# Precipitation of Heavy Metals Using NaOH/Sulphide

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PASSION FOR CHEMISTRY

# Introduction

- Every dissolved heavy_metal has a distinct pH at which the optimum hydroxide precipitation will occur. For example:

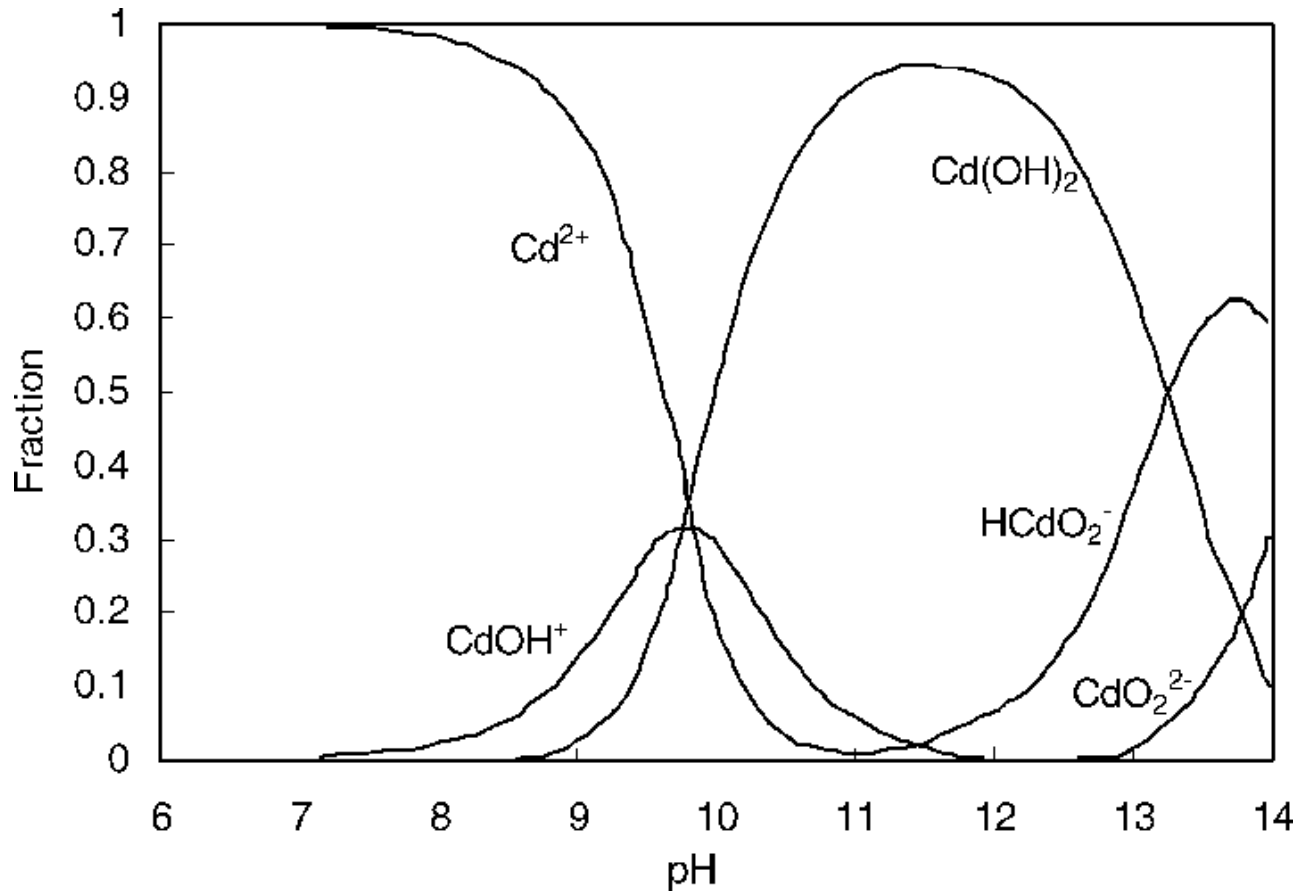
  Cadmium pH 11.0
  Copper pH 8.1
  Chromium pH 7.5
  Nickel pH 10.8
  Zinc pH 9.5
  Lead pH 8.5
  Arsenic pH 9.5
  Mercury pH 6-10

  Metal hydroxides are #amphoteric, i.e., they are increasingly soluble at both low and high pH, and the point of minimum solubility (optimum pH for precipitation) occurs at a different pH value for every metal. At a pH at which the solubility of one metal hydroxide may be minimized, the solubility of another may be relatively high. Since heavy metal hydroxides are quite soluble, many such hydroxides will start to go back into solution if the pH is too high or too low.

