SELENIUM, URANIUM, AND NITRATE: TREATMENT OF TROUBLESOME CONTAMINANTS IN MINING WASTEWATERS – EBR CASE STUDIES

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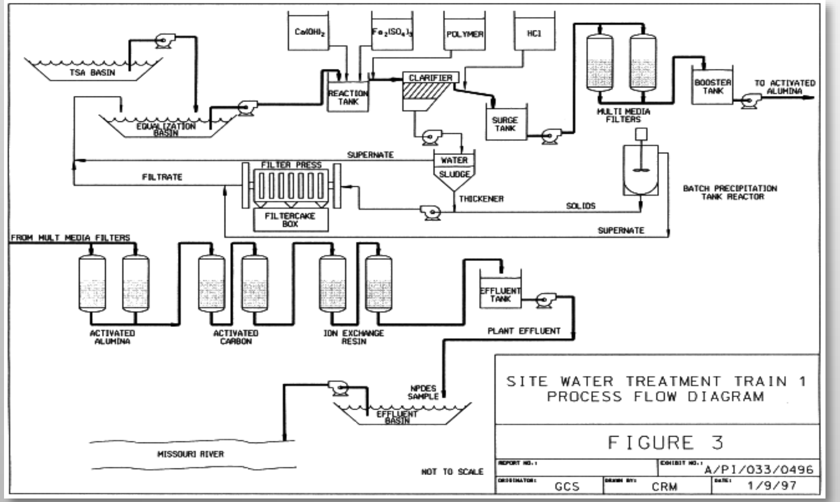
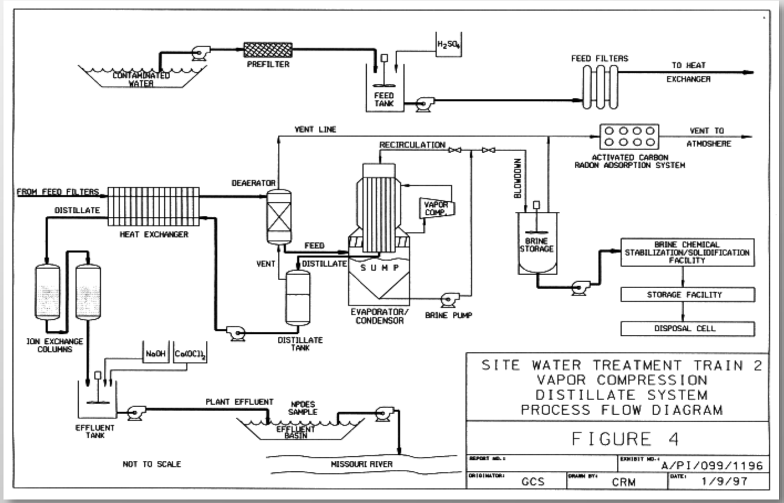
PROBLEM STATEMENT

- Selenium, uranium, and nitrate are common in many North American mining environments
- Often difficult to remove using conventional methods
  - Complex treatment trains with multiple unit processes
  - High capital and operating expenses
  - Disposal of sludge or brine stream





BIOLOGICAL TREATMENT

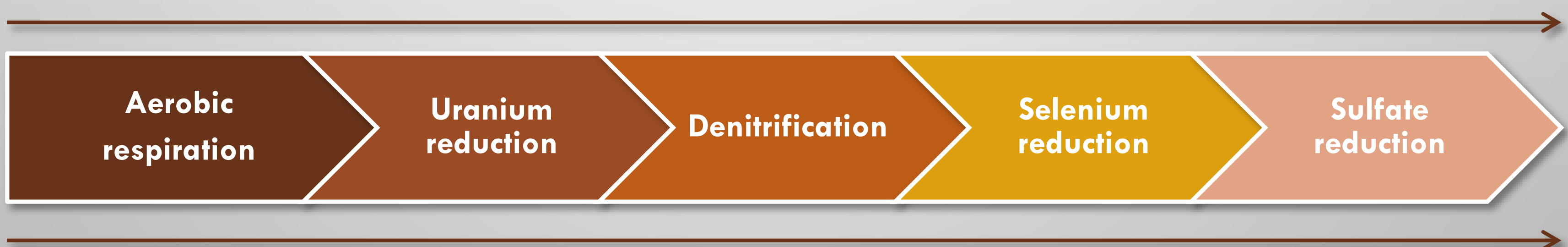
- Microbes mediate the removal of metal and inorganic contaminants through redox reactions

$$UO_4^{2+} + 2e^- + 4H^+ \rightarrow U_4^+ + 2H_2O$$

$$NO_3^- + 5e^- + 6H^+ \rightarrow \frac{1}{2}N_2 + 3H_2O$$

$$SeO_4^{2-} + 6e^- + 8H^+ \rightarrow Se_{(s)} + 4H_2O$$

Decreasing DO and ORP



Increasing electron requirement

CONVENTIONAL BIOREACTORS

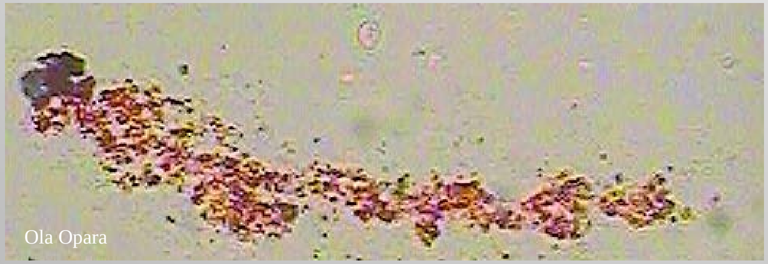
- Organic electron donors (nutrients) provide electrons under oxidation/ metabolism
  - One molecule of glucose = 24 electrons under full metabolism
  - Excess nutrients to control ORP

