Science of the Total Environment 646 (2019) 427–437

Contents lists available at ScienceDirect

Science of the Total Environment

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

Noroviruses in raw sewage, secondary effluents and reclaimed water produced by sand-anthracite filters and membrane bioreactor/reverse osmosis system

Tatiana Prado [a,*], Antônio de Castro Bruni [a], Mikaela Renata Funada Barbosa [a], Suzi Cristina Garcia [a], Luisa Zanolli Moreno [b], Maria Inês Zanoli Sato [a]

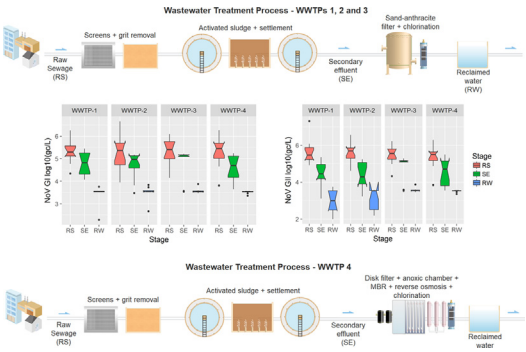
[a] Department of Environmental Analysis, Division of Microbiology and Parasitology, Environmental Company of the São Paulo State (CETESB), Av. Prof. Frederico Hermann Jr., 345, São Paulo, SP 05459-900, Brazil

[b] Laboratory of Molecular Epidemiology and Antimicrobial Resistance, School of Veterinary Medicine and Animal Science, University of São Paulo, Av. Prof. Dr. Orlando Marques de Paiva, 87, São Paulo, SP 05508-270, Brazil

HIGHLIGHTS

- Noroviruses are widely disseminated in the municipal wastewaters of São Paulo city.
- Higher viral loads were observed in winter season.
- Activated sludge processes showed higher impact on NoV GII removal than NoV GI.
- Results demonstrated the best performance of the MBR/RO systems in virus removal.
- Prevalence of GII.17 indicates a shift in the epidemiology of NoV GII in the city.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 19 May 2018
Received in revised form 20 July 2018
Accepted 21 July 2018
Available online 23 July 2018

Editor: Frederic Coulon

Keywords:
Membrane bioreactor-MBR
Noroviruses
Reclaimed water
Reverse osmosis
Sand-anthracite filters
Wastewater treatment plants

ABSTRACT

The importance of noroviruses (NoVs) in the epidemiology of waterborne diseases has increased globally in the last decades. The present study aimed to monitor genogroup I and II noroviruses in different treatment stages of four wastewater treatment plants (WWTPs) in the metropolitan São Paulo. WWTPs consist of secondary (activated sludge) and tertiary treatments (coagulation, sand-anthracite filters, membrane bioreactor (MBR)/reverse osmosis (RO) and chlorination). Raw sewage (500 mL) and treated effluents (1 L) were concentrated by celite and reclaimed water (40 L) by hollow-fiber ultrafiltration system. Quantitative (qPCR) and nested PCR with nucleotide sequencing were used for quantification and molecular characterization. NoVs were widely distributed in raw wastewater samples (83.3%–100% NoV GI and 91.6%–100% NoV GII) and viral loads varied from 3.8 to 6.66 $\log_{10}$ gc L^{-1} for NoV GI and 3.8 to 7.3 $\log_{10}$ gc L^{-1} for NoV GII. Mean virus removal efficiencies obtained for activated sludge processes ranged from 0.3 to 0.8 $\log_{10}$ for NoV GI and 0.4 to 1.4 $\log_{10}$ for NoV GII. NoVs were not detected in the reuse water produced by MBR/RO system, while sand-anthracite filters resulted in a NoV GI and GII decay of 1.1–1.6 $\log_{10}$ and 0.7–1.6 $\log_{10}$, respectively. A variety of genotypes (GI.2, GI.3a, GI.3b, GI.5, GII.1, GII.4 Sydney 2012, GII.5, GII.6, GII.17) was observed, with a predominance of GI.2 and GII.17 in the different genogroups. These results corroborate with recent data about the entry and dissemination of the emerging genotype GII.P17-GII.17 Kawasaki 2014 in the country, and may indicate a change in the epidemiological patterns

* Corresponding author.
E-mail address: tatianaprado436@gmail.com (T. Prado).

https://doi.org/10.1016/j.scitotenv.2018.07.301
0048-9697/© 2018 Elsevier B.V. All rights reserved.

of norovirus strains circulation in this region. This is the first large-scale study to evaluate burden and genotypes of noroviruses in WWTPs in Brazil, providing a rapid diagnosis of viruses circulating in the population.
© 2018 Elsevier B.V. All rights reserved.

1. Introduction

Noroviruses (NoV) are currently considered the main etiological agents in the world causing outbreaks of acute gastroenteritis associated with water and food (Kirk et al., 2015). Annually, they are estimated to cause 684 million episodes of diarrheal disease and 212,000 deaths among all ages and from all modes of transmission. The disease results in an economic burden of US $ 4.2 billion in direct health system costs and US $ 60.3 billion in societal costs (Bartsch et al., 2016). In Latin America, NoV are associated with almost 1 out of every 6 hospitalizations due to acute diarrhea in children younger than 5 years of age (O'Ryan et al., 2017).

In metropolitan São Paulo, NoV is the main cause of foodborne diseases outbreaks (25%) in total outbreaks investigated between 2012 and 2016 (58/231) (Coordination of Health Surveillance State of SP - SINAN NET/COVISA/CCD/Banco EPI/Surtos DTA) (personal communication).