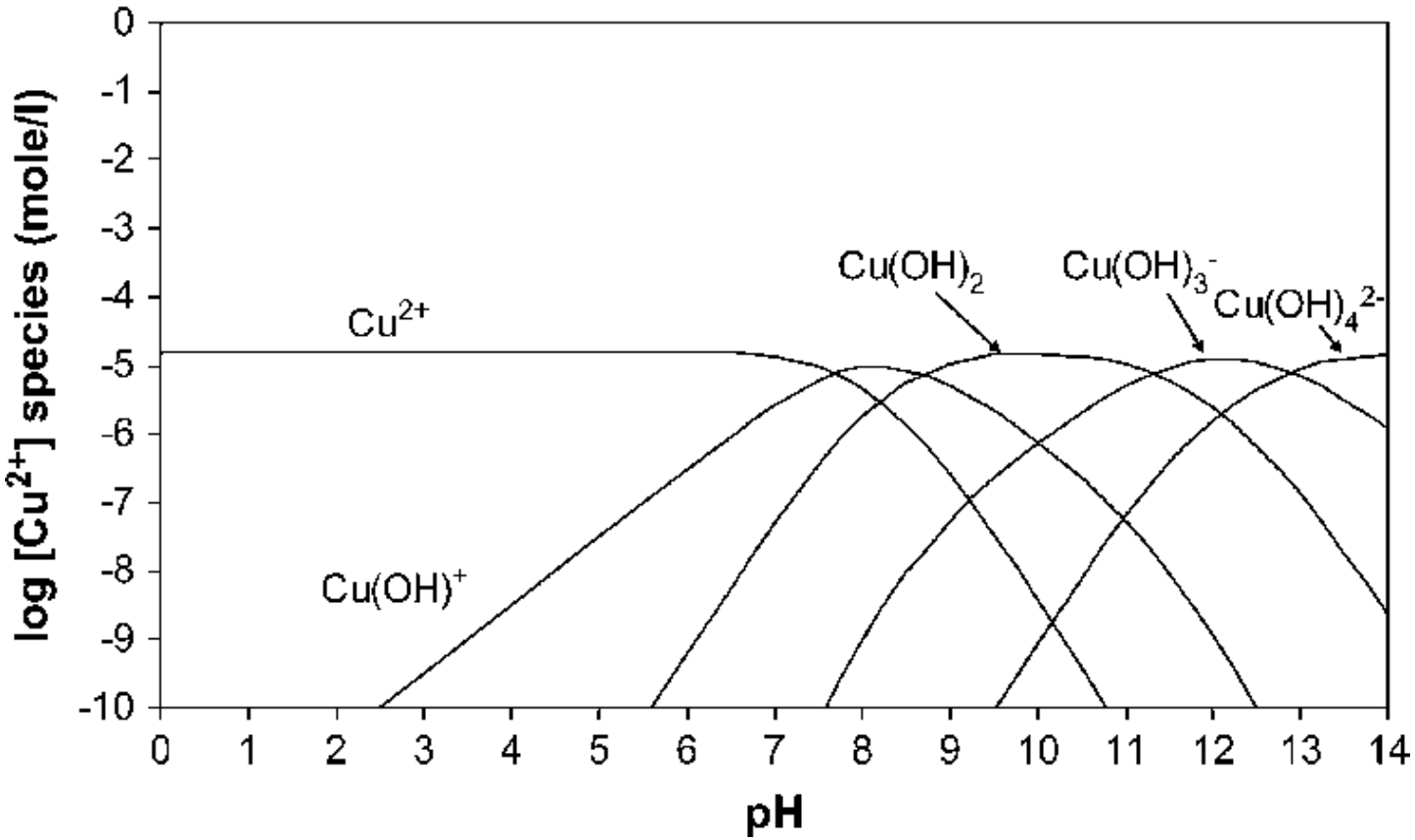
# Optimal pH depends on Mixture of HM’s

- pH 9 will precipitate most heavy metals except cadmium and antimony.

