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The Effect of Oak Leaves on the Leaching of Trace Metals from Sand

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"The Effect of Oak Leaves on the Leaching of Trace Metals from Sand"

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By
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Theory

Sand is fairly rich in some common trace metals, notably manganese and iron. However, these metals for the most part are in a state which renders them insoluble in water. It is thought that the prescence of organic matter (principally leaves) in the water enhances the dissolution of some of these trace metals into the aqueous solution.

This enhancement of dissolution is generally thought to come about in three main ways: (1) The organic matter present lowers the oxygen content of the water, and the metals are reduced into a soluble form, (2) The organic material, some of which is slightly acid, lowers the pH of the water, thereby enhanceing solubility conditions for some metals, and (3) Some of the organic compounds may actually chelate the metals, rendering them into a water soluble form.

As an example of how an insoluble metal species may be rendered soluble, Poon and Deluise list the following reactions[1]:

$$Mn^{+4} \xrightarrow[\text{Reduction}]{\text{biological}} Mn^{+2} \text{ (partly soluble)}$$

$$\begin{matrix} Mn^{+4} \\ Mn^{+2} \end{matrix} \text{ (insoluble)} + CO_2 \longrightarrow Mn^{+2} \text{ (soluble)}$$

1) Poon, C.P.C., and F.J. DeLuise. 1967. Manganese Cycle in Impoundment Water. Water Resources Bulletin. Vol. 3, Dec. 1967

$$\begin{matrix} Mn^{+4} \\ Mn^{+2} \end{matrix} \text{(insoluble)} + \text{Organic Acid} \longrightarrow \text{Soluble Complex}$$

$$Mn^{+2} \text{(insoluble)} \xrightarrow[\text{TRANSFORMATION}]{\text{biological}} Mn^{+2} \text{(soluble)}$$

$$\begin{matrix} Mn^{+4} \\ Mn^{+2} \end{matrix} \text{(insoluble)} \xrightarrow{H^{+}} Mn^{+2} \text{(soluble)}$$

It would probably be wise to include reactions for the simple reduction of some metals such as iron and manganese:

$$Mn^{+4} + 2e^{-} \longrightarrow Mn^{+2}$$

$$Fe^{+3} + e^{-} \longrightarrow Fe^{+2}$$

Purpose

It was the purpose of this work to determine the effect of oak leaves (which are abundant in the streams and impoundments of this area) on the leaching of trace metals (Pb, Ni, Zn, Cr, Fe, Mn, Cu, and Co, in particular) from sand.

Procedure

Two glass columns , approximately 1½ yards in length and 1 inch in diameter, were obtained. One column was packed with sand only, and the other with alternating sections of oak leaves and sand. Distilled water was run through the columns for about two days continuously. The first batches through were discarded.

Standard solutions of each of the metals to be determined were prepared (10, 25, 50, 75, and 100 ppb) by dilution of a 100 ppm stock solution.

Determinations were made by atomic absorption spectroscopy.

Determinations were first attempted by aspirating directly from the aqueous phase. Good calibration curves were obtained but it was decided that greater sensitivity was desirable for some elements. It was decided that chelation and solvent extraction would be necessary to obtain this enhanced sensitivity.

Aliquots were taken of each of the standard solutions and also of the solutions which had passed out of the two columns. The metals were chelated with the sodium salt of diethyldithiocarbamic acid at pH 4, and extracted with methyl isobutyl ketone. The pH of the aqueous phase left from this extraction was raised to 7 and manganese was chelated and extracted in a similar manner (using the extraction procedure of Nix[2]). Concentrations of the metals were determined by atomic absorption spectroscopy. Some of the determinations proved to be very insensitive and the data from the aqueous determination was preferred.

2) Nix, J.F., Ouachita Baptist University, unpublished results.