NoVs are single-stranded RNA viruses, positive polarity, not enveloped, and classified within the genus *Norovirus*, from the family *Caliciviridae* (De Graaf et al., 2016; Vinjé, 2015). The viral particle is 27 to 40 nm in diameter and 7.5 to 7.7 kb in genome length, containing 3 open reading frames (ORFs) (ORF1, ORF2 and ORF3) (Vinjé, 2015). NoV is currently divided into 6 genogroups, designated GI to GVI, based on the amino acid identity of the largest structural protein (VP1) (De Graaf et al., 2016). Genogroups I and II are responsible for the majority of human disease cases, while GIV is rarely detected as a cause of sporadic or epidemic disease (Vinjé, 2015). To date, 9 genotypes have been recognized in GI and 19 in GII (Vinjé, 2015).

Among the established genotypes, NoV GII.4 strains are prevalent in outbreaks of gastroenteritis around the world, including Brazil (Fioretti et al., 2011; Vinjé, 2015). Due to evolution, new pandemic variants of NoV GII.4 have emerged every 2 to 3 years since the mid-1990s, replacing previously dominant strains of GII.4, often, but not always, associated with an increased number of outbreaks (Vinjé, 2015).

Norovirus is stable in the environment, and has an infectious dose of 50% (ID_{50}) reaching 18 to 10^3 genome copies (Lopman et al., 2012; Vinjé, 2015). The ease with which noroviruses are transmitted and the low infectious dose required to establish an infection result in extensive outbreaks.

The risk of NoV infection associated with environmental exposure, particularly to water contaminated with human fecal matter and reclaimed water, is an emerging research topic (Eftim et al., 2017; Sano et al., 2016). Water reuse has been considered an environmentally sound and sustainable alternative to mitigate the effects of hydric stress already verified in several parts of the world (Sano et al., 2016).

However, a matter of considerable societal concern is the potential risk to human health associated with human contact with waterborne pathogenic microorganisms present in wastewater (Sano et al., 2016; Yasui et al., 2017). More specifically, waterborne viral pathogens are inadequately removed from existing wastewater treatment systems and bacterial indicators used to assess water quality fail to detect their presence accurately (Montazeri et al., 2015; Sano et al., 2016). Several researches have focused on the choice of suitable viral indicators to evaluate human fecal contamination in different aquatic ecosystems, including human adenoviruses (HAdV), JC polyomaviruses, pepper mild mottle viruses (PMMoV) and bacteriophages (Amarasiri et al., 2017; Fumian et al., 2013; Kitajima et al., 2014; Prado et al., 2018; Sidhu et al., 2017). Noroviruses, although are not considered good viral markers to evaluate human fecal contamination in aquatic ecosystems, are important pathogens associated to food and waterborne diseases.

Therefore, in order to reduce risks to human health associated with discharge of final effluents into the environment and to address the growing pressure for direct or indirect reuse of reclaimed waters, methods for the detection, removal and prediction of concentrations of viral pathogens need to be established and optimised.

A recent work using meta-analysis to characterize the NoV load in raw sewage from WWTPs of different parts of the world included survey data from several continents: Asia, Europe, USA and New Zealand, but none specifically from South America (Eftim et al., 2017). In Brazil, there are few relevant studies evaluating the load and efficiency of sewage treatment systems for NoV removal (Fumian et al., 2013; Victoria et al., 2010) and none specifically for tertiary or advanced treatment systems, including bioreactor membrane (MBR). Thus, there is a lack of information on the performance of conventional and advanced sewage treatment systems operating in real scale in the country and the virological quality of final effluents produced.

Reclaimed water generated in Municipal Wastewater Treatment Plants (WWTPs) has been used in São Paulo city mainly for industrial and urban purposes, including landscape irrigation, street and vehicle washing, civil construction, firefighting, among others. The volume produced is sold to Municipalities, construction companies and industries in the textile, petrochemical and paper and pulp sectors. There is also an expectation to expand the production of reuse water in the coming years, including reuse in the recharge of aquifers.

Despite the absence of more specific national legislations to regulate the practice in this sector, recently the State of São Paulo implemented legislation (Resolution SES/SMA/SSRH Nº. 01 - June 28, 2017) establishing standards for non-potable direct reuse of water from WWTPs for urban purposes. In this legislation, monitoring and water quality standards were established for reuse with moderate and severe restriction. Limits of thermotolerant coliforms (≤200 CFU/100 mL) and helminth eggs (1 egg/L) were included for severe restriction. Moderate restriction requires a treatment process that guarantees no measurable levels of pathogens, including viruses. Although, the legislation does not specify the viruses to be investigated, the competent authorities to enforce this regulation will require analyses of pathogenic viruses or viral indicator, such as bacteriophages or adenoviruses, to characterize the efficiency of reuse water treatment process.

Therefore, the aim of this study was to monitor NoV GI and GII in urban wastewaters, treated effluents and reclaimed water samples produced at four municipal WWTPs in the metropolitan region of São Paulo, during a one-year period (April 2015 to March 2016). WWTPs employ secondary (conventional activated sludge) and diverse tertiary treatments (coagulation/sedimentation/microfiltration/MBR/reverse osmosis system) and final disinfection by chlorination. Besides the viral loads detected in distinct stages of treatment processes, genotypes were identified through phylogenetic analysis, providing important information on virus circulation in the population served by sewage systems.

2. Material and methods

2.1. Sampling and characteristics of WWTPs

Grab samples were collected in different sewage treatment process stages from four WWTPs that receive sewage of approximately 8 million people living in São Paulo, the largest city in South America. The WWTP

Download English Version:

https://daneshyari.com/en/article/8858388

Download Persian Version:

https://daneshyari.com/article/8858388

Daneshyari.com