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Human exposure to endotoxins and fecal indicators originating from water features

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Highlights

- Endotoxins in air and water were measured at water features.
- Determinants of endotoxin content of air were explored using regression analyses.
- Endotoxin concentration in air depends on endotoxin concentration of source waters.
- Risk assessment may quantify the risks of infection from exposure to water features.

Abstract

Exposure to contaminated aerosols and water originating from water features may pose public health risks. Endotoxins in air and water and fecal bacteria in water of water features were measured as markers for exposure to microbial cell debris and enteric pathogens, respectively. Information was collected about wind direction, wind force, distance to the water feature, the height of the water feature and the tangibility of water spray. The mean concentration of endotoxins in air nearby and in water of 31 water features was 10 endotoxin units (EU)/m^3 (Geometric Mean (GM), range 0–85.5EU/m^3 air) and 773EU/mL (GM, range 9–18,170EU/mL water), respectively. Such mean concentrations may be associated with respiratory health effects. The water quality of 26 of 88 water features was poor when compared to requirements for recreational water in the Bathing Water Directive 2006/7/EC. Concentrations greater than 1000 colony forming units (cfu) Escherichia coli per 100mL and greater than 400cfu intestinal enterococci per 100mL increase the probability of acquiring gastrointestinal health complaints. Regression analyses showed that the endotoxin concentration in air was significantly influenced by the concentration of endotoxin in water, the distance to the water feature and the tangibility of water spray. Exposure to air and water near water features was shown to lead to exposure to endotoxins and fecal bacteria. The potential health risks resulting from such exposure to water features may be estimated by a quantitative microbial risk assessment (QMRA), however, such QMRA would require quantitative data on pathogen concentrations, exposure volumes and dose–response relationships. The present study provides estimates for aerosolisation ratios that can be used as input for QMRA to quantify exposure and to determine infection risks from exposure to water features.

Introduction

Water features may include decorative fountains, ornamental features and interactive fountains. These water features are often located in public areas such as shopping areas, hospitals, ponds, canals, parks or roundabouts. People may come into contact with water from the water features, which create aerosols to which people may be exposed e.g. by inhalation or ingestion.

Source water to fill water features may include local surface water, groundwater, rainwater or tap water determining the initial water quality. Subsequent contamination may occur through fecal bird droppings, runoff from paved surfaces (including e.g. dog feces), growth of micro-organisms in water (*Legionella* and algae), and in some cases discharges of combined sewer overflows (Schets et al., 2008). These contaminants may include a variety of chemical and biological contaminants, including pathogens and microbial cell debris, such as endotoxins.

A water feature sprays water, including its contaminants, into the air in the form of droplets and smaller water based aerosols. These aerosols may contaminate air, depending on feature specific factors such as water quality, flow rate, aerosolisation ratio (the fraction of the sprayed water that becomes an aerosol) and plume height (Environmental Protection Agency, 1982) and climatic factors such as temperature, rainfall, wind velocity and wind direction (Hunter, 2003). Contaminated aerosols potentially may have negative health effects for people who are exposed through contact, ingestion or inhalation (Carducci et al., 2000). Inhalation of aerosols will be the most likely route of exposure at water features if the spray device at the water feature produces aerosols within the respirable size range. At water features where produced aerosols are not in the respirable size range, ingestion of water may occur, whether intended (by swallowing mouthfuls of water) or unintended (through ingestion of aerosols or water droplets or through hand-mouth contact).

Exposure to contaminated aerosols has been discussed in the context of many studies in agricultural and industrial environments, and is potentially associated with adverse health effects (Health Council of the Netherlands, 2010). For instance, exposure through inhalation of endotoxins causes an increased prevalence of (work-related) airway and flu-like symptoms (Pillai and Ricke, 2002), and gastrointestinal and neurological complaints and joint pain in sewage workers (Laitinen et al., 1994, Lundholm and Rylander, 1983). Furthermore, exposure through ingestion of aerosols with fecal pathogens can cause gastrointestinal diseases (Uhrbrand et al., 2011).

To be able to indicate possible public health risks from exposure to water features we measured endotoxins in air and water as well as fecal indicator bacteria in water. Endotoxins and fecal indicators were measured to provide insight into exposure through inhalation and ingestion of water(spray) from water features. Since, exposures near water features may be influenced by several climatic and feature-specific factors (i.e. wind direction, distance to the fountain, height of the plume of the fountain etc.), these factors were measured as well.

Section snippets

Selection of markers to quantify exposure originating from water features

Endotoxin was measured as a marker for human exposure through inhalation of contaminated aerosols near water features. Endotoxins are lipopolysaccharides present in the outer membrane of gram-negative bacteria and some algae (Anderson et al., 2002) and were often regarded as a marker of exposure through inhalation to gram-negative bacteria (Douwes et al., 2003). Furthermore, endotoxins are easy to measure, which is an advantage as compared with the detection of living micro-organisms in air, …

Air measurements

Endotoxin concentrations in air were measured at 31 locations, described in Table 1, yielding 79 air samples. Of these samples, 6 samples were excluded due to failure of equipment, 34 samples (taken at 19 locations) exhibited endotoxin concentrations above the detection limit of 0.8 EU/m^3 and the other 39 samples exhibited endotoxin concentrations below this detection limit.

The average distance between the fountain and the air measurement equipment was 8 m (GM, range 0.5–49 m) with 18 …

Air quality

In this study, we explored whether human exposure to microbial markers can occur from inhalation near water features. The geometric mean of all air samples of 10 EU/m^3 air (GSD = 2.1, range 0–85.5 EU/m^3 air) was high compared to the study of Mueller-Annelling et al. (2004) who reported a weekly average with a geometric mean of 0.44 EU/m^3 in outdoor air (GSD 3.1, range 0.03–5.5 EU/m^3 air). Since similar data on endotoxin levels in outdoor air were limited (Health Council of the Netherlands, 2010 …

Conclusion

The present study has demonstrated the presence of endotoxins in air and water and fecal indicator bacteria in water of water features. Exposure to microbial content near water features may give rise to respiratory and gastrointestinal complaints. The extent to which exposure to water features causes these complaints should be investigated which exposure to water features causes these complaints should be investigated, probably through an epidemiological study. Exposure can be minimized by precautionary measures that improve the water quality or decrease the contact with …

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source analysis and health risk assessment

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2019, Journal of Allergy and Clinical Immunology

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2014, Water Research

Citation Excerpt :

…For instance, norovirus may be introduced in water of splash parks by people who interact with the water (Hoebe et al., 2004) or bird and other animals may introduce pathogens like Giardia and Cryptosporidium (Eisenstein et al., 2008). Given the poor water quality at splash parks (De Man et al., 2014b; De Man et al., 2014a,b,c), together with the increase of water temperature on warm days also gives rise to risks of non-fecal pathogens such as A. hydrophila and P. aeruginosa. While risks posed by these pathogens deserve evaluation, the necessary dose–response data is currently lacking.…

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