

Abstract of Report Prepared 4 DEC 2003  
By **Aria Amirbahman PhD PE**  
Associate Professor of Environmental Engineering  
**Department of Civil and Environmental Engineering**  
**THE UNIVERSITY OF MAINE**

Report contains data and analysis for metal content in “sea humic minerals”. Metals were extracted using two different techniques, and measurements specifically for Aluminum, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, and Zinc were performed.

Both procedures followed are well documented in scientific soil and sediment analysis literature.

- 1) “Sequential” Extraction involves the use of mild as well as strong reagents to sequentially extract different metal fractions. These extractions were performed in triplicate and based upon the procedure of Hieltjes & Lijklema, 1980, “Fractionation of inorganic phosphates in calcareous” sediments,” Journal of Environmental Quality, 9, 405-407 and consisted of four stages:
  - 1 Extraction with 1 M NH<sub>4</sub>Cl for 30 minutes using 10 mL + 10 mL rinse
  - 2 Extraction with 0.1 M NaOH for 20 hours using 25 mL + 25 mL rinse
  - 3 Extraction with 0.5 M HCl for 30 minutes using 25 mL + 25 mL rinse
  - 4 Total microwave-assisted digestion of remaining material using 8 mL aqua regia (1 part HNO<sub>3</sub> : 3 parts HCl) and final dilution to 100 mL
  
- 2) Extraction of fulvic and humic acid fractions procedures currently in place in the EPA-certified laboratory of the University of Maine, are based on the paper by E.M. Thurman and T.L. Malcom (1981) “Preparative isolation of aquatic humic substances.” Environmental Technology, 15 463-466. The methodology is also recommended by the international Humic Substances Society (IHSS).

Interpretations:

Base-insoluble fraction	925.9 g/kg – solid total	92.6%
Humic acid fraction	0.8 g/kg – total solid	<1.0%
Fulvic acid fraction	73.3 g/kg – total solid	7.3%

By definition, the humic acid is the precipitated fraction, and fulvic acid is the dissolved fraction at pH = 1.0

No detectable Fe could be extracted using NH<sub>4</sub>Cl indicating that all Fe is in the form of mineral oxide or hydroxide. The microwave-extractable Iron is primarily crystalline mineral Fe-(hydr)oxide that is not extracted using the 0.5 M HCl solution.

No detectable Pb was extracted either, suggesting that Pb is primarily associated with Fe minerals, as is usually observed in natural soil and sediments. Pb is normally not only associated with mineral surfaces, but its adsorption to these surfaces is enhanced as pH increases. Both these observations are expected for the association of Pb with natural soils and sediments. However, a strong acidic solution is necessary to desorb it. Association of Pb with mineral oxides, such as ferric hydroxide is prevalent in most environmental samples.

The ion-exchangeable As is 0.30 mg/kg-dry material. Most of this fraction is adsorbed to the mineral surface. Arsenic is anionic in environmental systems, even though it is classified as a metal. The anionic nature of As (whether arsenate or arsenite) inhibits its associations with natural organic matter to a great extent.

The ion-exchangeable Hg is 0.0025 mg/kg-dry material. It is expected that most of this fraction is associated with organic matter that is dissolved under basic (alkaline) conditions given the favorable association of Hg with natural organic matter. The microwave tests confirmed Mercury's association with insoluble, relatively non-bio-available organic matter.

Again, both these species (i.e., Arsenic and Mercury) are expected to be associated with the mineral surface in ionic form.

	As (ppm)	Pb (ppm)	Fe (ppm)	Hg (ppm)
Metals in fulvic acid	9.570	0.13	102.8	.00426
Metals in humic acid	0.986	0.00	14.6	.06645

Note: The chelation factor negates the toxicity of these heavy metals. In any event the parts per million are within limits established by the FDA in the USA even for free elements...Clay sediment studied was a Montmorillonite deposit stratified with matter of organic origin from Panaca, NV currently being exploited by US Rare Earth Minerals, Inc. go to [www.us-rem.com](http://www.us-rem.com)