L

- Fluoride, along with arsenic, is one of the most serious chemical contaminants that occurs naturally in drinking water [1]
- Fluoride is a common element in the earth's crust and enters water through interaction with rocks [1]
- Studies have also attempted to model global distribution of fluoride contamination in groundwater [2].

[1] Pg. 21, UNICEF (2008), [2] Amini et al. (2008)

Barium (Ba)

- Barium occurs naturally in rock, with an average of 250 mg/kg in continental crust [1]

- It is positively charged in water and typically occurs at less than 0.1 mg/L, though natural concentrations in groundwater can exceed 1 mg/L [1]

[1] Pg. 24, UNICEF (2008)

Boron (B) GV 0.5 mg/L

- Boron concentration in rocks averages 10 mg/kg, with up to 100 mg/kg in some rock types [1]
- Boron levels in natural waters range widely, and are dependent on local geology and geochemical conditions [1]
- Boron in surface water is highly variable, though concentrations above 1 mg/L are rare. Groundwater levels range more widely, from < 0.3 to over 100 mg/L [1]

[1] Pg. 25, UNICEF (2008),

Manganese (Mn) 0.4 mg/L

- Manganese is one of the most abundant metals in the earth's crust [1]
- Surface water generally contains low levels of manganese (< 0.1 mg/L), groundwater can contain much higher levels (above 1 mg/L) [1]
- Unlike contaminants such as arsenic and fluoride, high levels of manganese lead to unpleasant tastes or staining, which sometimes can cause people to avoid water with high concentrations of manganese[1]

[1] Pg. 27, UNICEF (2008),

Selenium (Se) GV 0.01 mg/L

- Selenium is a trace element in rocks, with an average concentration of less than 1 mg/kg [1].
- Sedimentary rocks may contain up to 100 mg/kg, while levels up to several thousand mg/kg have been reported in some coal deposits [1]
- Natural levels of selenium in drinking water are generally below 0.01 mg/L [1]

[1] Pg. 28, UNICEF (2008)

Uranium (U) GV 0.015 mg/L

- Uranium occurs naturally in rocks and sediments, with average concentration in soils and rocks of 3 mg/kg [1]

- Although the decay of uranium isotopes produces radioactivity, the main public health threat of uranium arises from its chemical toxicity as a heavy metal [1]

[1] Pg. 29, UNICEF (2008)

Contaminant fate and transport

- Natural pathways such as hydrogeological flow paths for groundwaters as well as surface flow paths (e.g. river flow paths) and groundwater-surface water interaction can lead to the transport of contaminants in the environment [1]
- Human activity such as groundwater pumping can also impact the transport of contaminants in the environment [2]

[1] Pg. 26, UNICEF (2008), [2] Pg. 40, UNICEF (2008)

SUMMARY

Summary

- There are a wide range of chemicals that contaminate water resources.
- The chemicals can significantly vary in toxicity and concentration in water.
- Arsenic and fluoride are generally regarded as the most serious and widespread natural chemical contaminants especially in groundwater

LEARNING EXERCISE

Learning exercises

- A trait of some natural contaminants is that they spread over large areas, so contaminant mapping is a useful tool.
- An example of this, and for you to investigate is: https://www.gapmaps.org/Home/Public#

- Two studies that have done this also are:
- (For arsenic) https://doi.org/10.1126/science.aba1510
- (For fluoride) https://doi.org/10.1021/es071958y

REFERENCES & FURTHER RESOURCES

References

- UNICEF, 2008. UNICEF Handbook on water quality. *United Nations Childrens Fund, New York/USA*. https://www.unicef.org/documents/2008-unicef-handbook-water-quality

- World Health Organization, 2011. *Guidelines for drinking-water quality*. Fourth edition. World Health Organization. Here is a link to download the document: https://www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en

- Podgorski, J. and Berg, M., 2020. Global threat of arsenic in groundwater. *Science*, *368*(6493), pp.845-850. https://doi.org/10.1126/science.aba1510

- Amini, M., Mueller, K., Abbaspour, K.C., Rosenberg, T., Afyuni, M., Møller, K.N., Sarr, M. and Johnson, C.A., 2008. Statistical modeling of global geogenic fluoride contamination in groundwaters. *Environmental science & technology*, *42*(10), pp.3662-3668. https://doi.org/10.1021/es071958y

Further Resources

Look at chapter 12 of World Health Organization, 2011. *Guidelines for drinking-water quality*. Fourth edition. World Health Organization.

Here is a link to the web page with access to download the document: https://www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/

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