IWA 17th SWWS AND 9th ROS
10th–14th November, 2024
Curitiba-Brazil

Quantitative microbial risk assessment for adenovirus in aerosols from two WWTPs in Brazil

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Highlights:

- **Comparison between the probability of infection by adenovirus inhalation for aerosol for scenarios with and without the use of PPE**
- **A tolerable risk of infection was calculated based on the burden of diseases caused by the adenovirus in Brazil**
- **One of the first studies in Brazil to use QMRA to analyze the impact of WWTP aerosols on workers' health**

Keywords: bioaerosol; adenovirus; QMRA

INTRODUCTION

Several pathogenic microorganisms can be found in wastewater, and during different treatment stages at Wastewater Treatment Plants (WWTP), aerosols may form, constituting a potential source of dissemination of pathogens. Therefore, the risk these aerosols pose to workers' health must be evaluated so that corrective and preventive actions can be taken.

Quantitative Microbial Risk Assessment (QMRA) is a tool used to quantify human health risks due to exposure to pathogenic microorganisms. It is seen as useful for classifying risks and comparing different problems and solutions (WHO, 2016).

In this work, QMRA was performed to evaluate the risk that adenoviruses, which are viruses of consistent stability and persistence in wastewater, present in aerosols generated at WWTP represent to the health of WWTP workers.

METHODOLOGY

Hazard identification: **Infection by inhalation of adenovirus present in aerosols from WWTPs.**

Dose-response model: **The dose-response model used in this study is a beta Poisson model developed by Teunis, Schijven, and Rutjes (2016) from five studies analyzing various adenovirus types and transmission routes. The dose-response parameters, for the inhalation route, are α = 5.24 and β = 2.95.**

Exposure assessment: **For risk characterization, the dose of microorganisms inhaled per day is given by the product between adenovirus concentration, exposure duration and inhalation rate. Adenovirus concentrations were obtained from aerosol sampling at different locations at two different WWTPs in Brazil. Table 1 shows the parameters and scenarios considered for this QMRA.**

Parameter	Distribution	Value	Reference
Adenovirus concentration	Uniform	Scenario A1: 0 – 11 GC m^{-3} / maximum aerosol concentration at WWTP A Scenario A2: 0 – 0.36 GC m^{-3} / second maximum aerosol concentration at WWTP A Scenario B1: 0 – 1.1 GC m^{-3} / maximum aerosol concentration at WWTP B Scenario B2: 0.89 – 1.1 GC m^{-3} / minimal and maximum aerosol concentration at downwind samples at WWTP B	Our previous work
Exposure duration	Constant	8 hours	-
Inhalation rate	Discrete	15,7 (50%) and 16,0 (50%) m^3 day^{-1}, considering age groups from 21 to 60 years	(U.S. Environmental Protection Agency (EPA), 2011)
Conversion from GC to $TCID_{50}$	Constant	1,43 × 10^{-3} $TCID_{50}$ GC^{-1}	(Bambic et al., 2011; Kundu, McBride, and Wuertz, 2013)
Removal fraction due to PPE use	Uniform	0.95 – 0.99	(Haas et al., 2017)

Table 1. Exposure assessment parameters

Risk characterization: **The probability of infection was calculated in Microsoft Excel® software, considering 10,000 interactions for each scenario. The annual probability of infection was also calculated as considering 239 work days, assuming 5 work days per week and 30 days of vacation.**

Tolerable infection risk: **For the estimation of tolerable infection risk for adenovirus in Brazil, similar to Zaneti et al. (2021) made regarding SARS-CoV-2, the calculation proposed by Mara (2008), was used. To find the tolerable infection risk, it is needed to calculate the tolerable disease risk (Tolerable DALY loss /DALY loss per case of disease) and divide by the disease/infection**

ratio. The WHO proposed the tolerable DALY loss of 10^{-6} DALY pppy. DALY loss per case of disease was defined using data from the Global Burden of Disease Study (GBD) of 2019 in Brazil, where it is shown that adenovirus caused a burden of disease of 0.53 DALY per 100,000 people for the age group of 15-49 years and 0.60 DALY per 100 thousand people for the age group of 50-69 years (Global Burden of Disease Collaborative Network, 2020). Due to the lack of information, a conservative disease/infection ratio of 1 was assumed.

RESULTS AND CONCLUSIONS

The mean annual probabilities of infection by inhalation of adenovirus found are shown in Figure 1. With and without PPE use, they are above the benchmark proposed by the US EPA, of 10^{-4} pppy. In this work, we have calculated a tolerable risk of 0.19 for people between 15 and 49 years old, and 0.17 for people between 50 and 69 years old, based on the burden of diseases tolerance of WHO, of 10^{-6} DALY pppy, and considering the burden of diseases caused by adenovirus in Brazil. For these benchmarks, 3 of 4 scenarios have shown acceptable infection risk when proper PPE is used, reinforcing the importance of using PPE.

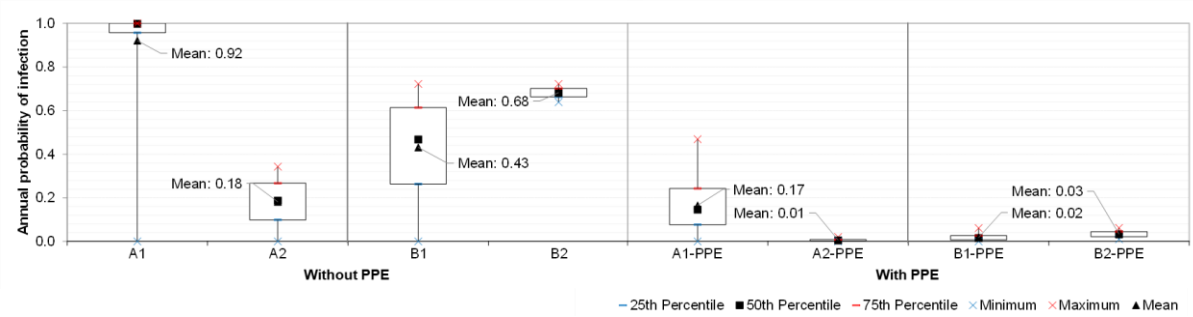

Figure 1. Probability of infection for each scenario without and with PPE use

The differences between Scenario A1 and Scenario A2 shows that one high concentration, given the uniform distribution used, can impact expressively the QMRA results, which could be more reliable if the distribution of adenovirus concentration in aerosols were better known. On the other hand, for WWTP B, Scenario B2, in which only results from the downwind sampler were considered, showed a probability of infection higher than the 75th percentile of Scenario B1, in which results from all samplers were considered. Notably, downwind samples were obtained and analyzed using a different approach than other samples at WWTP B. This shows the need to develop more studies on WWTP aerosol sampling and analysis. Furthermore, improvements must be made to the model for the results to be more reliable, mainly regarding the concentration, viability and types of adenoviruses to which workers may be exposed and the exposure routes considered.

Finally, this work is one of the first studies in Brazil to assess, based on QMRA, the risk that pathogenic microorganisms present in WWTP aerosols pose to workers' health.

ACKNOWLEDGMENTS

We would like to thank the financial support from the Instituto Nacional de Ciência e Tecnologia em ETEs Sustentáveis (INCT Etes Sustentáveis), the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and the Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG).

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