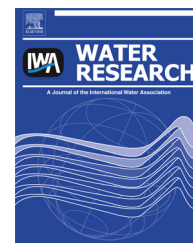


Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/watres

Adenovirus-associated health risks for recreational activities in a multi-use coastal watershed based on site-specific quantitative microbial risk assessment

Arti Kundu^a, Graham McBride^b, Stefan Wuertz^{a,c,d,*}

^a Department of Civil and Environmental Engineering, University of California, Davis, One Shields Avenue, Davis, CA 95616, USA

^b National Institute of Water and Atmospheric Research (NIWA), P.O. Box 11-115, Hillcrest, Hamilton 3216, New Zealand

^c Singapore Centre on Environmental Life Sciences Engineering (SCELSE), School of Biological Sciences, Singapore

^d School of Civil and Environmental Engineering, Nanyang Technological University, 60 Nanyang Drive, Singapore

ARTICLE INFO

Article history:

Received 16 February 2013

Received in revised form

2 August 2013

Accepted 3 August 2013

Available online 24 August 2013

Keywords:

Adenovirus

Risk assessment

Recreational waters

Human health

ABSTRACT

We used site-specific quantitative microbial risk assessment (QMRA) to assess the probability of adenovirus illness for three groups of swimmers: adults with primary contact, children with primary contact, and secondary contact regardless of age. Human enteroviruses and adenoviruses were monitored by qPCR in a multi-use watershed and Adenovirus type 40/41 was detected in 11% of 73 samples, ranging from 147 to 4117 genomes per liter. Enterovirus was detected only once (32 genomes per liter). Seven of eight virus detections occurred when *E. coli* concentrations were below the single sample maximum water quality criterion for contact recreation, and five of eight virus detections occurred when fecal coliforms were below the corresponding criterion. We employed dose-harmonization to convert viral genome measurements to TCID₅₀ values needed for dose–response curves. The three scenarios considered different amounts of water ingestion and Monte Carlo simulation was used to account for the variability associated with the doses. The mean illness risk in children based on adenovirus measurements obtained over 11 months was estimated to be 3.5%, which is below the 3.6% risk considered tolerable by the current United States EPA recreational criteria for gastrointestinal illnesses (GI). The mean risks of GI illness for adults and secondary contact were 1.9% and 1.0%, respectively. These risks changed appreciably when different distributions were fitted to the data as determined by Monte Carlo simulations. In general, risk was at a maximum for the log-logistic distribution and lowest for the hockey stick distribution in all three selected scenarios. Also, under default assumptions, the risk was lowered considerably when assuming that only a small proportion of Adenovirus 40/41 (3%) was as infectious as Adenovirus type 4, compared to the

* Corresponding author. Department of Civil and Environmental Engineering, University of California, Davis, One Shields Avenue, Davis, CA 95616, USA. Tel.: +1 530 754 6407; fax: +1 530 752 7872.

E-mail address: swuertz@ucdavis.edu (S. Wuertz).

0043-1354/\$ – see front matter © 2013 Elsevier Ltd. All rights reserved.

<http://dx.doi.org/10.1016/j.watres.2013.08.002>

assumption that all genomes were Adenovirus 4. In conclusion, site-specific QMRA on water-borne adenoviruses in this watershed provided a similar level of protection against public health risks as would be obtained by enumeration of fecal indicator bacteria under the new U.S. EPA guidelines.

© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

There are 38.6 million illnesses annually from known pathogens in the U.S., including 5.2 million (13%) from bacteria, 2.5 million (7%) from parasites, and 30.9 million (80%) from viruses (CDC, 1999). Enteric viruses are considered major etiological agents of gastrointestinal (GI) illnesses in individuals from human impacted waters (Schoen and Ashbolt, 2010; Sinclair et al., 2009; Soller et al., 2010). Worldwide, noroviruses are believed to be the single largest cause of outbreaks (45%), followed by adenovirus (24%), echovirus (18%), hepatitis A virus (7%) and coxsackievirus (5%), documented in the published literature (Sinclair et al., 2009). Adenovirus testing has been advocated for monitoring of enteric human viral pathogens (Aslan et al., 2011; Fong et al., 2010). Adenoviruses are considered the second leading cause of viral gastroenteritis in children after rotavirus (Enriquez et al., 1995; Goncalves et al., 2011). Although they are included in the U.S. EPA candidate of contaminant list (U.S. EPA, 1998), very few studies are available that document the presence of adenoviruses in freshwater using molecular techniques such as quantitative polymerase chain reaction (qPCR) (Rajal et al., 2007a; Viau et al., 2011; Xagorarakis et al., 2007).