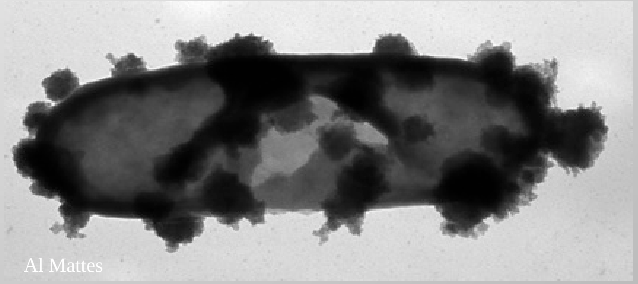
$$\mathbf{UO_4^{2+} + 2e^- + 4H^+ \rightarrow U_4^{+} + 2H_2O}$$

$$\mathbf{NO_3^- + 5e^- + 6H^+ \rightarrow \frac{1}{2}N_2 + 3H_2O}$$

$$\mathbf{SeO_4^{2-} + 6e^- + 8H^+ \rightarrow Se_{(s)} + 4H_2O}$$

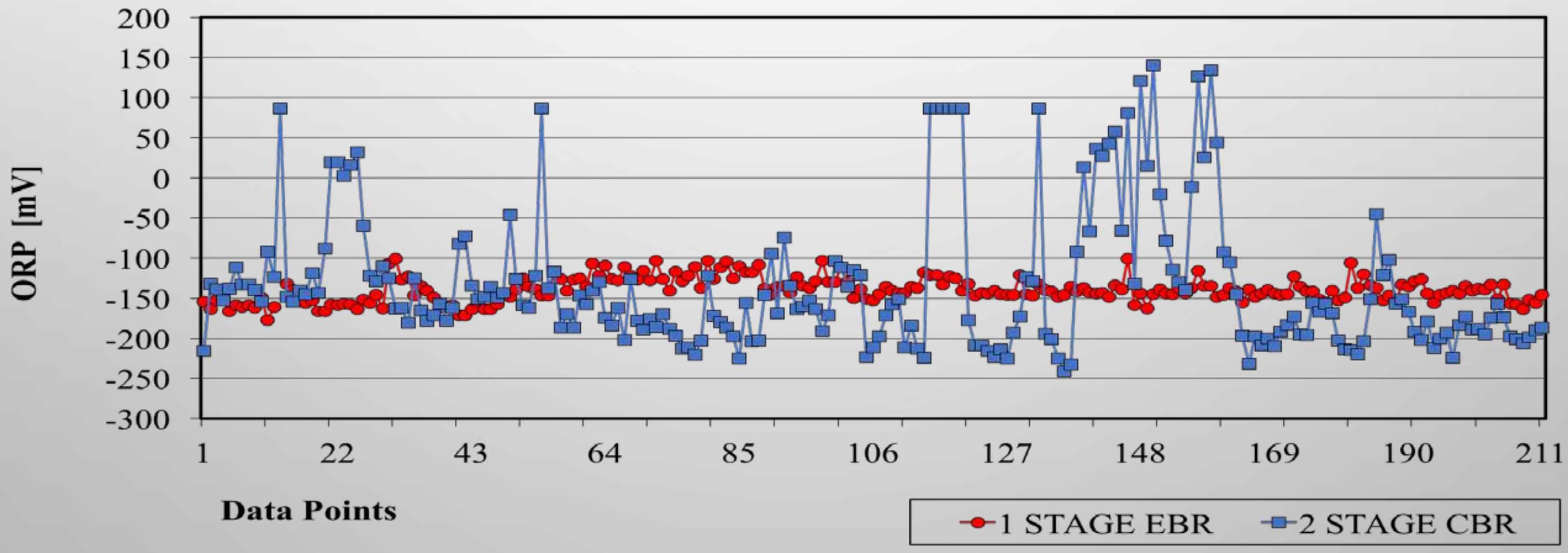
- Excess biomass production
  - High TSS leads to post-treatment solids management
  - Biomass carries metals → post-treatment management
  - High CAPEX /OPEX costs





ELECTRO-BIOCHEMICAL REACTOR

- Low voltage (1-3 Volts potential) supplied directly
- 1 mA provides 6.24 x 10^{15} electrons/second
  - Electrons and electron acceptor environments for controlled contaminant removal environment
  - Compensation for inefficient and fluctuating electron availability through nutrient metabolism



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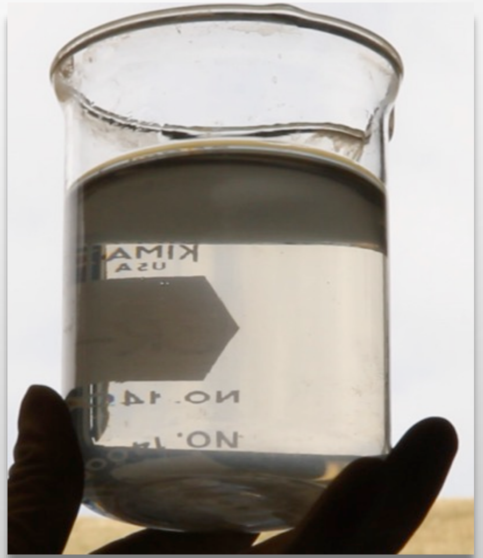
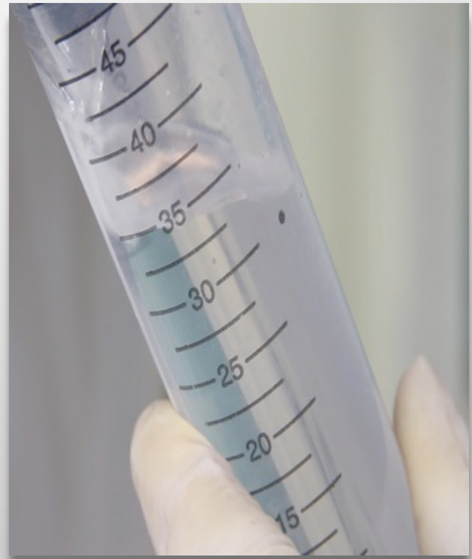
  - Electrons and electron acceptor environments for controlled contaminant removal environment
  - Compensation for inefficient and fluctuating electron availability through nutrient metabolism
  - Replaces up to 2/3 of the nutrients/electron donors required, while producing lower contaminant concentrations
  - Produces much less TSS (bio-solids)

