



Selenite Removal With Zero-Valent Iron in Different Ion Strength Solution (Steel Wool)

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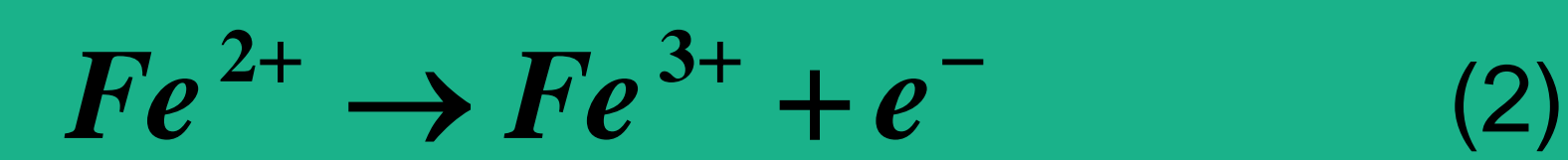
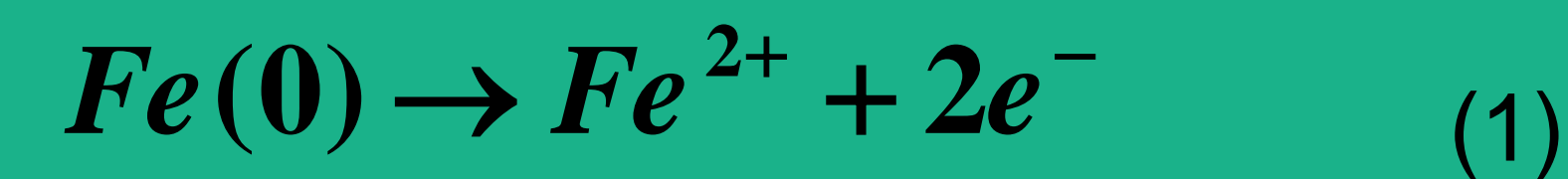
Introduction

- Selenium is a natural occurring element, with very narrow threshold being beneficial nutrient to biota.
- Selenium is associated with sulfide minerals and in some coal seams in West Virginia. With coal mining activities, selenium in the form of SeO_3^{2-} and SeO_4^{2-} are released into surface water.
- Fe based technologies are widely used in a variety of contaminant treatment systems. Zero-valent iron has been used to reductively remove chlorinated organic compounds and heavy metal ions.
- The main ingredient of steel wool is zero-valent iron, it is less subject to rust in the air, but is low cost and readily available.
- Lab scale experiments have shown that steel wool efficiently removes selenite in both anoxic and oxic systems.

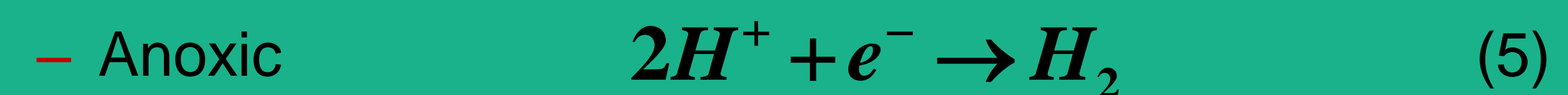
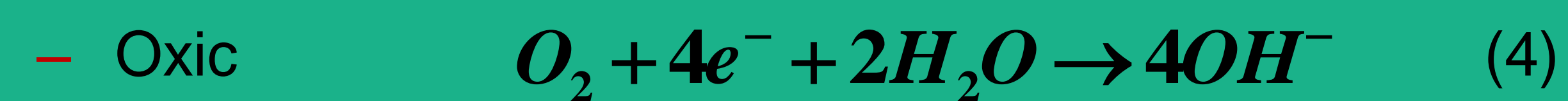
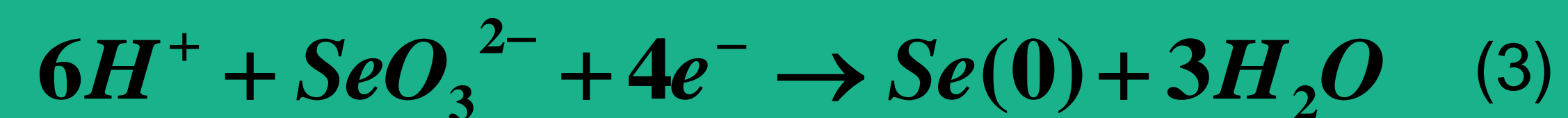
Hypothesized Removal Mechanisms