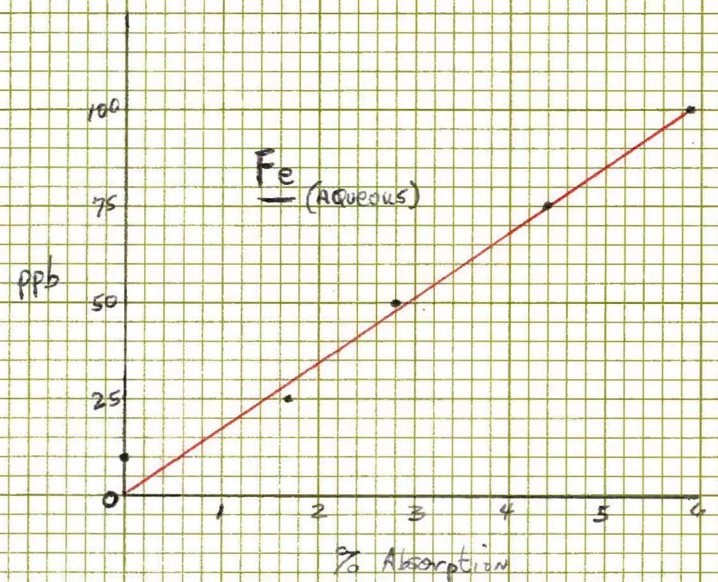
Results

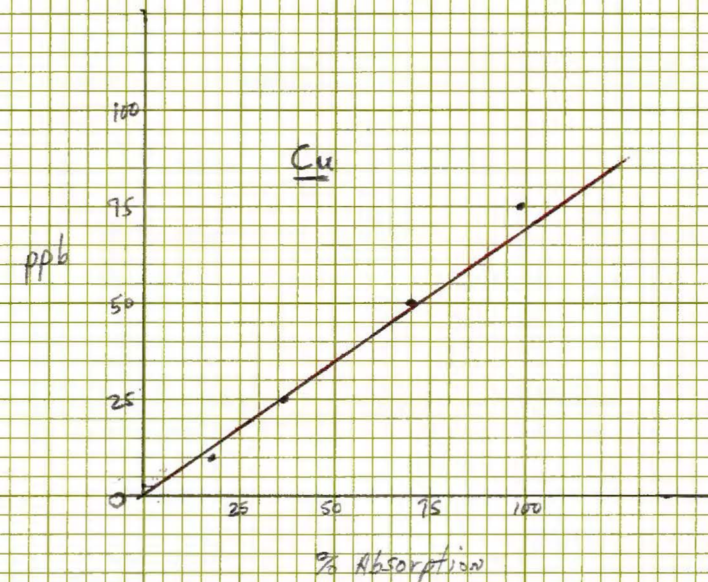
The calibration curves for the eight metals are enclosed. Data for the aqueous determinations for Fe, Ni, Zn, and Cr are recorded, in addition to the data for the organic solvent determinations for Mn, Cu, Pb, and Co. The concentrations in parts per billion for each of the metals in the water from both columns is listed below:

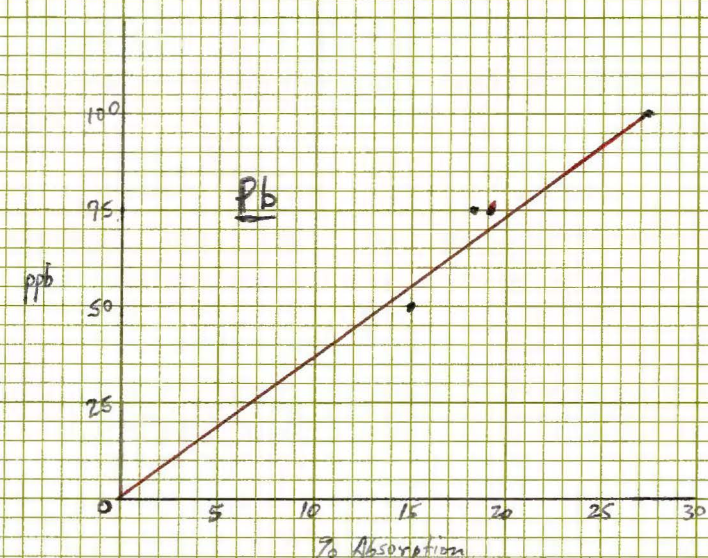
	Sand	Sand and Leaves
Copper	0.0	4 ppb
Lead	85 ppb	75 ppb
Cobalt	5 ppb	6 ppb
Manganese	80 ppb	170 ppb
Chromium	0.0	0.0
Nickel	0.0	5 ppb
Iron	0.0	90 ppb
Zinc	38 ppb	42 ppb