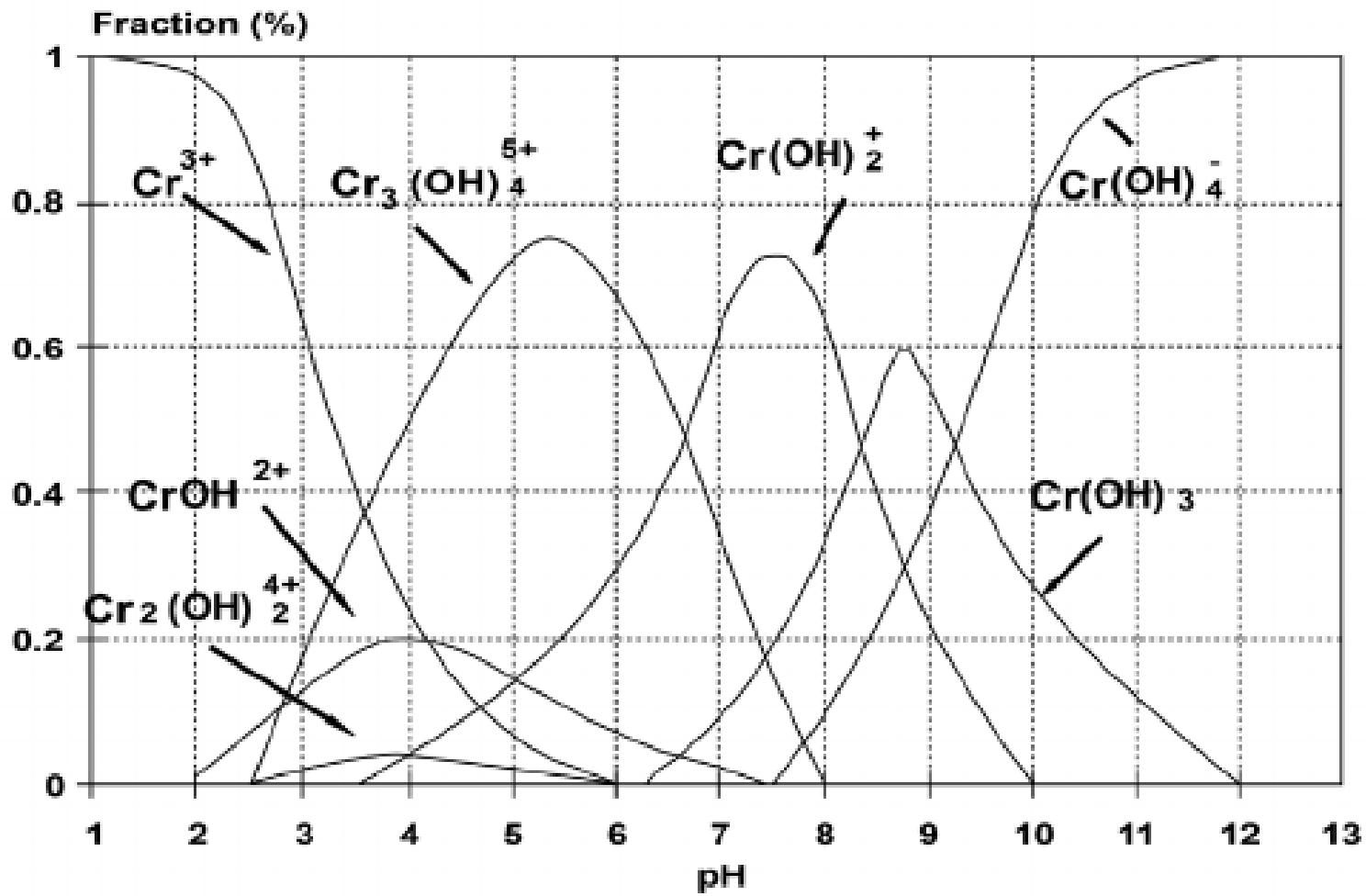
# Cadmium


Fraction
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
6
7
8
9
10
11
12
13
14
pH
Cd2+
Cd(OH)2
HCdO2-
CdOH+
CdO22-

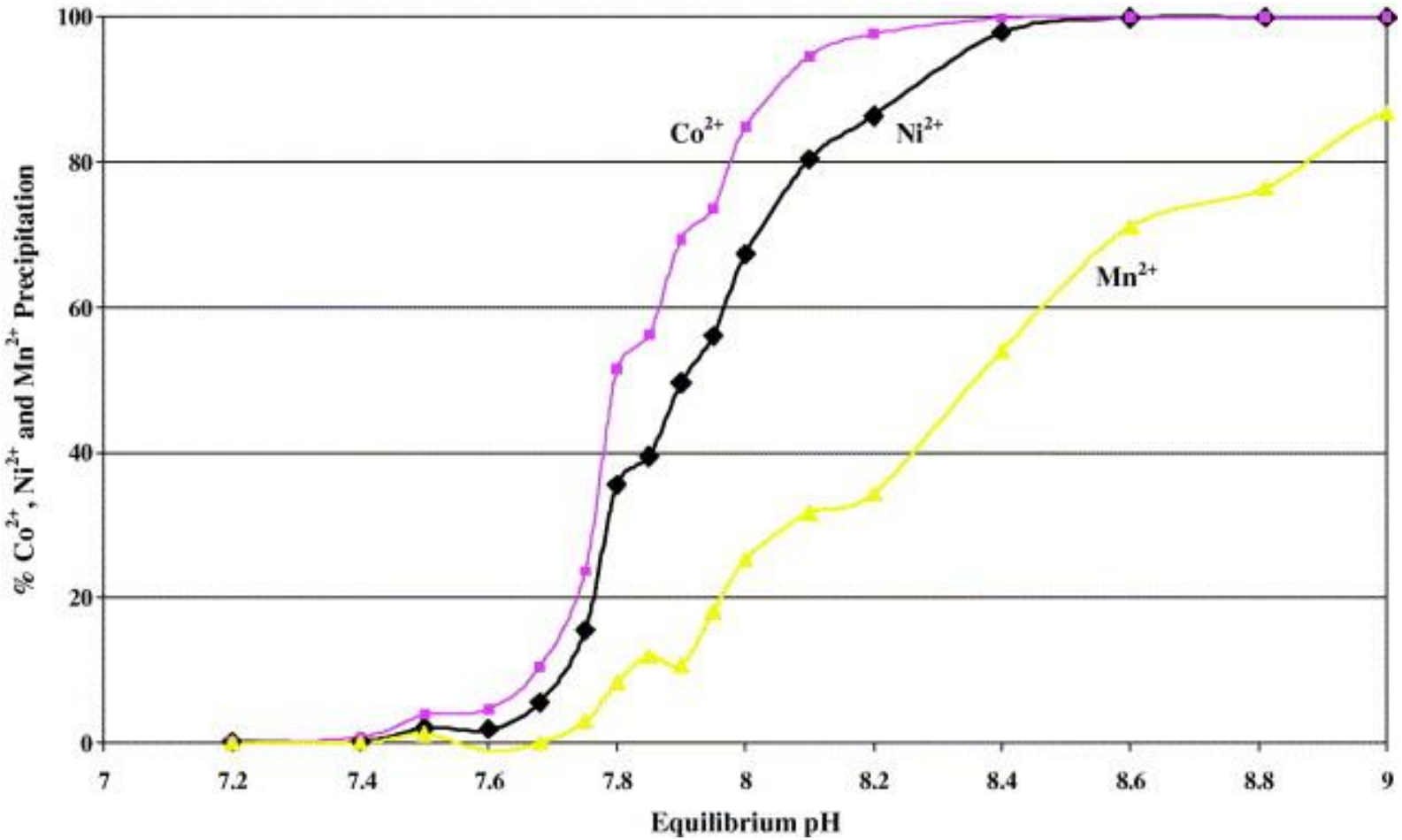
# Copper


log [Cu2+] species (mole/l)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
pH
Cu2+
Cu(OH)+
Cu(OH)2
Cu(OH)3-
Cu(OH)42-