Redox reactions

Electron donor



Electron acceptor



Adsorption

SeO_3^{2-} are adsorbed onto Fe oxidation product.

Methodology

Speciation and Analysis

- Selenite (IV) was determined by flow injection–hydride generation–Inductively coupled plasma spectroscopy (FI-HG-ICP).
- Elemental Se(0) was fully oxidized in hot concentrated HNO_3 , reduced in hot 6M HCl and determined as Se(IV) as described above.

Reaction Kinetics

- All experiments were conducted in duplicate at 30°C, in a water-jacketed, glass reaction flask (Figure 1).
- Experimental treatments were
 - air-purged or N_2 -purged
 - Different background salts (CaCl_2 , Na_2SO_4 , NaCl)
 - Different ionic Strength (7.5×10^{-3} and $75 \times 10^{-3} \text{ mol L}^{-1}$)
 - pH controlled (3.5-4.5) or pH uncontrolled (7-8.8)
- Samples were collected with time, filtered ($0.45 \mu\text{m}$), acidified and Se(IV) determined as described above.
- Elemental Se(0) was determined at the end of the experiment, as described above.



EXAFS (extended X-ray absorption fine structure) spectrum

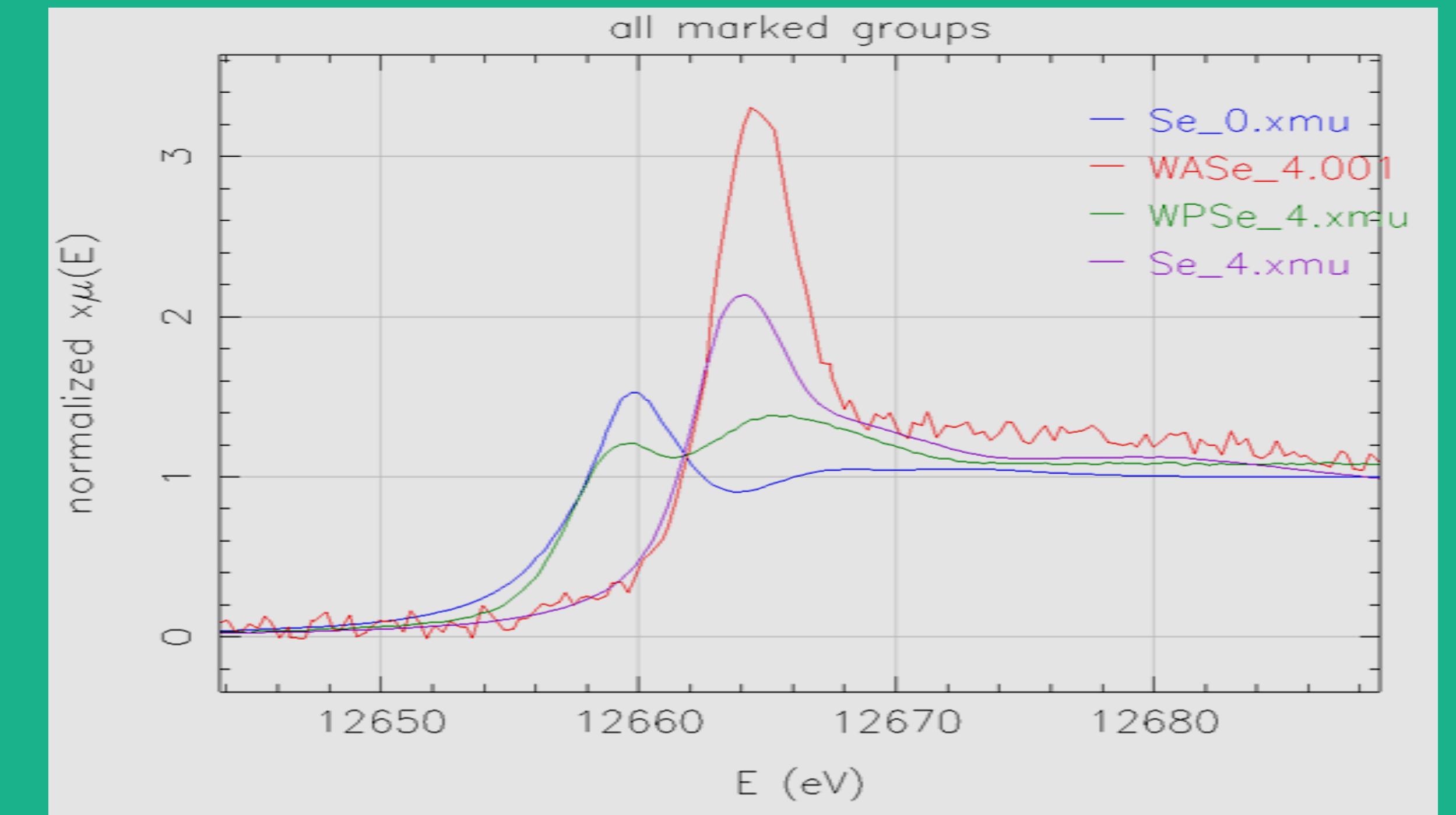


Figure 6. Selenite solutions (Ar-purged, green and unpurged, red) after reaction with steel wool for 24 hrs. Purple and blue line (peaks) are indicated for each Se species. Only the purged solution has a peak at 12658 eV indicating the presence of elemental Se.

Table 1 Percentage of initial Se reduced to elemental Se and time of reaction

	Air purged		N_2 purged	
	pH uncontrolled	pH controlled	pH uncontrolled	pH controlled
Percentage of Se(0) product	58	59	60	-
Reaction time (hr)	1-3	1-2	3.5-6	>7

