Toxicity of cadmium to two Streptomyces species as affected by clay minerals

ZEINAT KAMEL
Faculty of Science, Botany Department, University of Cairo, Egypt

Received 5 December 1983. Revised August 1985

Key words Bentonite Cadmium Kaolinite Streptomyces bottropensis S. rimosus Vermiculite

Summary The effect of cadmium on the growth of Streptomyces rimosus and S. bottropensis (both isolated from soil) was investigated. The modifying effect of the presence of the clay minerals kaolinite, bentonite and vermiculite on Cd toxicity was also included. After four days no growth was observed at 100 ppm CdCl₂ of S. bottropensis and at 150 ppm in case of S. rimosus. After six days some growth of S. rimosus occurred at 150 ppm CdCl₂ and of S. bottropensis at 100 ppm. Addition of the three clay minerals decreased the Cd toxicity considerably.

Introduction

Various industrial processes lead to an increasing release of a variety of pollutants, into the biosphere. A very serious form of pollution is that by heavy metals which have been shown to enter biological systems and enter into various food chains.

One of the numerous particulate heavy metal contaminants currently being emitted is cadmium (Cd). Sources of pollution with Cd are by-products of metal processing, mine wastes, electroplating, fertilizers and pesticides. The Cd content in the biosphere has been reported to be increasing with subsequent increased uptake and accumulation of Cd in the biota.

Most of the research on toxicity of Cd was concentrated on man, animals, and plants, whereas there is little investigation on the response of micro-organisms to Cd. There are some data on the effect of Cd on bacteria. Most investigations on the response of fungi to Cd have been focussed on the use of Cd as a fungicide. Babich and Stotzky studied the response of a variety of microorganisms, including actinomycetes, to the toxicity of Cd and found large differences in the sensitivity of Cd among microorganisms.

Micro-organisms influence or even change their environment, whereas their growth is strongly affected by the environmental conditions. In soil the kind of clay minerals being present is of prime importance in this connection. Previous studies have shown that the
phytotoxicity of Cd depends on the physiochemical characteristics of the environment; pH\textsuperscript{2.4}, inorganic mineral composition\textsuperscript{29}, temperature\textsuperscript{16,28}, and the binding capacity of adsorbent particles such as humic acid and organic soils\textsuperscript{5,6,24}.

There is, however, little information on the response of actinomycetes to Cd and studies on the interaction between pollutants, the environment and the biota are rare. This study evaluates the sensitivity to Cd of two \textit{Streptomyces} species, isolated from soil \textit{in vitro}. The effect of clay minerals on this sensitivity was also investigated.

**Materials and methods**

**Micro-organisms**

\textit{Streptomyces rimosus} CU-2 and \textit{Streptomyces bottropensis} CU-13 previously isolated from Egyptian soil\textsuperscript{23}, were grown and maintained on glycerol-casein agar\textsuperscript{22}. The cultures were stored in a refrigerator at 4 °C.

**Medium**:

The tolerance of two \textit{Streptomyces} species to Cd was evaluated with broth consisting of: glucose, 10.0 g; peptone, 3.0 g; MgSO$_4$·7H$_2$O, 0.5 g; CaCl$_2$·2H$_2$O, 1.0 g; yeast extract, 1.0 g; and distilled water, 1000 ml. The medium was adjusted to pH 7.0. It was amended with various concentrations of Cd (as CdCl$_2$). Inorganic phosphorus was eliminated from the broth to avoid precipitation of phosphate salts of Cd$^{4+}$. Peptone and yeast extract satisfied the requirements of micro-organisms for phosphorus and potassium.

**Clay minerals**

Three pure clay minerals, kaolinite, bentonite and vermiculite were supplied by the Institute of Soil and Water, Agric. Res. Centre, Giza, The clay minerals had the following cation exchange capacity (CEC) meq/100 g oven-dried clay): kaolinite, 4.8; bentonite, 76.5; vermiculite, 108.7.

**Influence of Cd on growth of Streptomyces species**

Each \textit{Streptomyces} sp. was grown for one week at 28 °C on agar slants. The slants were then flood with sterile distilled water and portions (1.0 ml) of this standard spore suspension were inoculated into Erlenmeyer flasks (250 ml cap.) containing 50 ml of the broth, which had previously been amended with 0, 1.0, 10, 50, 75, 100 or 150 ppm of CdCl$_2$. The flasks were incubated at 28 °C for 8 days. At 2 days intervals, dry weights were determined. The contents of each flask was filtered and rinsed twice with distilled water, the mats were dried at 100 °C and weighed. Three replicates were employed for each concentration.

**Effect of clay minerals on toxicity of Cd towards Streptomyces species**

A standard spore suspension of each organism was inoculated into Erlenmeyer flasks (250 ml cap.) containing 50 ml of the nutrient broth amended with 0, 1.0, 50, 100 or 150 ppm Cd Cl$_2$ to which was added either 3% kaolinite, 3% bentonite, 3% vermiculite, or nothing. The flasks were incubated at 28 °C for 6 days, after which time the dry weights were determined. Three replicates were employed for each object.

**Results**

The data in Table 1 reveal that 1 ppm Cd seemed without significant effect on dry weight gain by both \textit{Streptomyces} species. Higher Cd