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Effect of Antimony on Microorganisms in Aerobic and Anaerobic Environments

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Abstract : Antimony is a toxic and carcinogenic metalloid considered a pollutant of priority interest by the United States Environmental Protection Agency. It is present in the environment in two oxidation states: antimonite (Sb (III)) and antimony (Sb (V)). Sb (III) is toxic to several aquatic organisms, but the potential inhibitory effect of Sb species for microorganisms has not been extensively evaluated. The fate and possible toxic impact of antimony on aerobic and anaerobic wastewater treatment systems are unknown. For this reason, the objective of this study was to evaluate the microbial toxicity of Sb (V) and Sb (III) in aerobic and anaerobic environments. Sb(V) and Sb(III) were used as potassium hexahydroxoantimonate (V) and potassium antimony tartrate, respectively (Sigma-Aldrich). The toxic effect of both Sb species in anaerobic environments was evaluated on methanogenic activity and the inhibition of hydrogen production of microorganisms from a wastewater treatment bioreactor. For the methanogenic activity, batch experiments were carried out in 160 mL serological bottles; each bottle contained basal mineral medium (100 mL), inoculum (1.5 g of VSS/L), acetate (2.56 g/L) as substrate, and variable concentrations of Sb (V) or Sb (III). Duplicate bioassays were incubated at 30 ± 2°C on an orbital shaker (105 rpm) in the dark. Methane production was monitored by gas chromatography. The hydrogen production inhibition tests were carried out in glass bottles with a working volume of 0.36 L. Glucose (50 g/L) was used as a substrate, pretreated inoculum (5 g VSS/L), mineral medium and varying concentrations of the two species of antimony. The bottles were kept under stirring and at a temperature of 35°C in an AMPTSII device that recorded hydrogen production. The toxicity of Sb on aerobic microorganisms (from a wastewater activated sludge treatment plant) was tested with a Microtox standardized toxicity test and respirometry. Results showed that Sb (III) is more toxic than Sb (V) for methanogenic microorganisms. Sb (V) caused a 50% decrease in methanogenic activity at 250 mg/L. In contrast, exposure to Sb (III) resulted in a 50% inhibition at a concentration of only 11 mg/L, and an almost complete inhibition (95%) at 25 mg/L. For hydrogen-producing microorganisms, Sb (III) and Sb (V) inhibited 50% of this production with 12.6 mg/L and 87.7 mg/L, respectively. The results for aerobic environments showed that 500 mg/L of Sb (V) do not inhibit the Allivibrio fischeri (Microtox) activity or specific oxygen uptake rate of activated sludge. In the case of Sb (III), this caused a loss of 50% of the respiration of the microorganisms at concentrations below 40 mg/L. The results obtained indicate that the toxicity of the antimony will depend on the speciation of this metalloid and that Sb (III) has a significantly higher inhibitory potential compared to Sb (V). It was shown that anaerobic microorganisms can reduce Sb (V) to Sb (III). Acknowledgments: This work was funded in part by grants from the UA-CONACYT Binational Consortium for the Regional Scientific Development and Innovation (CAZMEX), the National Institute of Health (NIH ES- 04940), and PAPIIT-DGAPA-UNAM (IN105220).

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