From onsite EBR effluent, no filtration or post-treatment

EBR CASE STUDIES

	Source	Ave. total Se [µg/L]	Ave. total U [µg/L]	Ave. NO_3-N [mg/L]
Water A	Underground metals mine, flotation-influenced process waters	2,712	1.99	0.8
Water B	Open pit coal mine, seepage waters	105	18.4	49.8
Water C	Prospect gold mine, leach solutions	3.17	92.5	189

EBR CASE STUDY A (FLOTATION)

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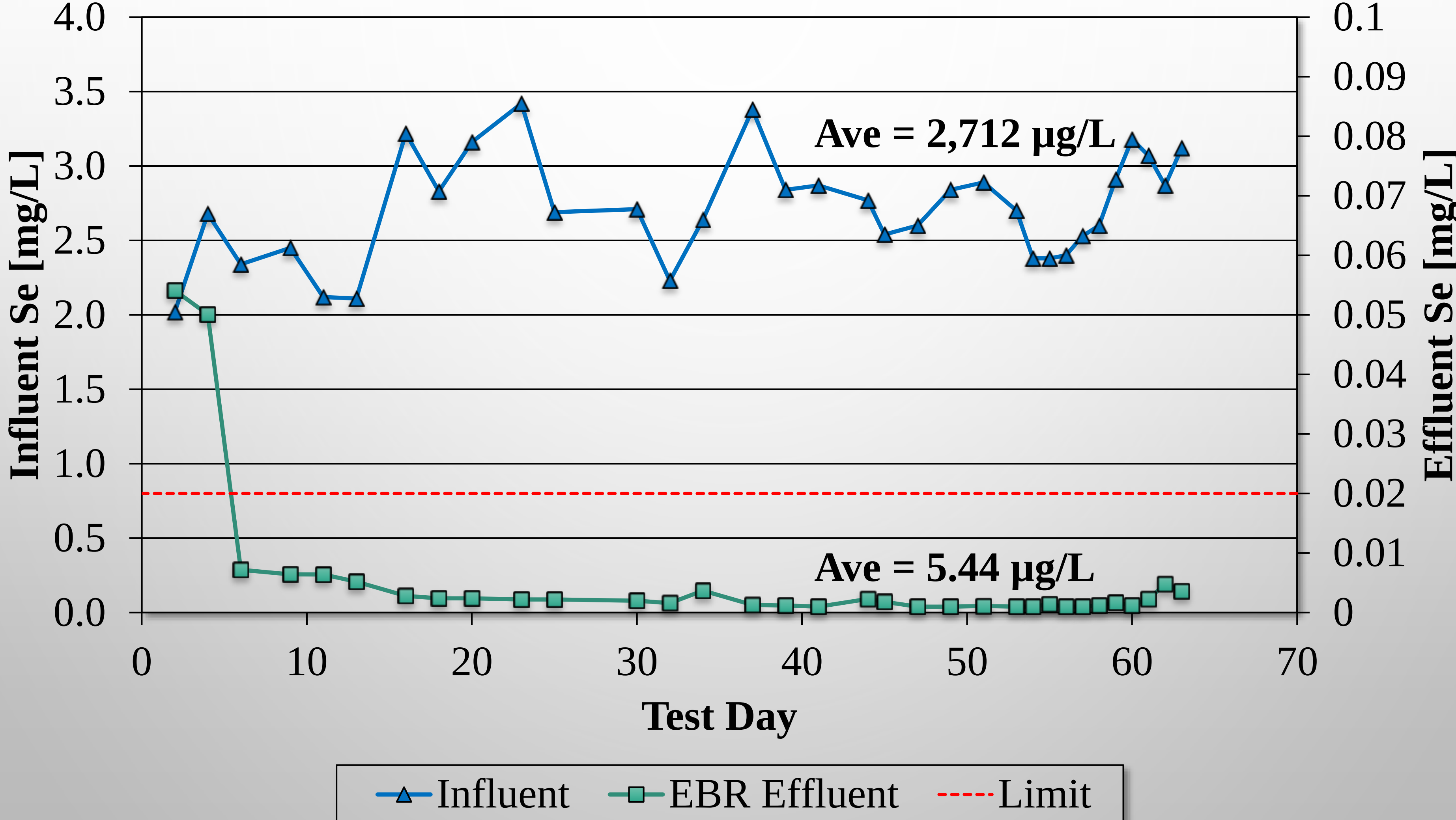