Results

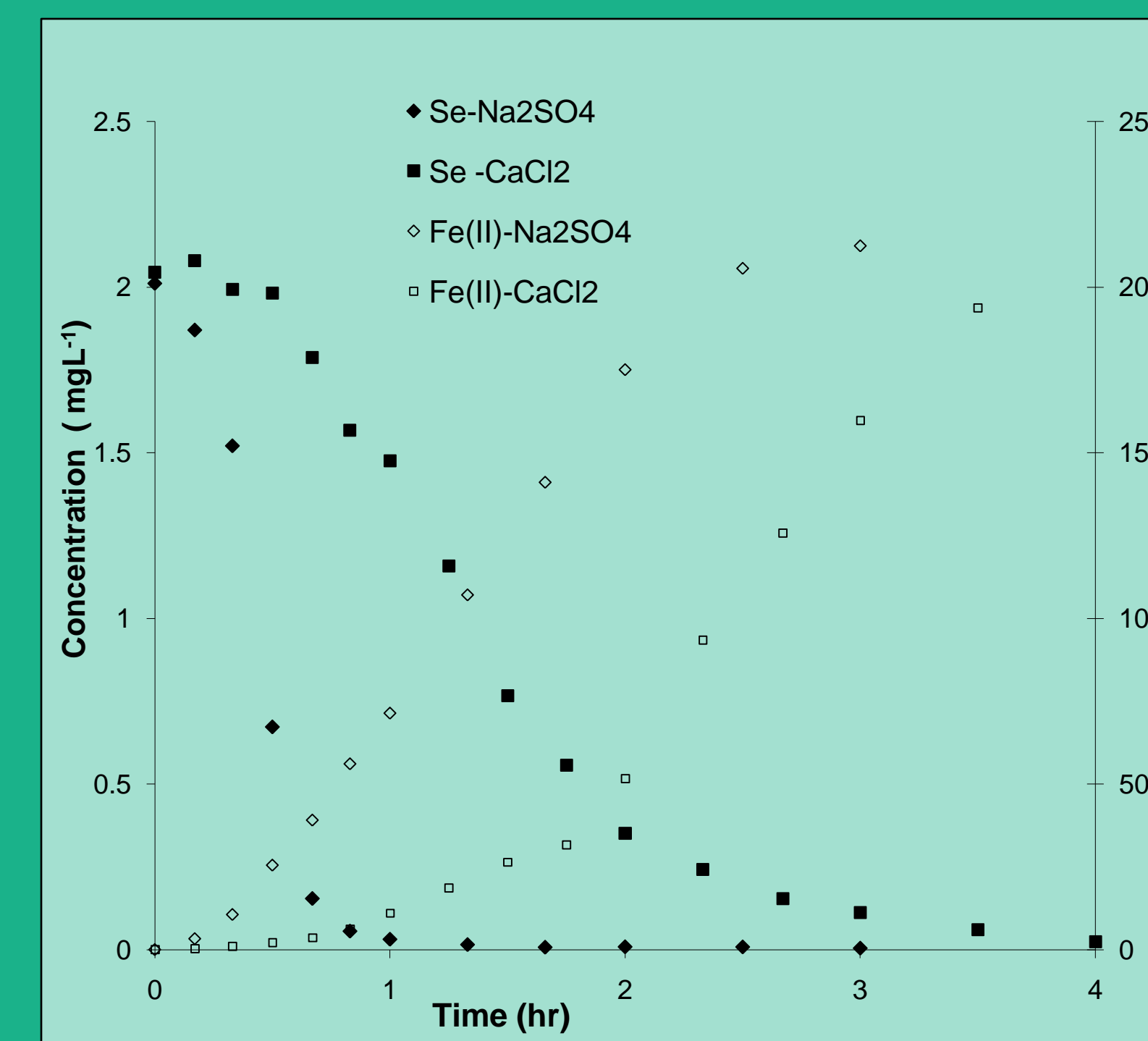


Fig. 2 Se(IV) 2 ppm in 75 mmolL⁻¹ CaCl₂, Na₂SO₄ with air purged

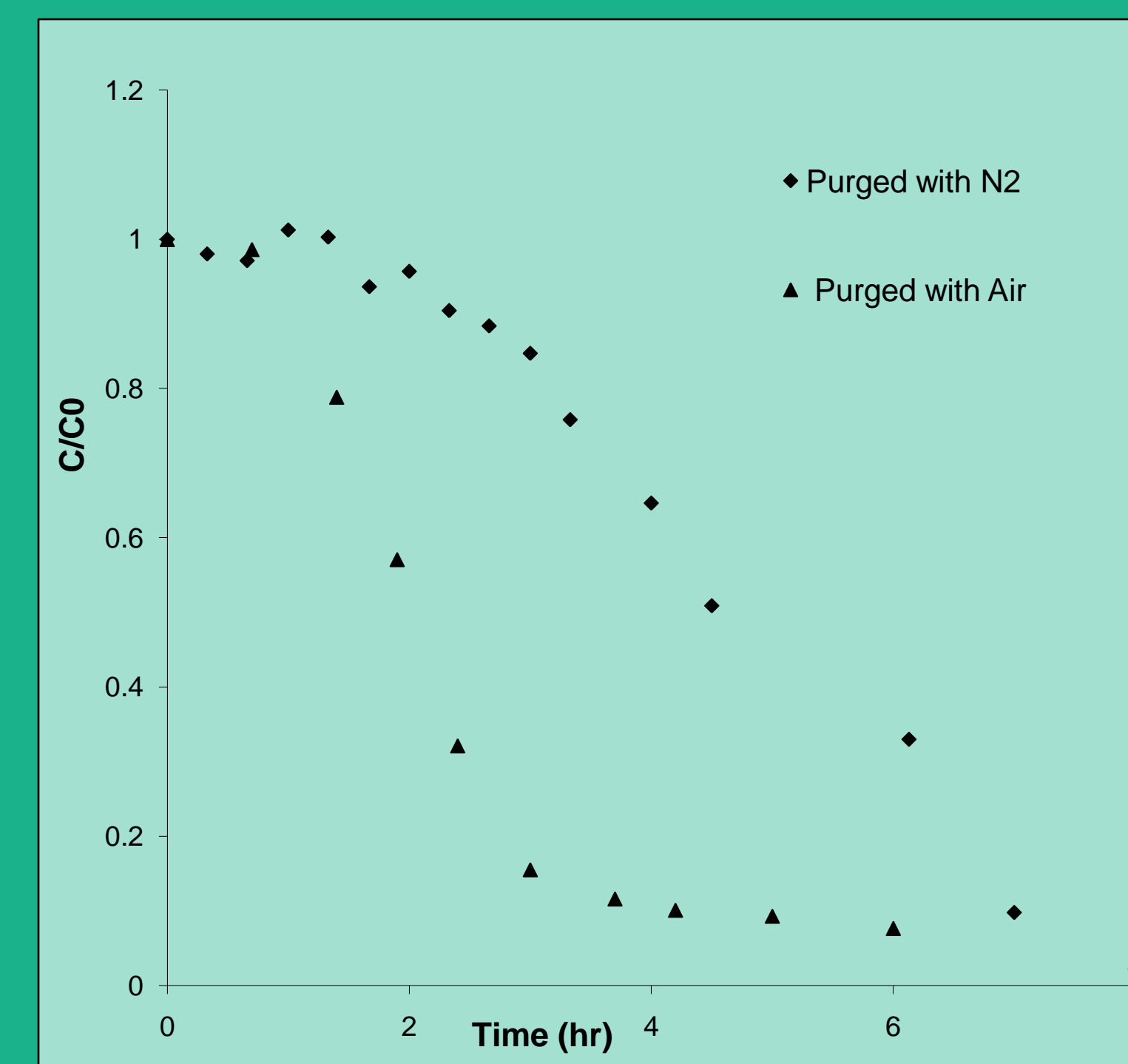


Fig. 3 Se(IV) 2 ppm in 75 mmolL⁻¹ CaCl₂ with N_2 vs. Air-purged pH 6.8-7.5

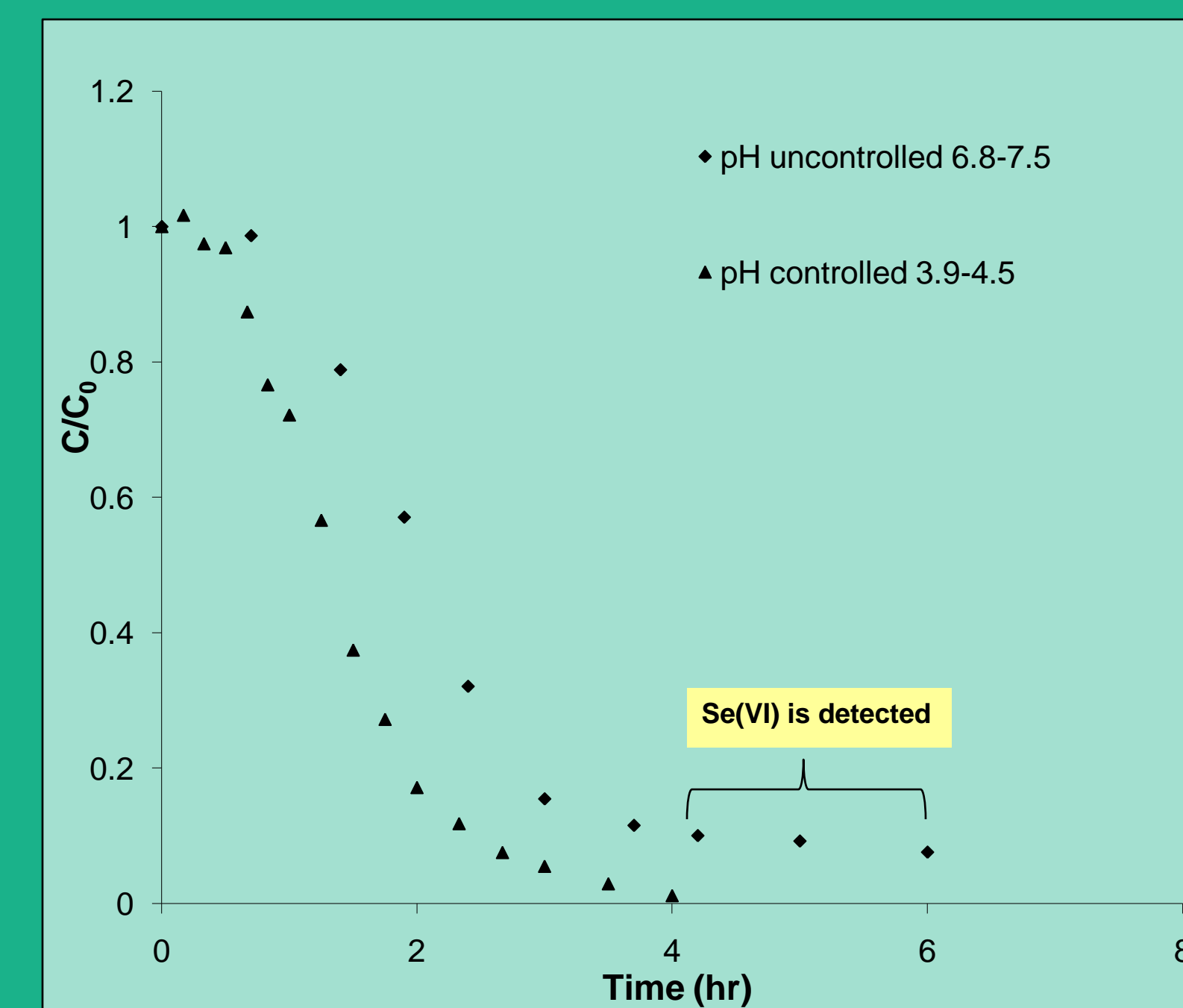


Fig. 4 Se(IV) 2 ppm in 75 mmolL⁻¹ CaCl₂ with air purged at different pH

