# Interactions of noncompetitive inhibitors on the nitrification process

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Nitrogenous fertilizer industries are fast multiplying to meet the food demands of an expanding world population. In 1971 the global use of various chemical fertilizers was 63.5 Mg (70 mil tons), and is expected to reach about 104 Mg (115 mil tons) in the next few years.[1] Current annual use of more than 29 Mg (32 mil tons) of nitrogenous fertilizers alone is approaching the amount of total nitrogen estimated to be fixed biologically worldwide.[2]

The wastewater of nitrogenous fertilizer industries usually has an ammonium concentration of 20.0 to 4 000.0 mg/L, along with varying concentrations of arsenic, chromium, and fluoride.[3,4] In the literature, these inorganic compounds have been reported to be potentially toxic.[5-8] For normal fertilizer plant operations, the maximum concentrations of trivalent arsenic, hexavalent chromium, and fluoride have been found to be 10.0, 20.0, and 200.0 mg/L, respectively.[9] But because of process spills, which are very irregular in frequency and size, the concentrations of these toxicants may sometimes exceed normal maximum concentration.

To reduce these high ammonium concentrations in nitrogenous wastewater to ecologically acceptable levels, biological nitrification-denitrification may be a promising method. But this depends on how the kinetics, design, and performance of the nitrification-denitrification system will be affected by the presence of the above toxicants. Therefore, an investigation to study such effects is very important, especially when the nitrifiers are slow-growing organisms and particularly susceptible to toxicants.[10]

**Information on the possible interactions of toxic materials is necessary for the design of efficient nitrification systems.**

Moreover, if the growth rate of the nitrifiers falls below the minimum needed to maintain nitrification in the system, failure will be imminent. The inhibitory effect may also severely reduce the allowable rates. Hence, the presence of arsenic, chromium, and fluoride may dictate against the choice of nitrification as a reliable ammonium removal alternative. Recently, only the individual effects of trivalent arsenic, hexavalent chromium, and fluoride were studied under shock load in a fixed-film, packed-bed reactor.[9] But no information is available in the literature about the combined effects and interactions of these compounds on nitrification that more truly represent practical situations.[11-14]

Therefore, this study investigates these interactive phenomena under shock load in a fixed-film, packed-bed reactor. The results of the study will make it possible to design more adequately nitrification systems and operational procedures to maintain efficient and reliable nitrification.

## THEORETICAL CONSIDERATIONS

For a closed system under given hydrodynamic and environmental conditions, if it is assumed that the substrate concentration is much greater than the total microorganism concentration, and that ammonium oxidation proceeds under the equilibrium concentrations of the enzyme-substrate complex, then Monod's expression represents the rate of nitrification:[15-17]

$$\alpha_0 = -\frac{ds}{dt} = \frac{V_{max} S}{K_s + S} \qquad (1)$$

where

$V_{max}$ = maximum oxidation rate,
$S$ = growth limiting substrate concentration ($NH_4^+ - N$), and
$K_s$ = saturation constant.

Inhibitors for which the activity of the enzymes returns on removing the free inhibitor are called reversible inhibitors. The modes of action of such inhibitors are listed below.

**Noncompetitive inhibition.** In this case, the substrate concentration does not affect the degree of inhibition.[17] The corresponding rate equation is:[18,19]