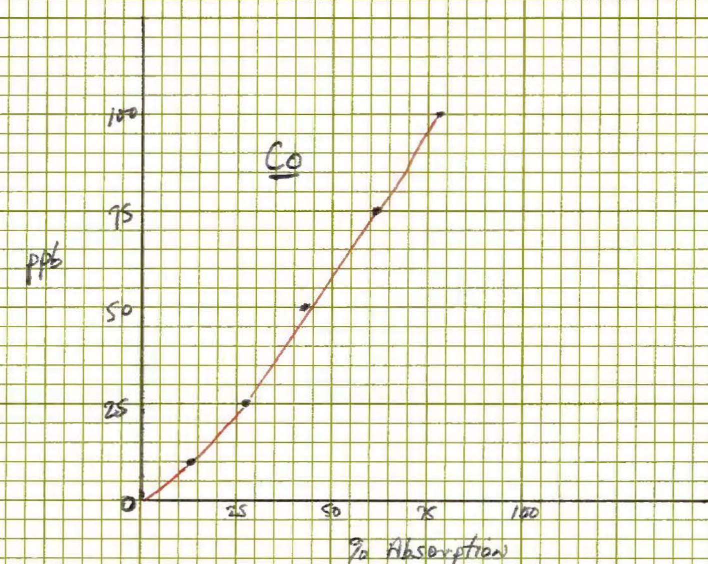
Conclusion

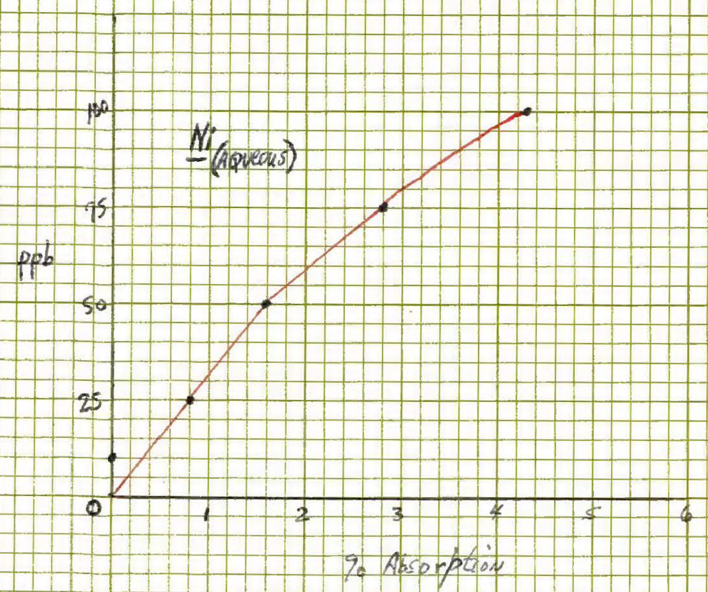
Oak leaves definitely enhance the solubility of some metals in water, and contribute to the causes of leaching of these metals from sand. Iron and manganese data showed most dramatically the result of this leaching process. These results help to explain why there is an increase in the levels of iron and manganese in natural waters in the autumn.