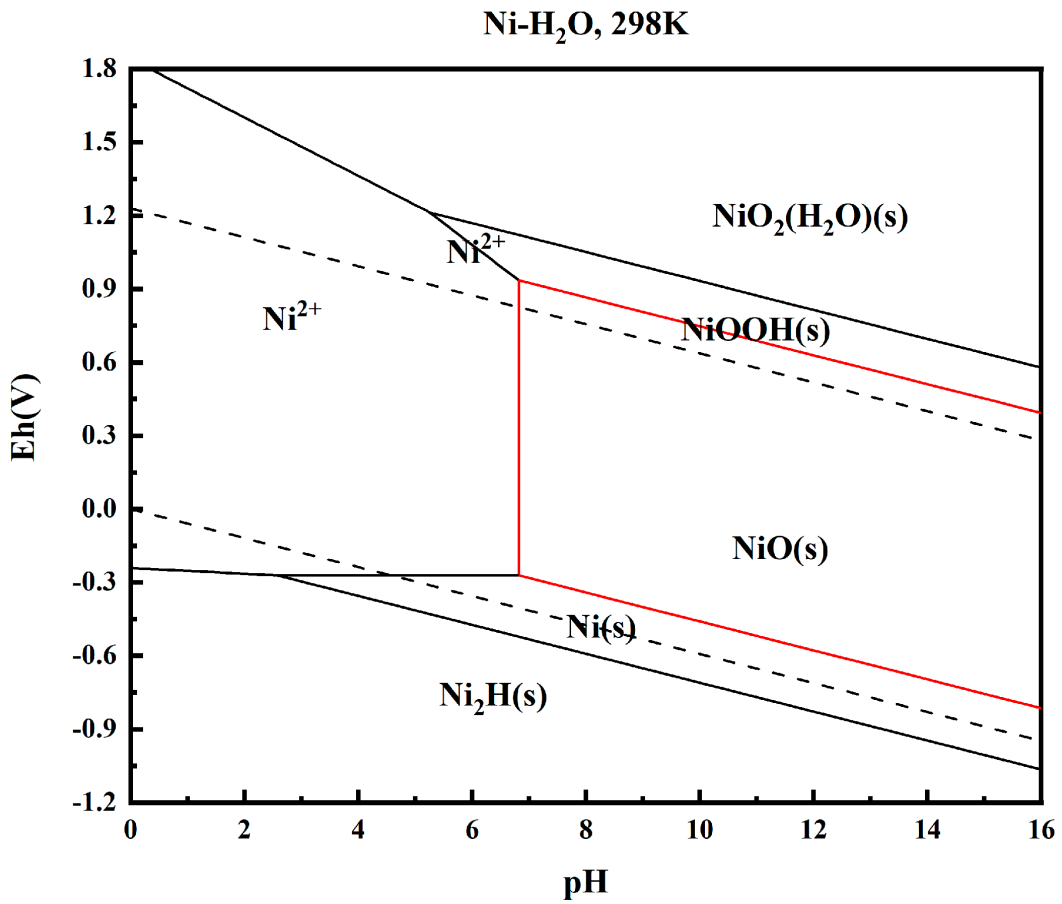
# Chromium


Fraction (%)
1
0.8
0.6
0.4
0.2
0
$Cr^{3+}$
$Cr_3(OH)_4^{5+}$
$Cr(OH)_2^+$
$Cr(OH)_4^-$
$CrOH^{2+}$
$Cr_2(OH)_2^{4+}$
$Cr(OH)_3$
1
2
3
4
5
6
7
8
9
10
11
12
13
pH

