

# A PARTIAL EXTRACTION OF METALS FROM SOIL TO EVALUATE POLLUTION

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The purpose of this investigation was to develop an optimum procedure for the extraction of metal "contaminants" from natural soils, so that metals deposited in the soils because of environmental pollution, such as runoff, or land disposal of wastes, may be quantified. To be useful for pollution evaluation, the procedure must achieve nearly complete extraction of metals that are water soluble, exchangeable, and tightly bound through complexation, chelation or adsorption, yet cause no damage to the soils crystalline structure. Malo (1977) has stated that the optimum procedure should also be suitable for the processing of large numbers of samples, i.e., involve a minimum of manipulation.

The partial extraction procedure of Agmian and Chau (1977), which consists of the use of a 20 to 1 ratio of extraction solution to dry weight soil sample and 12 hours contact time at room temperature on a reciprocating platform shaker, was selected as a starting procedure for investigation and optimization. A room temperature procedure was selected to minimize handling problems. Therefore, the specific objective of this study was to find an optimum combination of three test variables, solvent type, solvent strength, and extraction time on a shaker, which would extract the maximum amount of metals from the soil surface coatings, in the shortest time span, without causing crystalline structure damage.

An experimental matrix of the three experimental variables was developed so that statistical techniques could be used to analyze the results and find the optimum combination. The matrix is given in Table 1. Two soils, a sandy loam and a clay loam, both of which were known to be contaminated by metals from highway traffic, were obtained for study purposes. The total metals contents of the soils were determined using the procedure of Bernas (1968), and free iron measurements were made using the method of Mehra and Jackson (1960). Following extraction, iron, aluminum, manganese, lead and zinc were measured. The matrix data were analyzed by Response Surface Methodology to find the optimum combination of the three variables.

## RESULTS

Each metal measured approached some maximum value asymptotically with time for each set of conditions. These values were used to determine the optimum procedure. The "pollutant" metals, i.e., lead and zinc, generally reached the maximum value in 12 hours and then the recovered concentration decreased with

digestion beyond that time. Recovery of the naturally-occurring metals, i.e., aluminum and iron, continued with digestion time throughout the 24 hours. When the amount of iron extracted exceeded the free iron determinations, crystalline structure damage was considered to have occurred, and these values were not used for optimum procedure determination.

Table 1. EXPERIMENTAL MATRIX

Type of Solvent	Variables Used	
	Strength of Solvent	Contact Time*
Nitric acid	0.25 N	2 hours
Hydrochloric acid	0.50	4
	1.00	8
	2.00	12
	4.00	18
		24

\*1.5 gram soil, dry weight, and 30 ml. acid in a 50 ml. polyethylene tube, sealed and placed on a Model J-210 Eberbach reciprocating platform shaker with stroke length of 35.6 cm. at 100 cycles per minute.

The clay soil was more difficult to extract than the sandy soil and hydrochloric acid was a more effective extraction solvent than nitric acid. Because of the differences between the soils, optimum procedures were determined for each soil as well as a single optimum for both. Since its use would require a greater extraction time, nitric acid was rejected as a suitable extraction solvent.

The optimum procedure for sandy loam extraction was determined to be 1.4 N HCl for a digestion time of 10.5 hours, whereas the optimum for the clay loam was 3.5 N HCl for 19.3 hours. Because the recovery from the clay loam at its optimum was only 10.5% greater than what could be obtained from it using the optimum extraction conditions for the sandy loam, it is possible to use 1.4 N HCl for 10.5 hours as the compromise optimal combination. It was concluded, however, that the variation in soils is large enough that separate optimization of extraction procedures for each soil should be performed to be confident of the pollution evaluation results.

The observed decreases in recovery of lead and zinc with digestion time beyond a specific time should be a matter of concern during pollution evaluations. If a specific metal is of primary concern, the extraction procedure should be optimized for that particular metal. If several metals are being evaluated by one procedure, as in this investigation, the effect of digestion time on recovery of each metal should be investigated before extensive use of the procedure.

The heat extraction procedure of Anderson (1974) was used to extract the two soils and the results were compared to those obtained using the room temperature methods of this investigation. It was found that heat extraction caused extensive crystalline structure damage and should not be used for pollution evaluations. In fact, because the damage was partial rather than complete, the results of the procedure cannot be interpreted for any purpose. Also, the amount of lead recovered after heating was only 60-65% of that obtained at room temperature from the clay soil, and about 80% from the sandy soil. Apparently insoluble lead products form during heating and prolonged extraction.

## CONCLUSIONS

Based on this investigation's results, the following conclusions were reached:

1. Nitric acid is not as effective an extractant of metals as hydrochloric acid. Optimum extraction of adsorbed metals can be accomplished using more dilute solutions and shorter digestion periods if hydrochloric acid is used.
2. Strong acid solutions (0.5 to 4.0 N) can cause crystalline structural damage at digestion times of 24 hours or less at room temperature. The time at which structural damage will occur is a function of the type of acid used, the strength of the acid, and the type of soil being digested.
3. Nearly complete extraction of adsorbed heavy metals from soils can be accomplished without causing crystalline structural damage, but the optimum conditions will vary significantly with soil type.
4. The optimum extraction procedures for the sandy soil, i.e., 1.4 N HCl and 10.5 hours, also extracted 89.5% of the metals from the clay soil. Thus it is possible to use a single procedure to extract both types of soil with reasonable results.
5. Extraction procedures which utilize heat and concentrated acids are too destructive to the crystalline structure of soils to be useful for evaluating adsorbed metals.
6. The metals, such as lead and zinc, which are most likely to originate from environmental pollution are the most completely and the most easily extracted from soils, i.e., they are less tightly bound.
7. There was generally a direct variability observed between the quantity of metal extracted and increasing acid strength or digestion time. This was not true for lead, however, and it generally decreased after long digestion times, indicating the formation of insoluble precipitates during extraction.

## REFERENCES

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