Adenoviruses occur in many water environments and these viruses are exceptionally resistant to purification and disinfection processes (Eisechid et al., 2009; Nwachuku et al., 2005). They are the only human enteric viruses that have a double-stranded DNA genome making them more resistant to UV-light than single-stranded RNA of other enteric viruses such as polio and hepatitis A viruses (Yates, 2008). Adenovirus can multiply in the intestine and be shed in feces. Adenovirus types 40 and 41 of subgroup F are responsible for most cases of adenovirus-associated gastroenteritis. Important issues regarding the occurrence of Adenovirus 40/41 in water are its resistance to conventional methods of disinfection, a high excretion rate in infected individuals, and high persistence in the environment (Enriquez et al., 1995; Kuo et al., 2010; Rigotto et al., 2011). For these reasons, the presence of Adenovirus in waters represents a public health concern. Also, non-enteric adenoviral infections can spread through coughing and sneezing and are a major source of concern with respect to acute respiratory disease (ARD).

Adenoviruses are prevalent all over the world, including in Australia (Grohmann et al., 1993), Singapore (Aw and Gin, 2011), USA (Arnold and Walling, 2007; Aslan et al., 2011; Jiang, 2006; Viau et al., 2011), Eastern Chad (Guerrero-Latorre et al., 2011), Europe (Wyn-Jones et al., 2011), Japan (Haramoto et al., 2005; Katayama et al., 2008), Korea (Lee and Kim, 2008), West and South Africa (van Heerden et al., 2005; Verheyen et al., 2009), New Zealand (Till et al., 2008) and Brazil (Barrella et al., 2009; Silva et al., 2011). Thus, the use of

widely geographically divergent enteric viruses has been advocated as indicators for microbial pollution of recreational waters (Fong and Lipp, 2005; Irving and Smith, 1981; Jiang et al., 2001; Krikelis et al., 1985; Muscillo et al., 2008; Pina et al., 1998; Silva et al., 2011).

Current recreational water quality criteria (RWQC) are based on epidemiological studies and do not provide any insight into specific microbial agents that are responsible for the observed illnesses in recreators (U.S. EPA, 2012a). Quantitative microbial risk assessment (QMRA) is a mechanistic approach to estimate the risk of infection/illness from exposure to pathogens (Soller et al., 2010) in a given location via direct or indirect consumption of contaminated water (Haas et al., 1993; Razzolini et al., 2011; Rose et al., 1991; Soller and Eisenberg, 2008). The main advantage of using QMRA is that one can quantify the probability of infection, illness, and morbidity by estimating the exposure to pathogens; hence this can result in better management options related to health protection of recreational users. U.S. EPA is evaluating the role of site-specific QMRA criteria for the Beaches Environmental Assessment and Coastal Health Act (BEACH) (U.S. EPA, 2012) and has issued a general guideline for risk assessment to be performed in food and water (U.S. EPA, 2012b). Site-specific QMRA helps in understanding the risks from various contaminant sources and can provide estimates which pathogens cause illnesses to recreators in a specific water body. This also accelerates management decisions and aids communication related to a contaminated water body.

The objectives of this study were to 1) estimate risks associated with environmental concentrations of adenovirus in a mixed-use coastal watershed, Calleguas Creek Watershed (CCW), using QMRA; 2) estimate risks for three groups of recreational users (primary contact by adults who are bathing, primary contact by children who are bathing, and secondary contact by other recreational activities); 3) compare risk estimates derived from QMRA on adenovirus with protection levels afforded by regulatory standards of fecal indicator bacteria (FIB); 4) test the sensitivity of results to an assumed proportion of adenoviruses that are infectious for respiratory illness; and 5) test the sensitivity of results to the assumed type of distribution function of virus concentrations.

2. Materials and methods

2.1. Sampling area

The Calleguas Creek Watershed (CCW, Fig. 1) measures 343 square miles (888 square kilometers) and is situated in Ventura County in southern California. The major tributaries monitored in the watershed were Revlon Slough, Arroyo Las

Download English Version:

<https://daneshyari.com/en/article/6367326>

Download Persian Version:

<https://daneshyari.com/article/6367326>

[Daneshyari.com](https://daneshyari.com)