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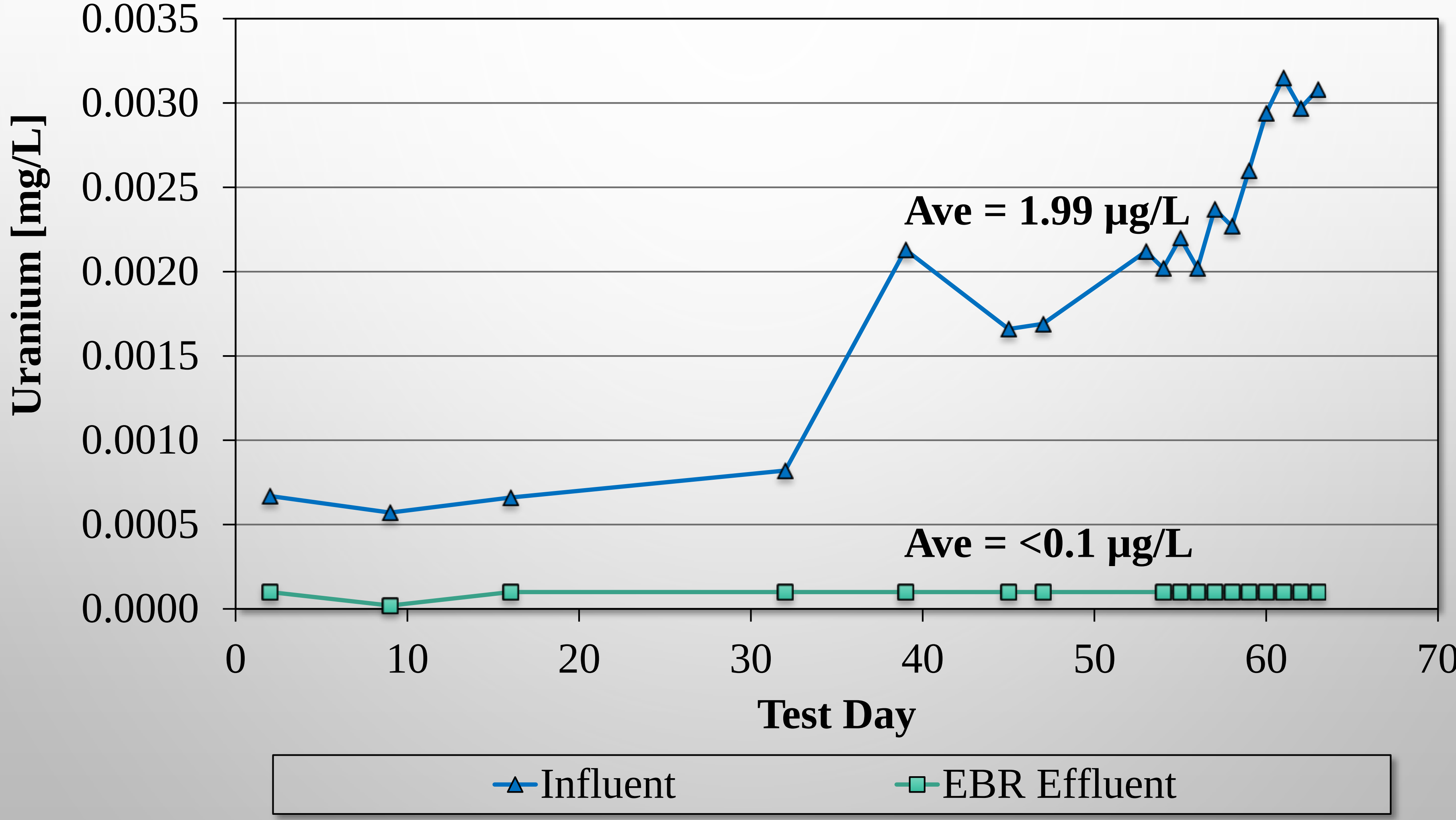

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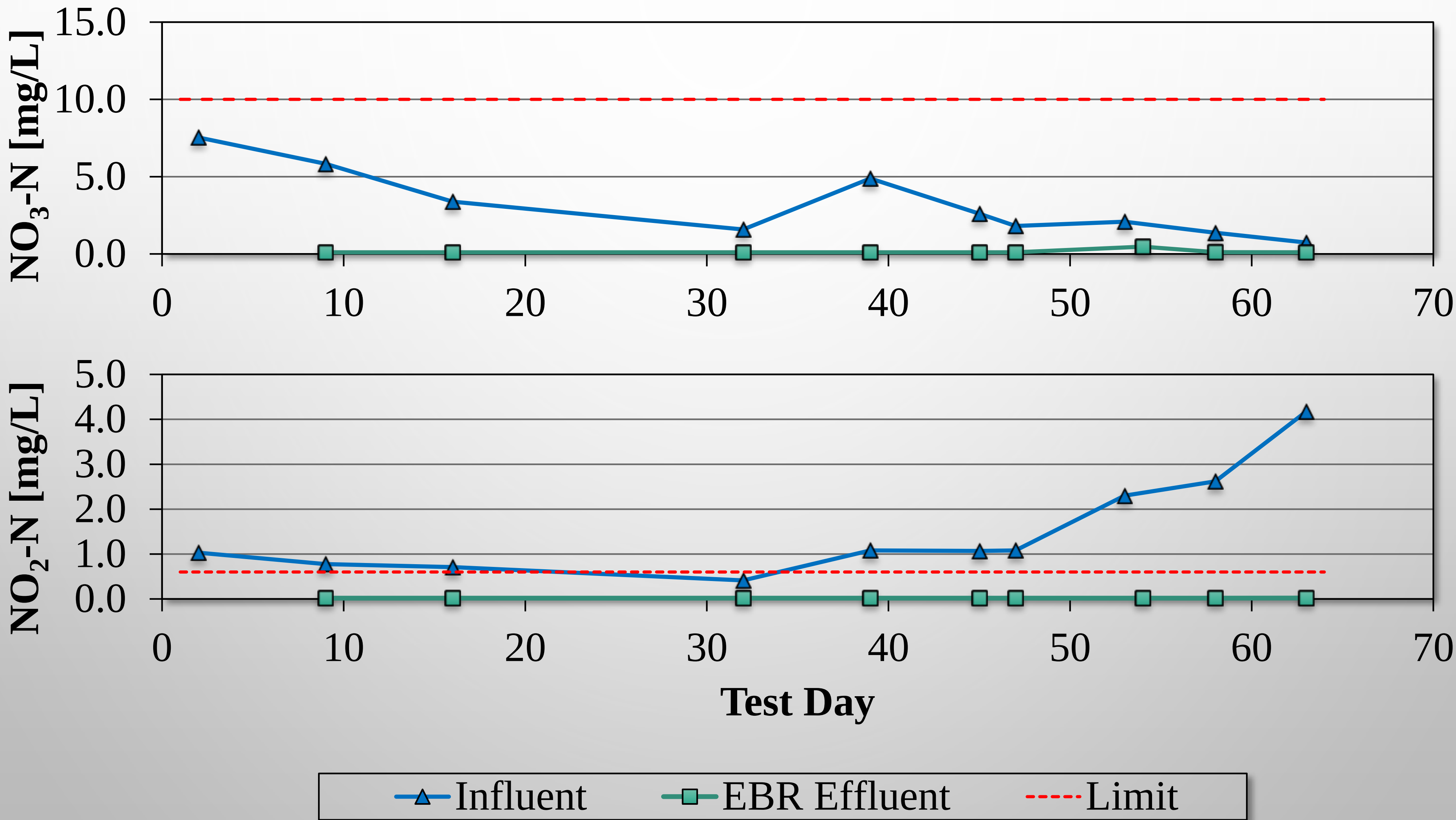