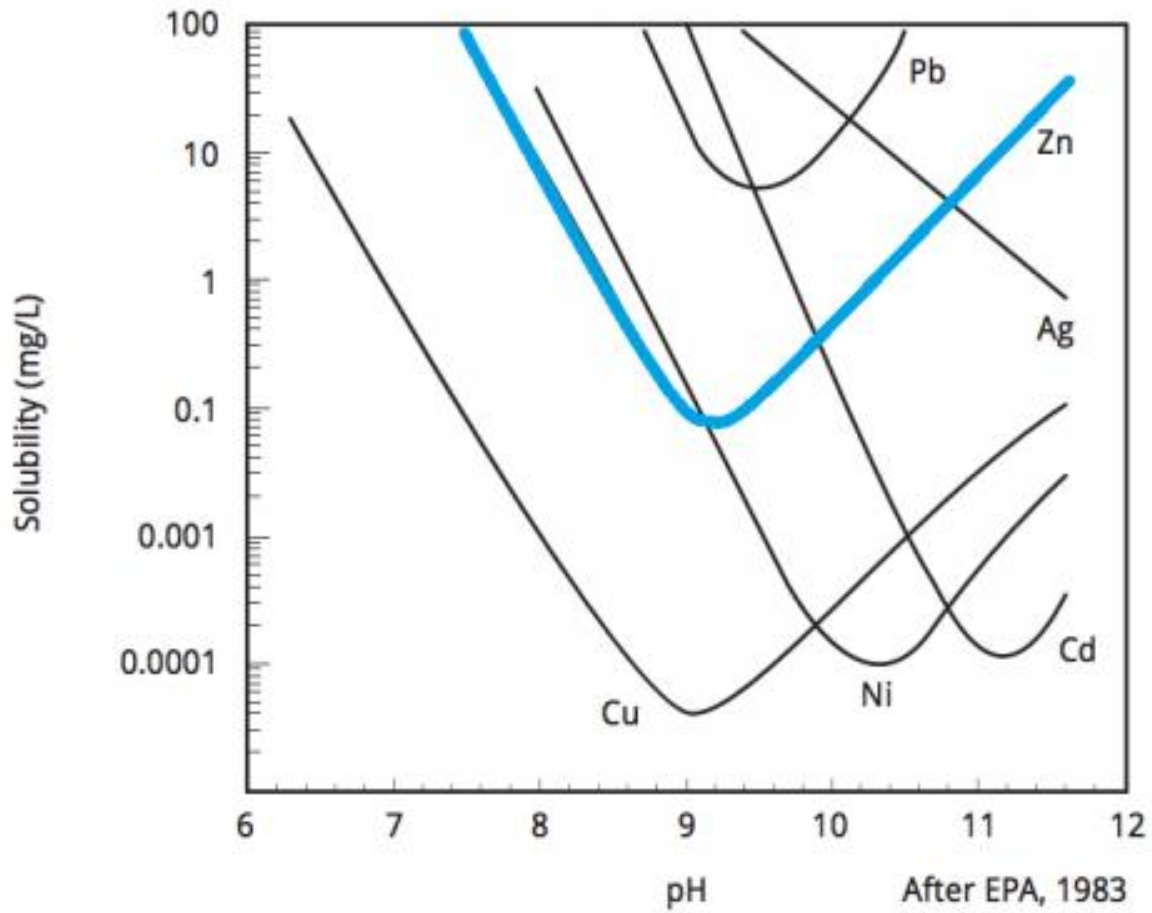
# Nickel


100
80
60
40
20
0
% Co2+, Ni2+ and Mn2+ Precipitation
Co2+
Ni2+
Mn2+
7
7.2
7.4
7.6
7.8
8
8.2
8.4
8.6
8.8
9
Equilibrium pH

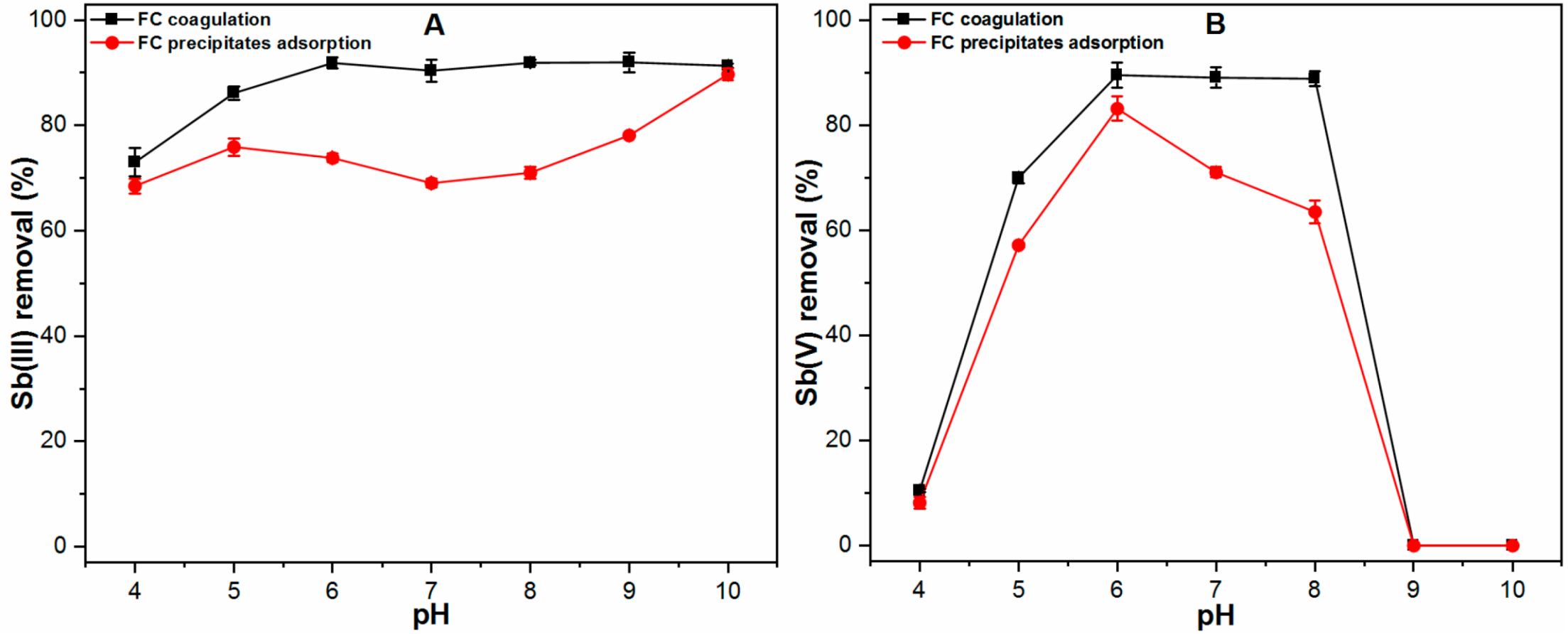
# Nickel - II


Ni-H2O, 298K
Eh(V)
pH
1.8
1.5
1.2
0.9
0.6
0.3
0.0
-0.3
-0.6
-0.9
-1.2
0
2
4
6
8
10
12
14
16
NiO2(H2O)(s)
Ni2+
Ni2+
NiOOH(s)
NiO(s)
Ni(s)
Ni2H(s)