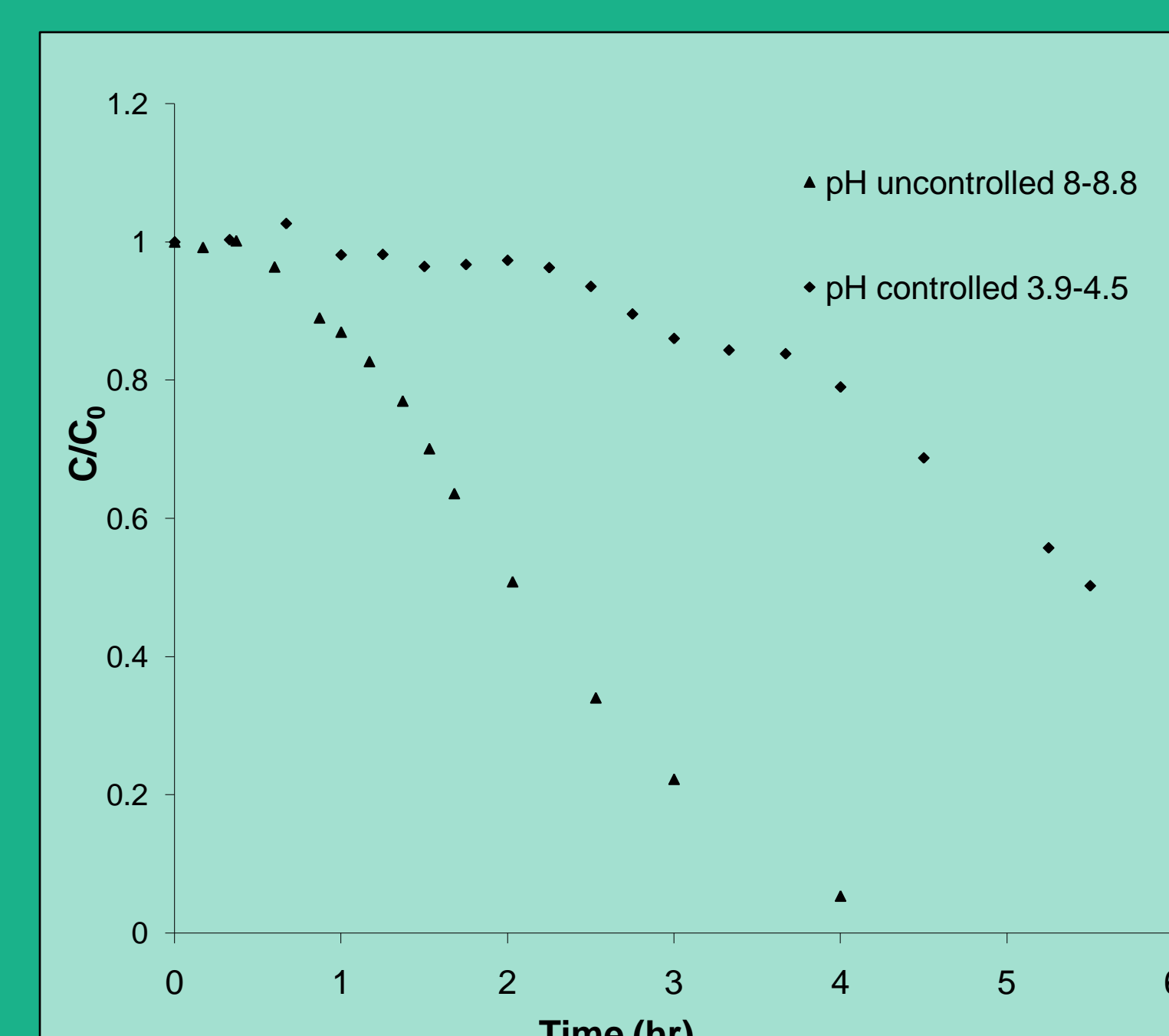


Fig. 5 Se(IV) 2 ppm in 75 mmolL⁻¹ CaCl₂ with N_2 purged at different pH

Discussion

Average Se(0) recovery percentage in oxic and anoxic systems was about 60%; the main removal mechanism was reduction (Table 1).

Se(IV) removal kinetics had two stages, they responded well to Fe(II) concentration. Once [Fe(II)] increased, the removal rate was much faster. Fe(II) may play an electron carrier role, facilitating electrons transfer from Fe(0) to Se(IV) (Fig.2).

Kinetics of Se(IV) were affected by salt type in both oxic and anoxic systems. This may due to their differing effect on the Fe(0) corrosion reaction (Fig.2).

Removal rate of Se(IV) was faster in the oxic environment than in the anoxic environment (Fig.3).

In air purged system, low pH increased Se(IV) removal rate, and no Se(VI) was detected (Fig.4). In the N_2 -purged system, low pH decrease Se(VI) removal rate (Fig.5). It may due to the difference between competitive electron acceptor reaction (Eq.4, 5).