EBR CASE STUDY B (COAL MINE)

	Source	Ave. total Se [µg/L]	Ave. total U [µg/L]	Ave. NO_3-N [mg/L]
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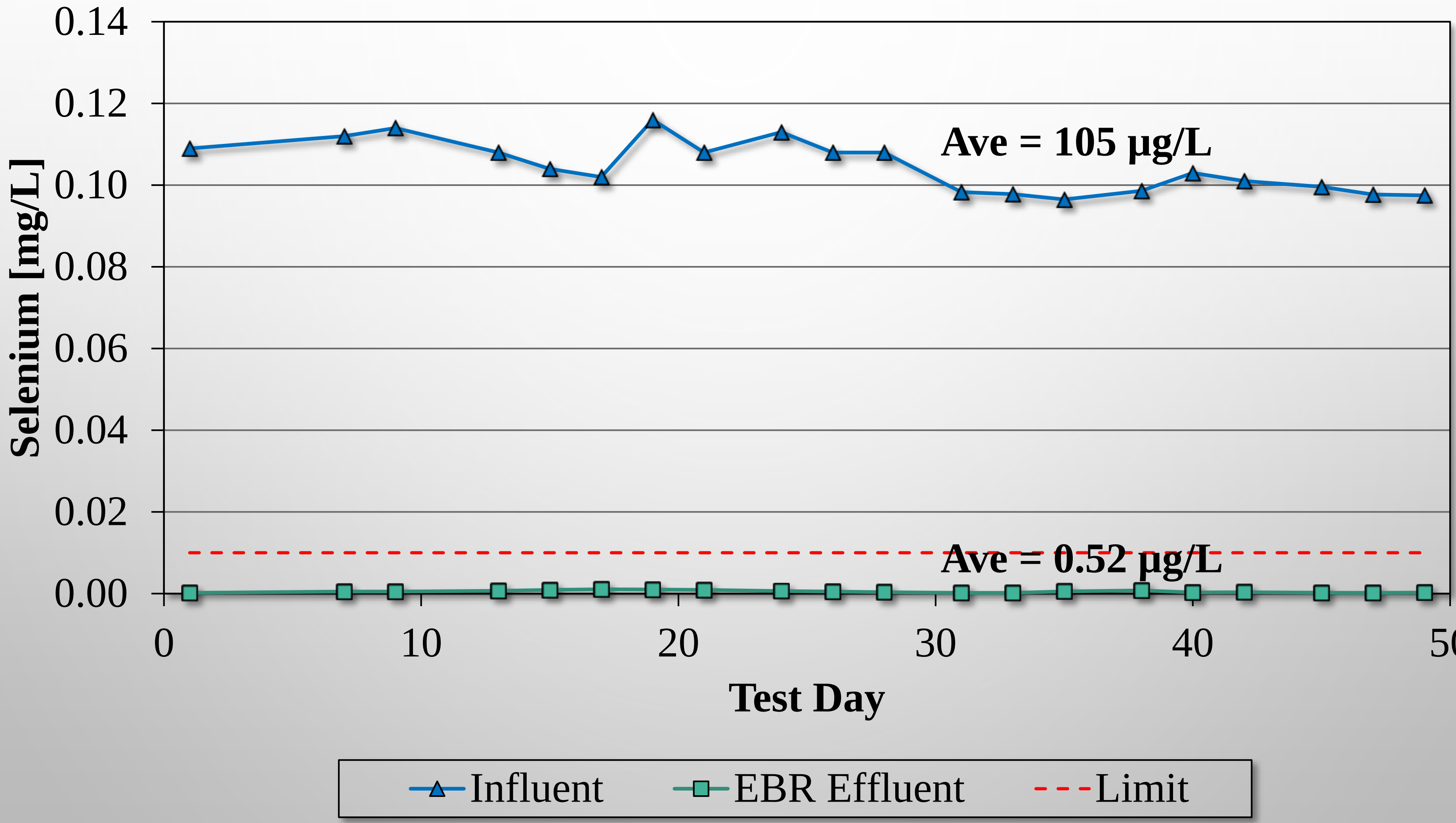