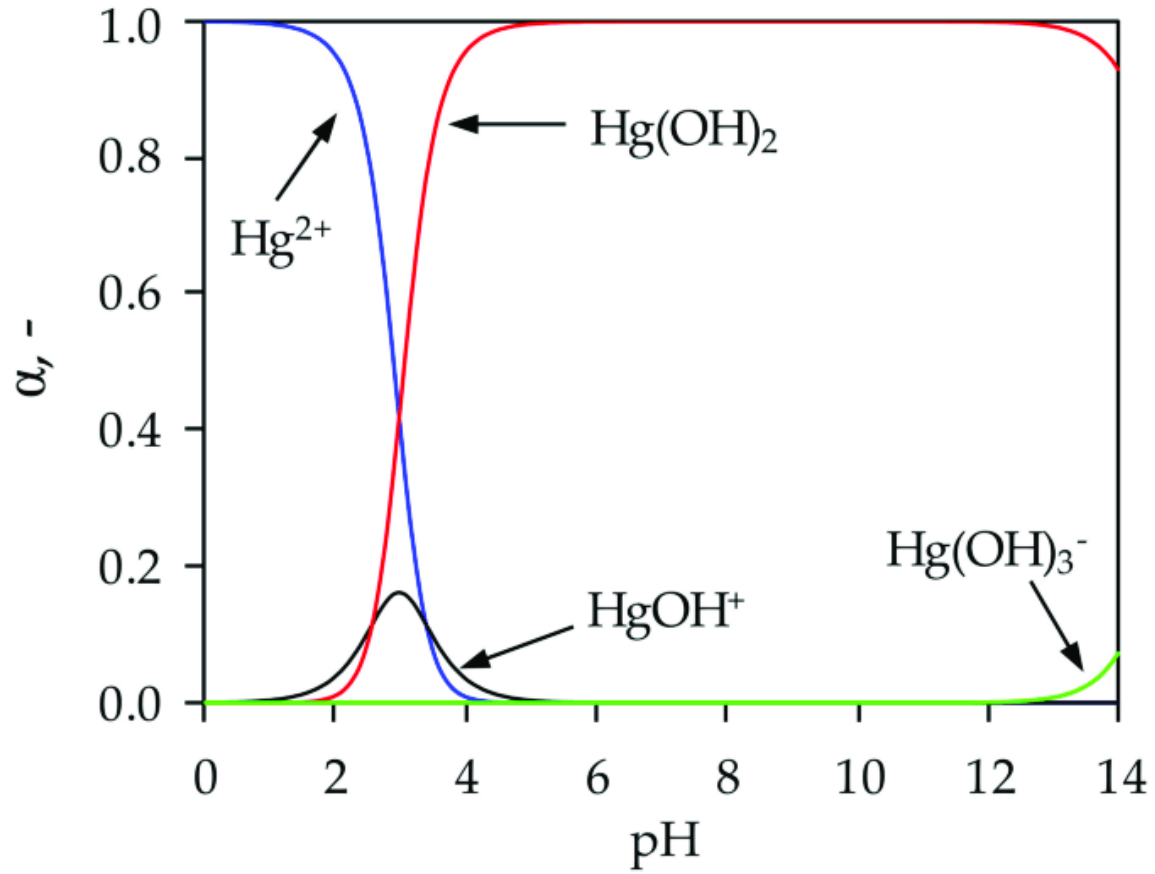
# Zinc


100
10
1
0.1
0.001
0.0001
Solubility (mg/L)
Pb
Zn
Ag
Cd
Ni
Cu
6
7
8
9
10
11
12
pH
After EPA, 1983

