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In vitro toxicity of arsenic rich waters from an abandoned gold mine in northeast Portugal

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ABSTRACT

This is a follow-up study of physicochemical water monitoring data from the abandoned Freixeda gold mine in Portugal, where arsenic (As) has remained above drinking water and irrigation limits over the years. The main objective of the current work was to investigate the toxicological potential of As-containing water on human cell line as an indicator of a potential health risk to humans. Six water samples collected in February 2018 were analysed for arsenic, major anions, cations and trace elements. Toxicity experiments were carried out on the human gastrointestinal cell line Caco-2 with five water samples containing As above 10 μg L^{-1}. The results show that groundwater contains higher amounts of dissolved minerals than surface water, particularly with higher concentrations of SO_4^{2-}, Fe and HCO_3^- and also higher As(III), reaching 336 μg L^{-1} (As(T) = 607 μg L^{-1}). In surface waters As concentration decreased and reached 150 μg L^{-1}, mainly as As(V). Metabolic activity was generally lower in Caco-2 cells exposed to As-containing water samples compared to pure As(III) solution, adapted to As concentrations, while production of reactive oxygen species (ROS) was higher. Short-term exposure to As-contaminated water samples also resulted in increased genotoxicity. This study suggests that mixture of As with various chemical elements in water may have a synergistic effect in promoting cytotoxicity. It is likely that prolonged exposure, as is common in areas with contaminated water, would have even more harmful effects.

1. Introduction

Arsenic contamination of natural waters is a global problem and a major health issue (Arain et al., 2009; Garelick et al., 2009; Hamidian et al., 2019; Kumar et al., 2020; Sarkar and Paul, 2016; Singh et al., 2015; Soujanya Kamble et al., 2020). Pollution of drinking water with arsenic (As) is a health threat to more than 150 million people around the world, particularly in South and East Asia (Arain et al., 2009; Singh et al., 2015; Zhang et al., 2017). A special case of arsenic water contamination is the surrounding of abandoned mining areas, with a particular threat to ecosystems and human health, if exposure to possible pathways occur (Abraham et al., 2018; Antunes and Albuquerque, 2013; Khaska et al., 2018). Arsenic can persist over time, even when the concentration of other trace metals in the solution decreases due to natural attenuation or lime treatment of Acid Mine Drainage (AMD) (Ali et al., 2016; Berger et al., 2000; Nordstrom, 2020; Younger, 1997).

Arsenic is a metalloid that occurs in the environment in various oxidation states and forms different species, e.g., As(V), As(III), As(0) and As(-III) (Choong et al., 2007; Singh et al., 2015). It is the most problematic oxyanion-forming element due to its mobility over a wide range of redox conditions (Smedley and Kinniburgh, 2002). Controlling factors of As speciation and mobilization include sorption/desorption on Fe and Mn oxides/hydroxides, pH and redox potential (Eh) and other factors such as the presence of interfering ions and organic matter (Machado et al., 2019; Sarkar and Paul, 2016). Mobility of As species in groundwater is largely controlled by redox reactions and increases under reducing conditions, and pH values of 6.5–8.5, which is common

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