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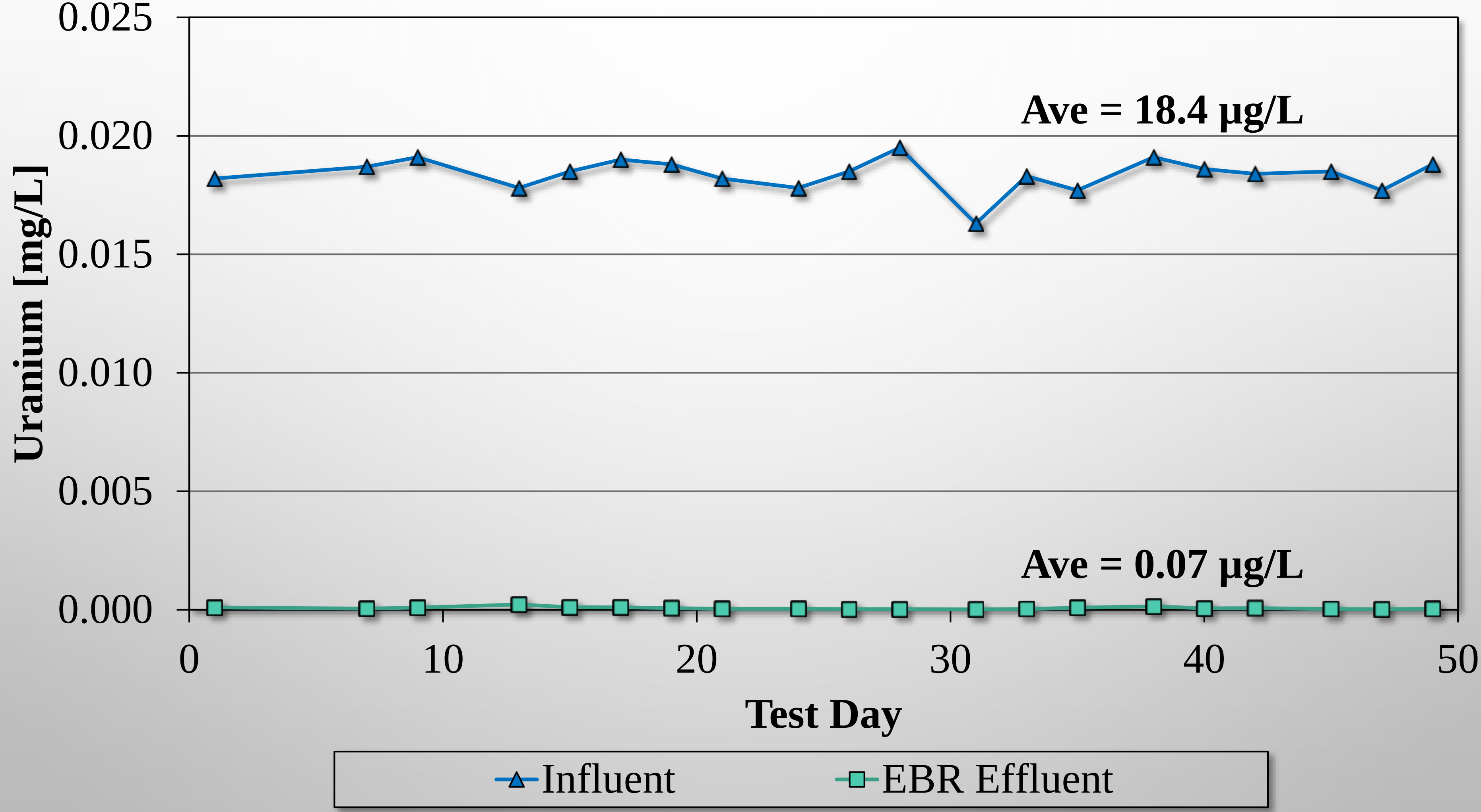

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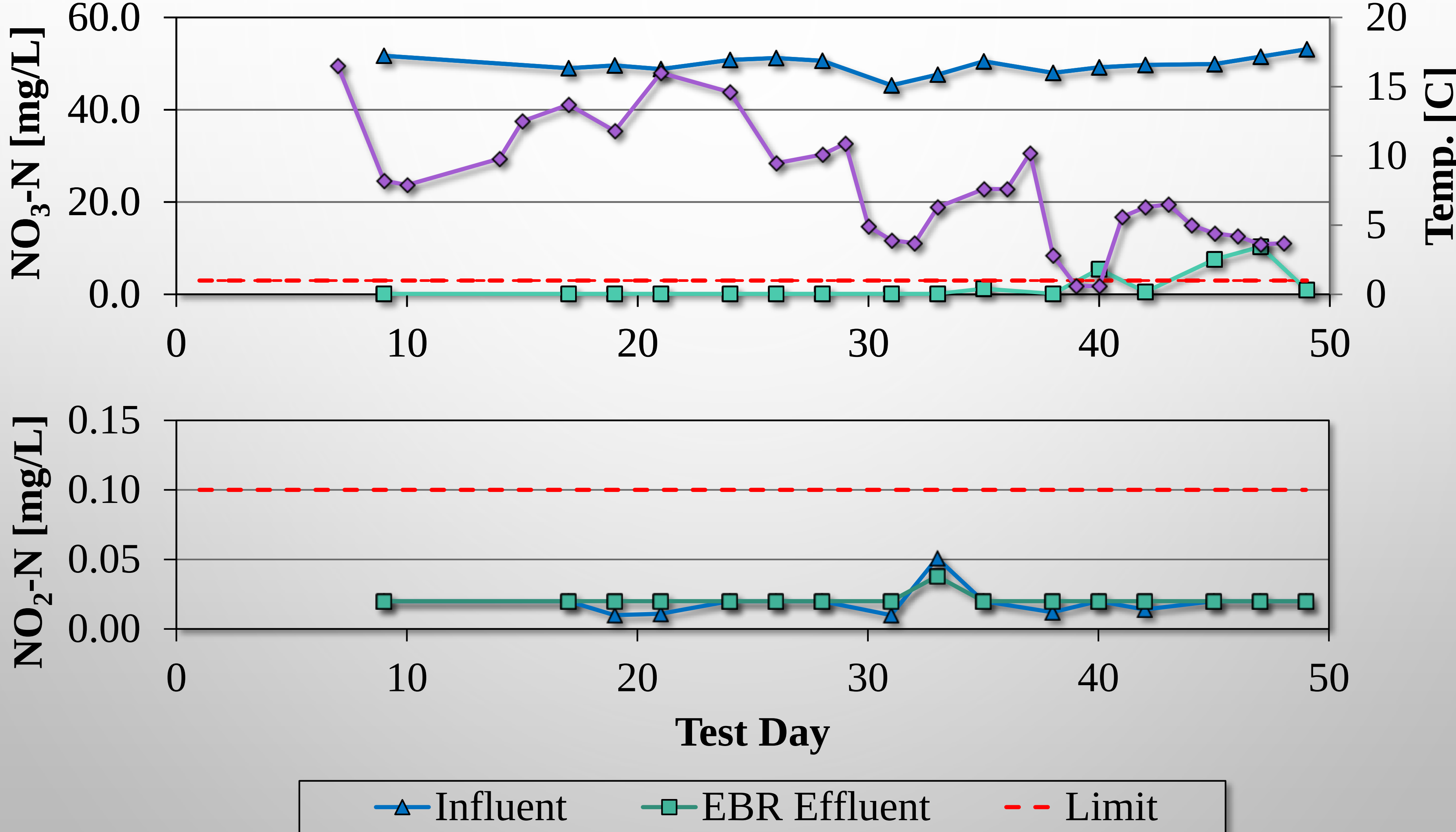

EBR CASE STUDY C (GOLD MINE)