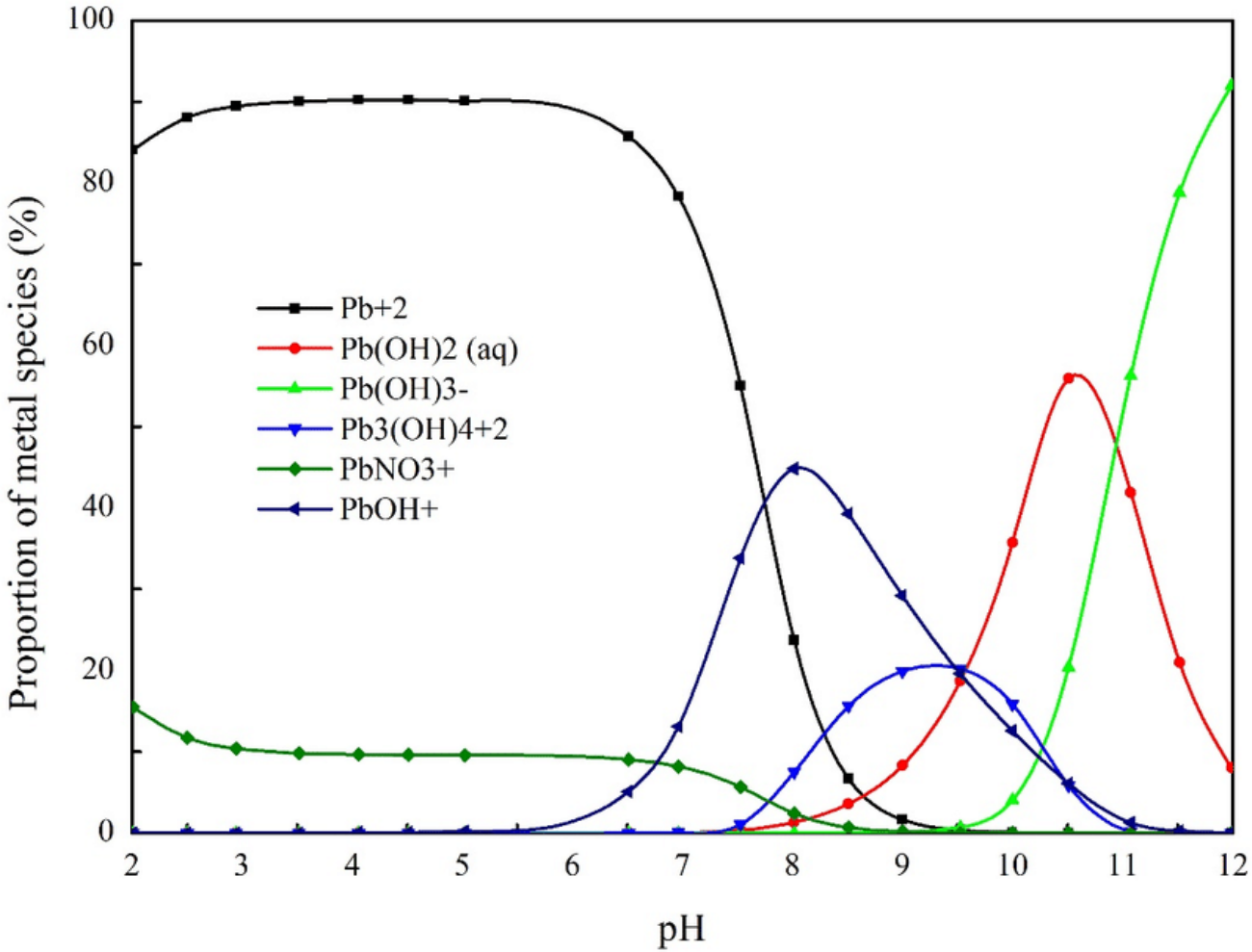
# Antimony


A
FC coagulation
FC precipitates adsorption
Sb(III) removal (%)
pH
B
FC coagulation
FC precipitates adsorption
Sb(V) removal (%)
pH

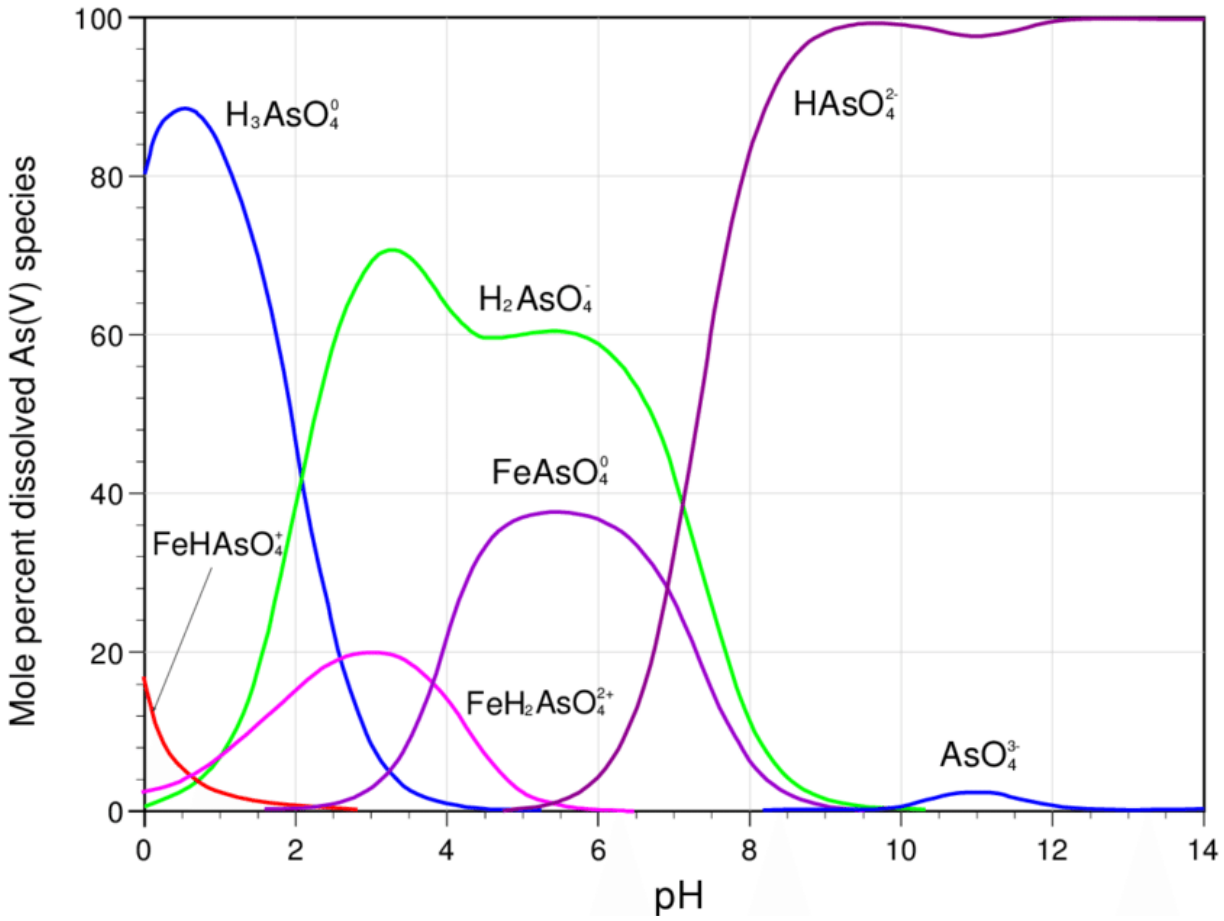
# Mercury



# Lead


100
80
60
40
20
0
Proportion of metal species (%)
Pb+2
Pb(OH)2 (aq)
Pb(OH)3-
Pb3(OH)4+2
PbNO3+
PbOH+
2
3
4
5
6
7
8
9
10
11
12
pH

