water

Supplementary

Techno-economic evaluation of iron and aluminum coagulants on Se(IV) removal

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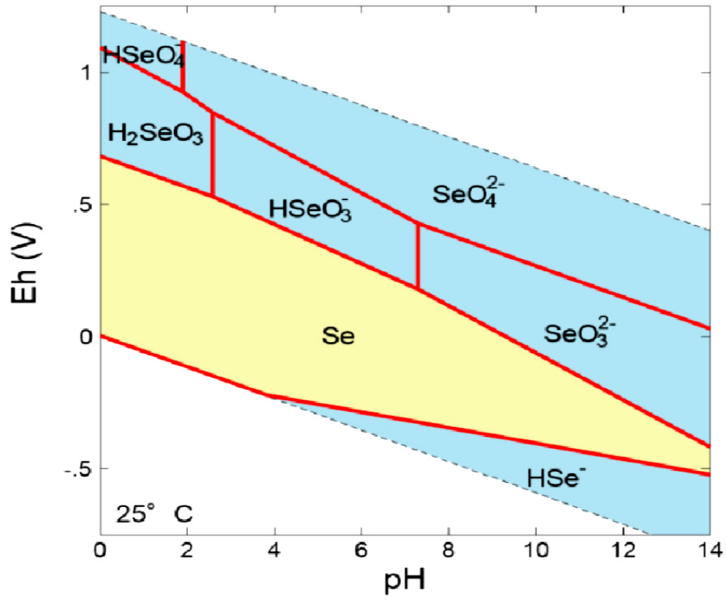

Figure S1. Selenium speciation as a function of Eh vs pH (Tabelin et al., 2018).

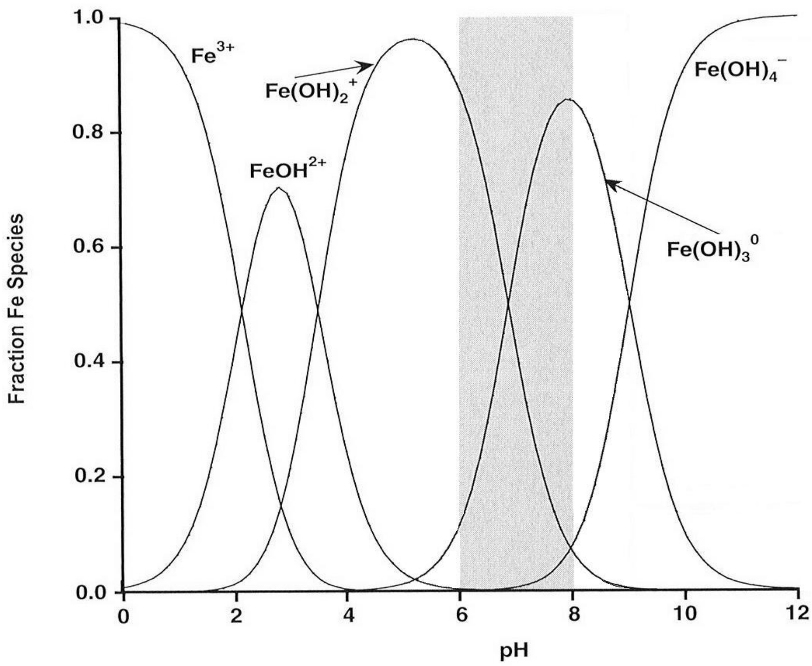

Figure S2. Fe(III) speciation as a function of pH.