	Source	Ave. total Se [µg/L]	Ave. total U [µg/L]	Ave. NO_3-N [mg/L]
Water C	Prospect gold mine, leach solutions	3.17	92.5	189

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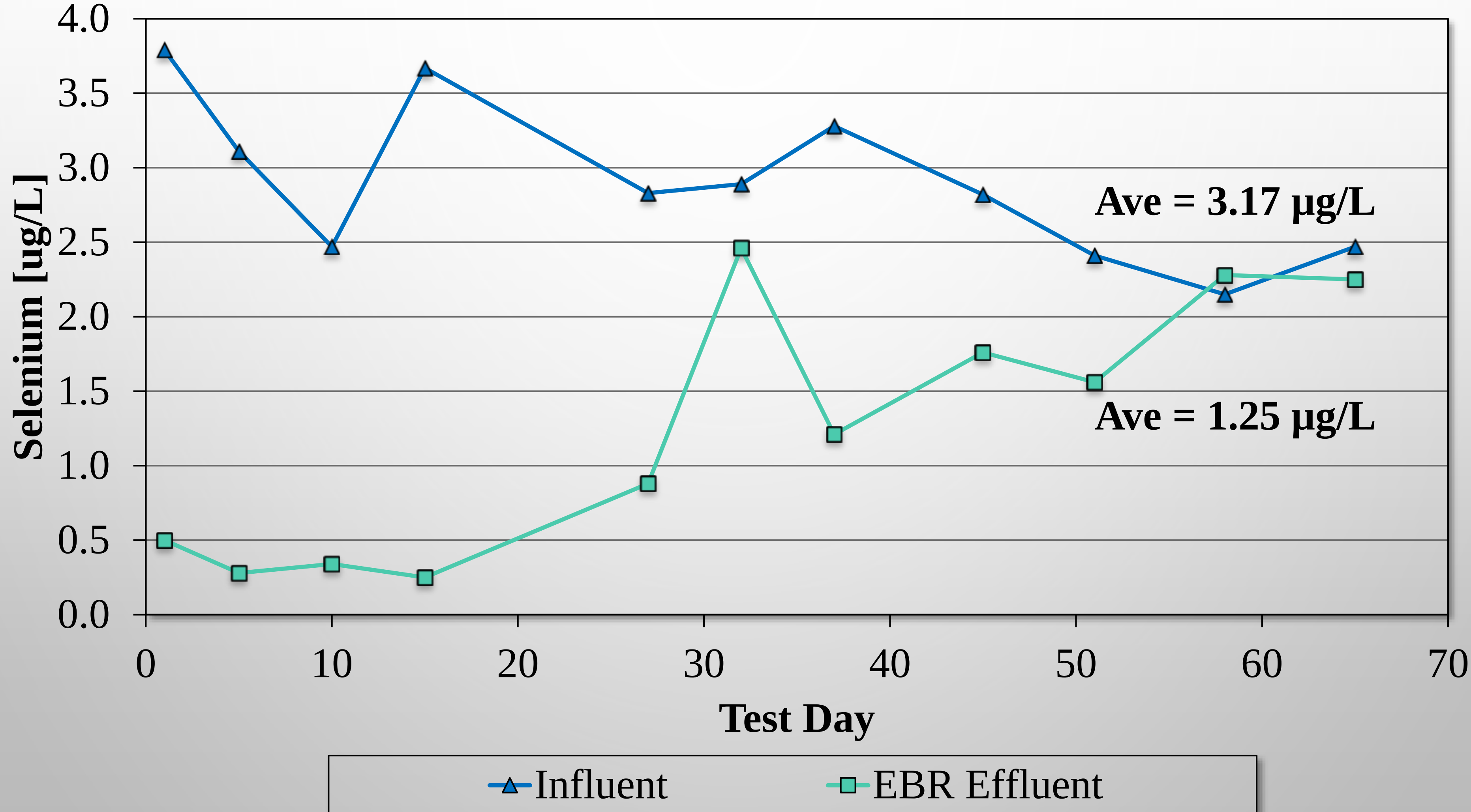

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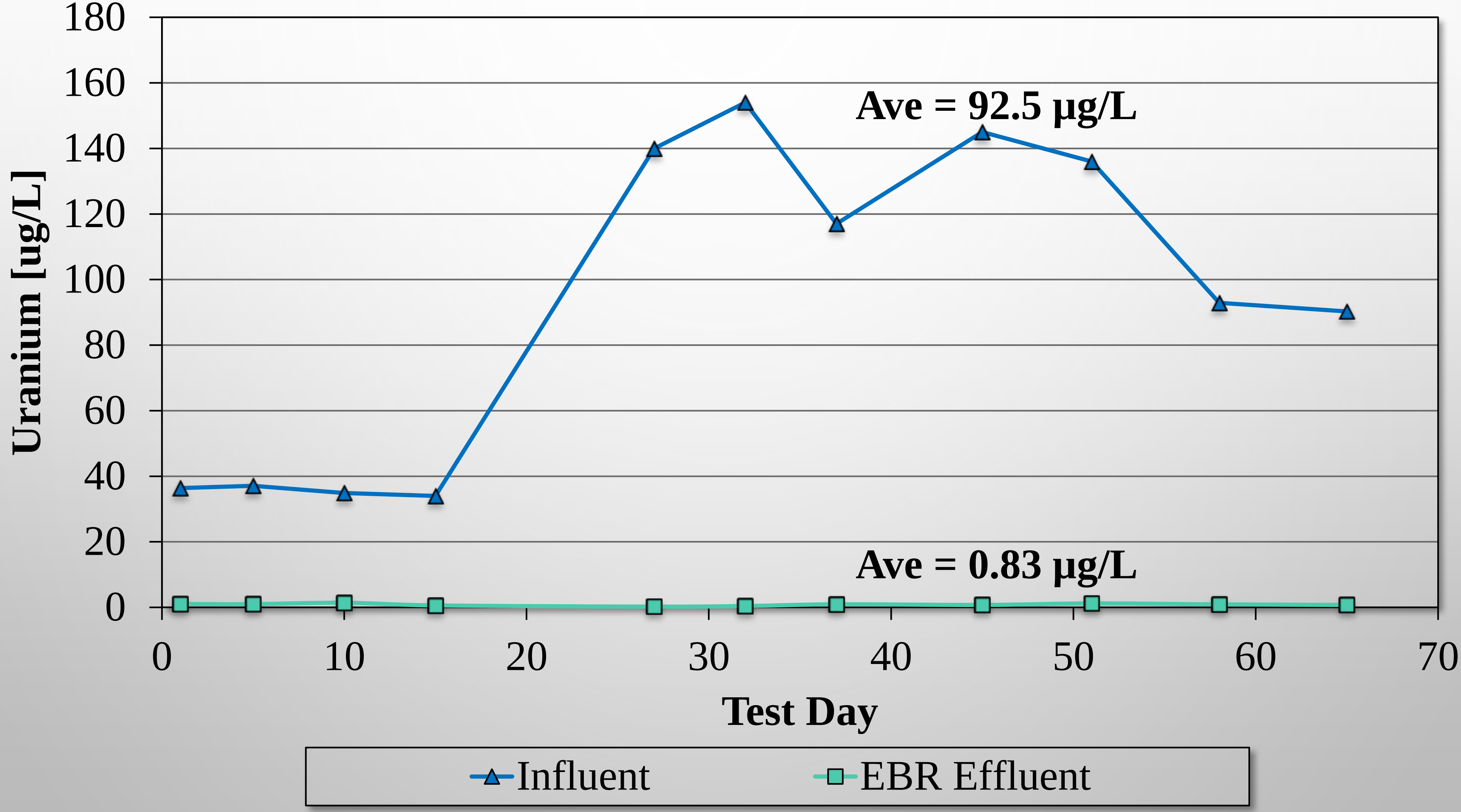