# Arsenic – tricky to remove



# Arsenic Removal Using Sulphide

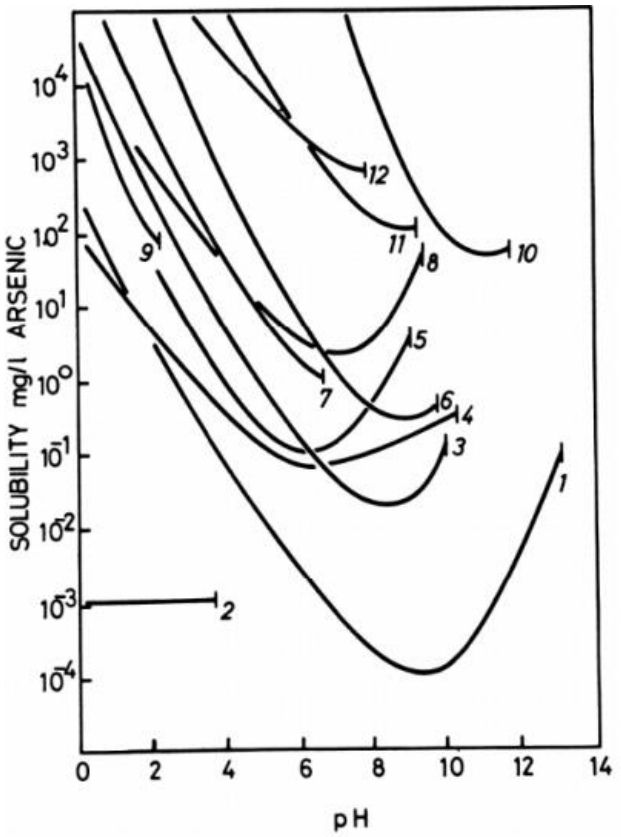



FIGURE 1. THE SOLUBILITY OF VARIOUS ARSENIC COMPOUNDS. The curves indicate the region of pH in which the particular compound is stable.

1. Ba(II)As(V) 2. $As_2S_3$ 3. Fe(II)As(V) 4. Hg(I)As(V)
5. Cr(III)As(V) 6. Ca(II)P(V)/As(V) 7. Pb(II)As(V)
8. Ti(IV)As(V) 9. Fe(III)As(V) 10. $MgNH_4As(V)$

# $OH^-$ Compared to Sulphide Precipitation

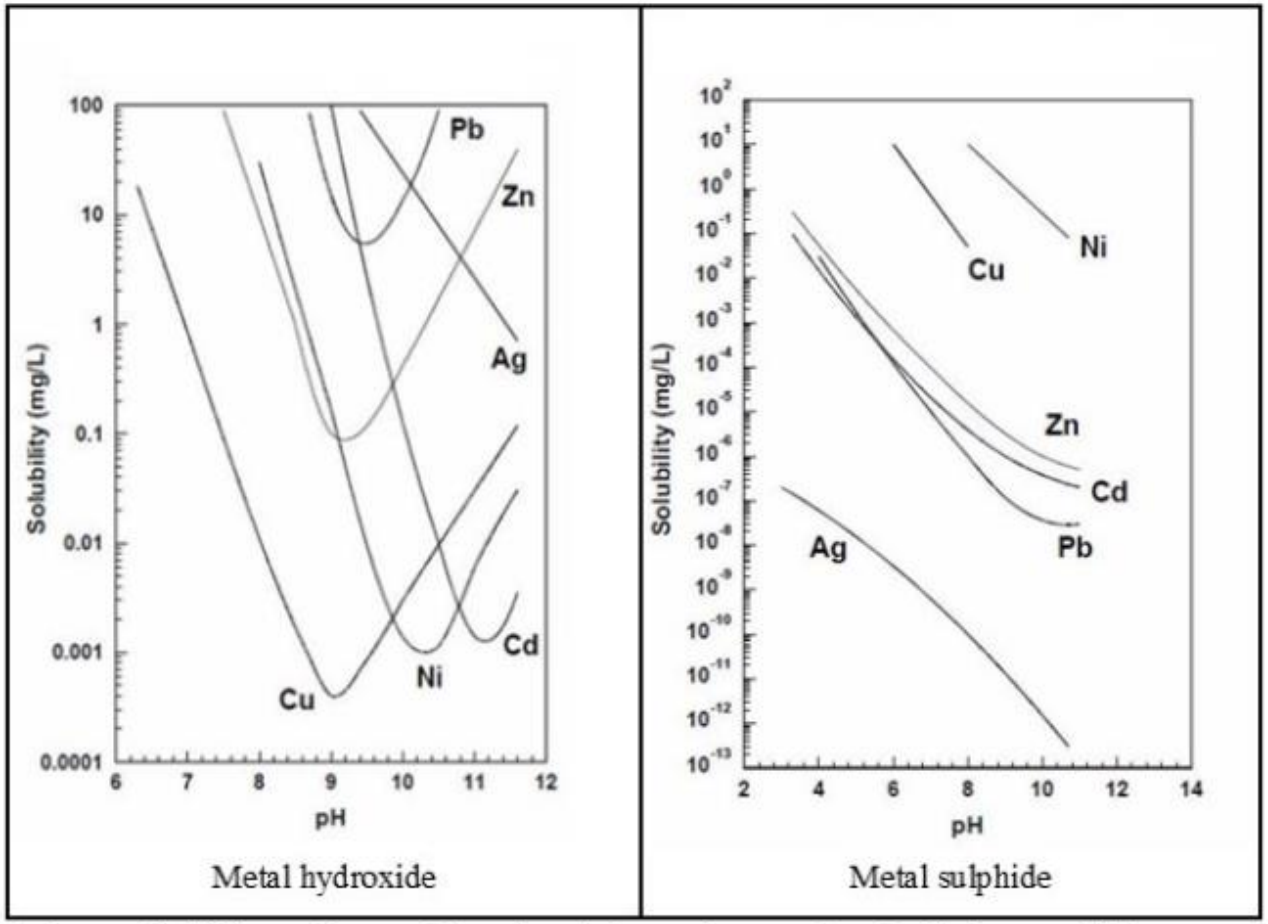



**Figure 1.** The solubility of metal hydroxide and metal sulphide on different pH [3].

# Enhancing Precipitation Rates

- Precipitation rates can be enhanced using Coagulation and Flocculation