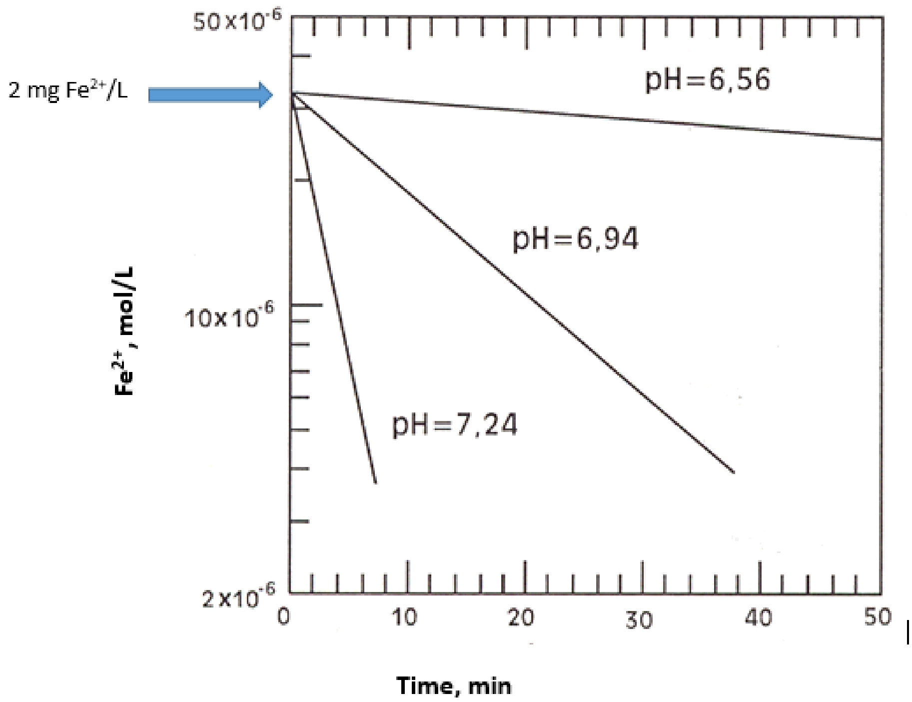

Figure S3. Oxidation rate of Fe(II) by oxygen as function of water pH (Stumm W. and Lee G.F., 1961)

Text S1
The energy cost estimated as follows:
Water pumping from raw water buffer tank, coagulation (residence time: 5 min – mixing: 250±50 W/m^3), flocculation (residence time: 30 min – mixing: 30±10 W/m^3), backwash, sludge handling, reagents pumping, lights and collection of water in treated water tank.
It is obvious that the treatment energy and labor cost does not incorporate the cost of water pumping from initial source to raw water buffer tank, nor the cost of pumping the treated water to municipality distribution network, because this cost is not related to the treatment process.

- ***Estimation of energy cost e.g. for water flow 100 m^3/h.***

1. Raw water pumping energy
   $P_q = Q\rho g\Delta h/n =$ [(100 m^3/h)/3600 s x 1000 kg/m^3 x 9.81 m/s^2 x 10 mwc]/0.65 = 4,200 W ≈ 101 kWh/d
2. Coagulation – V = 10^3 – 250 W/m^3
   P_c = 10 m^3 x 250 W/m^3 = 2,500 W = 60 kWh/d
3. Flocculation – 50 m^3 – 30W/m^3
   P_F = 50 m^3 x 30 W/m^3 = 1,500 W = 36 kWh/d
4. Dosing reagents pumps ≈ 4 kWh/d
5. Backwash: Q_b = 300 m^3/h for 12 min daily.
   $P_b = Q\rho g\Delta h/n$ = [(300 m^3/h)/3600 s x 1000 kg/m^3 x 9.81 m/s^2 x 10 mwc]/0.65 = 12,600 W ≈ 3 kWh/d
6. Sludge handling: Sludge pumping to thickener (0. 5 kW for 12 h), scraper of thickener (0.5 kW for 24 h), filter press for sludge dewatering 3 kW for 4 ≈ 30 kWh/d
7. Lights: 0.250 kW x 12 h = 3 kWh/d

Conclusively, the spent electric energy for (100 m^3/h) x 24 h/d = 2,400 m^3/d estimated to be:

$$101 + 60 + 36 + 4 + 3 + 30 + 3 = 237\ kWh/d$$

Which means ~ 100 $kWh/10^3\ m^3$

Since the commercial electric energy cost in Greece is 0.1 €/kWh, it is concluded that the energy cost is around 10 €/$10^3\ m^3$, independently of water flow in the range of 25 – 250 m^3/h.

- ***Estimation of labor cost e.g. for water flow in the range of 25 – 250 m^3/h.***

Commonly in Greece 1 worker is used for a water flow ≤ 50 m^3/h and approximately 2 workers for a water flow 50 – 100 m^3/h and 3 workers for a water flow 10 – 250 m^3/h with a monthly cost around 1,500€.

- ✓ Labor cost for 25 m^3/h ≈ (1,500€/month)/(25 m^3/h x 24 h/d x 30 d/month) = 83x10^{-3} €/m^3 = 83 €/$10^3\ m^3$
- ✓ Similarly, the labor cost for 50 – 100 – 250 m^3/h estimated 42 – 42 – 25 €/$10^3\ m^3$

According to the above-mentioned analysis of labor and energy cost is estimated as 60±30 €/$10^3\ m^3$ treated water. Furthermore, the total cost of treatment incorporates also the maintenance cost, which is estimated by the depreciation cost of the mechanical equipment at 5 years operation, which according to our experience is estimated around 20±5 €/$10^3\ m^3$ treated water.