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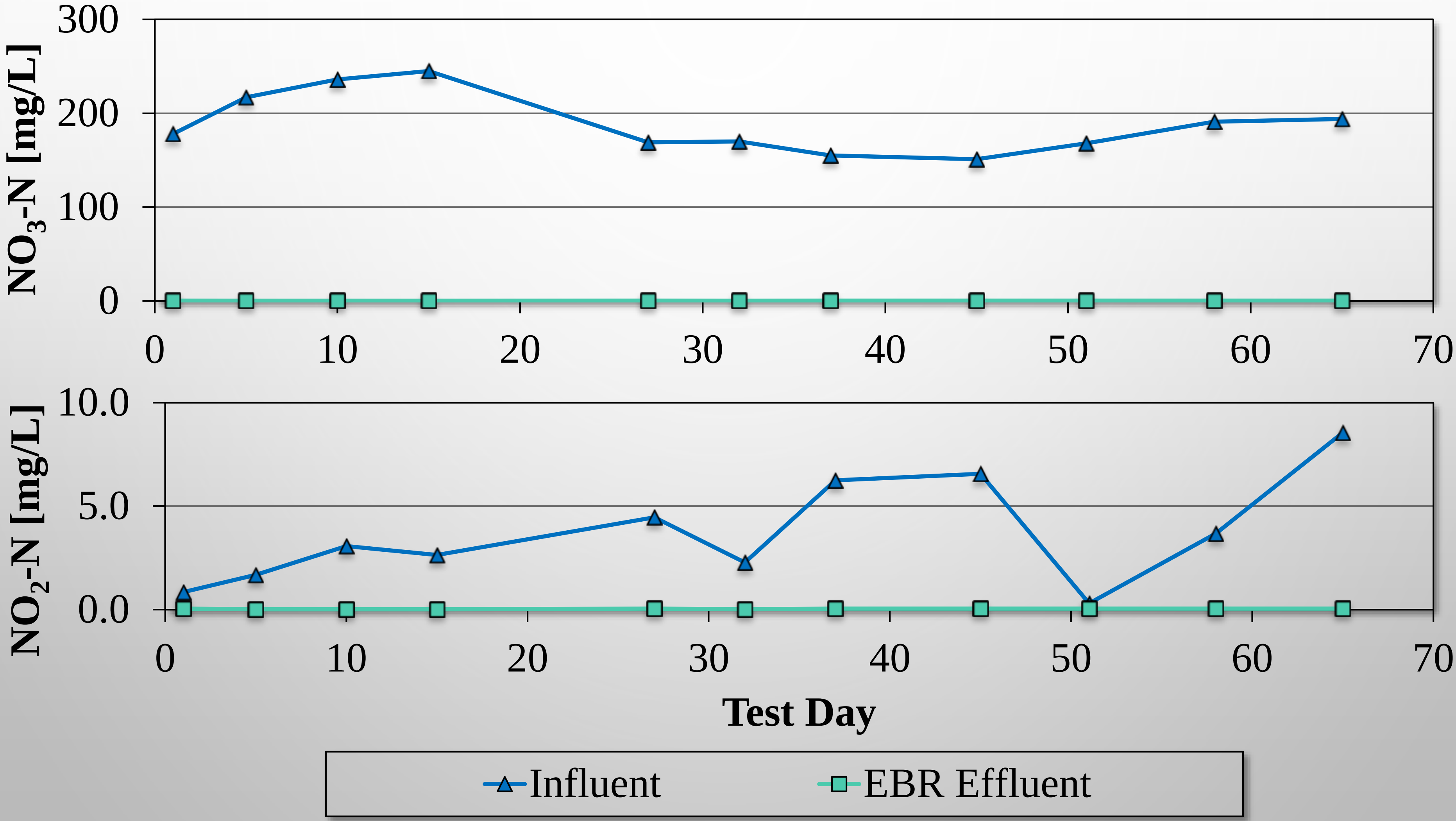

CONCLUSIONS

		Water A	Water B	Water C
$Se_{,tot.}$	Influent [µg/L]	2,712	105	3.17
	EBR Effluent [µg/L]	5.44	0.52	1.25
	Removal [%]	99.8%	99.5%	60.6%

The successful EBR trials have positive implications for mine sites facing challenges of simultaneous treatment of multiple contaminants to low discharge levels, in a simplified and more affordable manner.

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