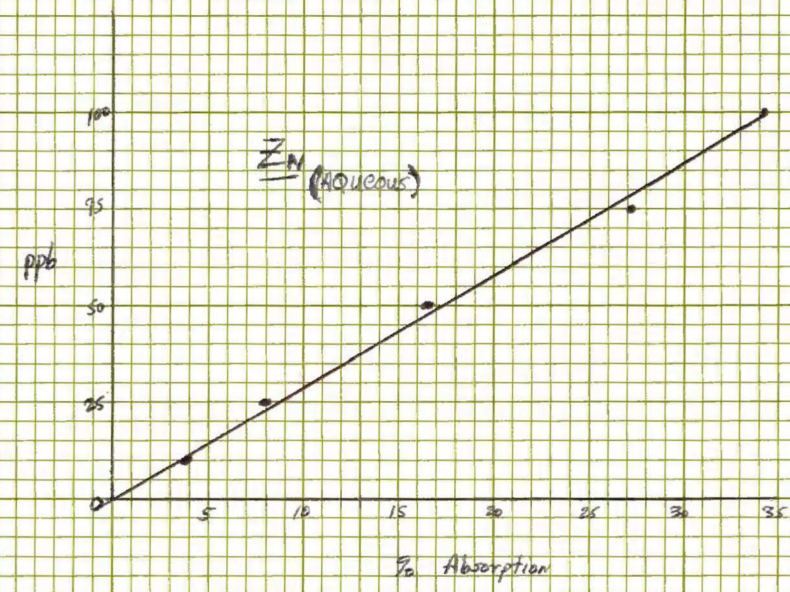

Fe (Aqueous)
ppb
0
25
50
75
100
1
2
3
4
5
6
% Absorption

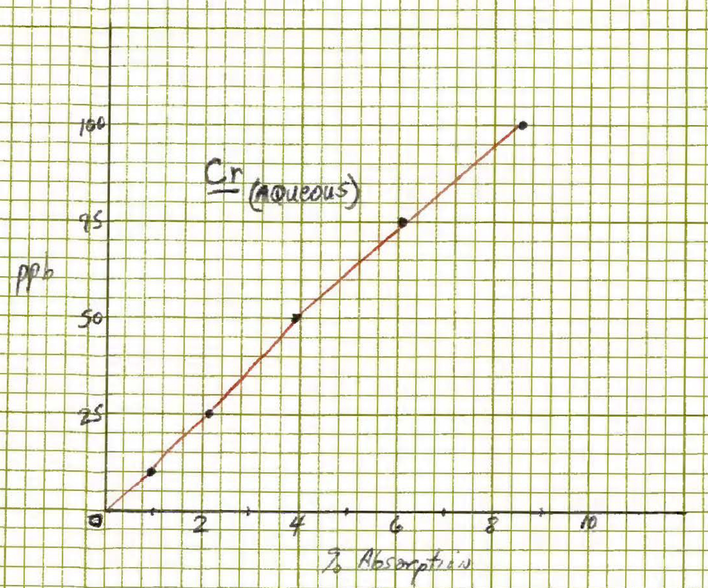

Cu
ppb
0
25
50
75
100
25
50
75
100
% Absorption

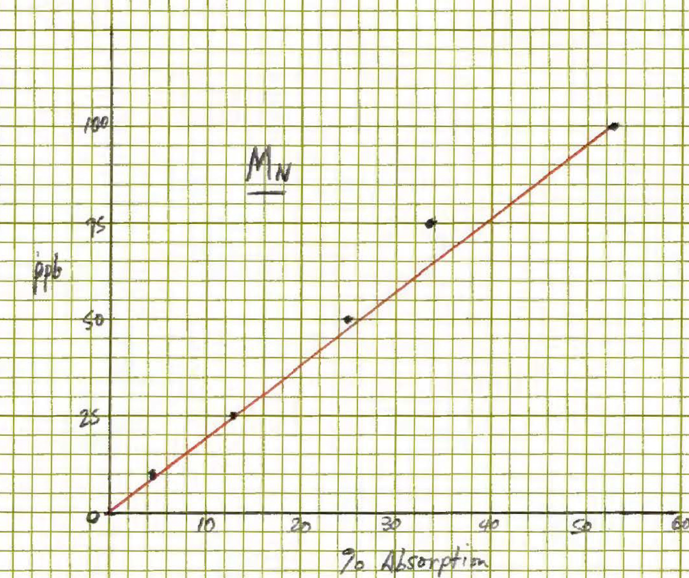

Pb
ppb
0
25
50
75
100
5
10
15
20
25
30
% Absorption


Co
ppb
0
25
50
75
100
25
50
75
100
% Absorption


Ni (Aqueous)
ppb
0
25
50
75
100
1
2
3
4
5
6
% Absorption


Zn (Aqueous)
ppb
0
25
50
75
100
5
10
15
20
25
30
35
% Absorption


Cr (Aqueous)
ppb
0
25
50
75
100
2
4
6
8
10
% Absorption


Mn
ppb
0
25
50
75
100
10
20
30
40
50
60
% Absorption