Spatial and Temporal Variation of Elemental Deposition in Maricopa County

T. Zschau[1], S. Getty[2], C. Gries[1], T.H. Nash III[1]

Dept. of Plant Biology, Arizona State University, 2 University of New Mexico

ABSTRACT

Trace elemental deposition patterns in Maricopa County were assessed using lichens as deposition receptors for a spatial grid of 28 field sites collected in 1998. In addition, historical trends were assessed for six sites, from which lichen collections from the mid-1970's were available. After cleaning and wet digesting, samples were analyzed for Sr, Cr, Ni, Co, Cu, Zn, Ag, Cd, Sn, Sb, Ce, Pr, Nd, Eu, Gd, Tb, Sc, Dy, Ho, Er, Tm, Yb, Lu, Au and Pb via inductively coupled plasma mass spectrometry (ICP-MS). Patterns were elucidated in part by cluster and principal component analysis, as well as spatial maps based on ArcView. With the exception of the Phoenix metropolitan area, mining regions near Wickenburg and smelting operations near Ajo, elemental concentrations were generally comparable to unpolluted regions. Copper deposition patterns were indicative of both mining and smelting activities. Secondarily Pb, Sb and Zn were associated with mining. Lead was, of course, associated with high vehicular traffic densities in urban areas, where elevated levels of Cd, Sb and Zn were also found. The occurrence of the rare earth elements reflected the influence of blowing dust and in the NE part of the county a special geological deposit resulted in high levels of Co, Cr, Ni and Sc. Over the 30+ year period, Pb decreased by 71%, a pattern that reflects the switch to unleaded gasoline. Similarly the closure of the Ajo smelter has resulted in a substantial reduction of Cu, particularly in southern Maricopa County. In contrast, Zn has increased as much as 246% over the same period in metropolitan areas.

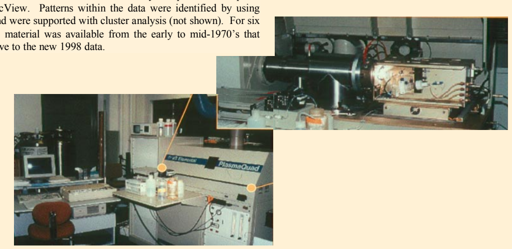
INTRODUCTION

Lichens have been used extensively as bioindicators of air pollution. They are differentially sensitive to some gaseous air pollutants, such as SO_2. In addition, they accumulate and tolerate high levels of elements from atmospheric deposition. Spatial and temporal deposition patterns integrated over years can be gleaned from elemental levels accumulated by lichens. Advantages to using lichens as surrogate atmospheric deposition receptors include:

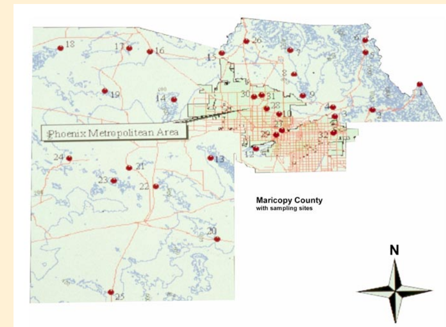
- their ability to accumulate elements to concentrations that vastly exceed their physiological requirements through particulate entrapment and ion uptake mechanisms.
- their lack of roots and minimal interaction with the soil (many are epiphytes and/or occur on rocks), resulting in a almost total dependence on an atmospheric source of nutrients.
- their perennial nature (often living decades to hundreds of years) and slow growth rate, resulting in their morphology remaining relatively unchanged with time.
- their wide-spread distributions that allows investigation of one species at many different locations.
- their lack of stomates and waxy cuticle that allows elemental uptake across their entire surface.

METHODS

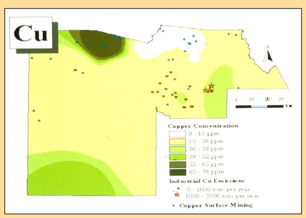
Samples of lichens (*Xanthoparmelia* spp. – see picture below) were collected between February and April, 1998 from 32 sites through out Maricopa County (map to right). Twenty-five of the sites had been previously collected for lichens by Nash (1975) and seven additional sites were added to increase spatial resolution. Several different procedures for wet digesting lichens were tested for recovery of known standards for several elements. After cleaning and wet digesting three replicates of samples from each site, the digests, were analyzed for the elemental levels by ICP-MS in the Department of Geosciences at the University of New Mexico under Dr. Getty's supervision. Spatial patterns were plotted using ArcView. Patterns within the data were identified by using principle component analysis and were supported with cluster analysis (not shown). For six sites sufficient *Xanthoparmelia* material was available from the early to mid-1970's that means could be compared relative to the new 1998 data.

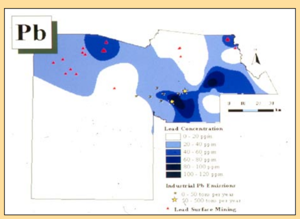


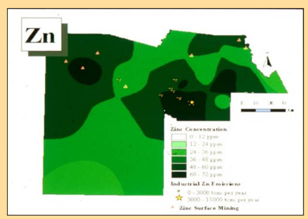
SAMPLING DESIGN



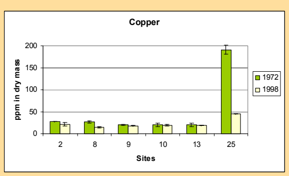
SPATIAL PATTERNS 1998

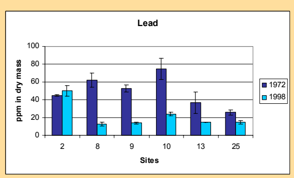




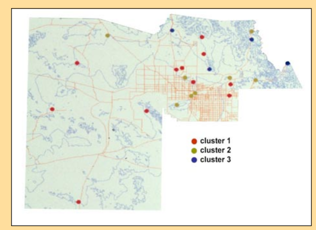


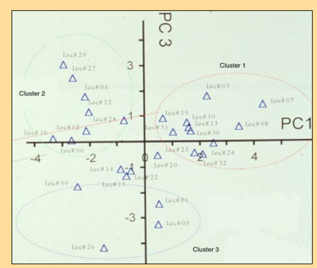
TEMPORAL PATTERNS (mid 1970's to 1998)





PRINCIPAL COMPONENT ANALYSIS





CONCLUSIONS

Copper:
Spatial:
Concentrated in copper mining regions and north of old smelter.
Temporal trends:
Levels remain fairly constant for most parts of the county.
A sharp decline in the south is related to closure of Ajo smelter in 1986.

Lead:
Spatial:
Concentrated in the Phoenix metropolitan area.
Temporal trends:
Lead levels dropped substantially (except in station #02), which is probably due to the shift from leaded to unleaded gasoline in the 1970's and 1980's.

Zinc:
Spatial:
Concentrated in metropolitan areas and adjacent agricultural areas.
Temporal trends:
Zinc levels have increased by 116 – 246 %, due to new industrial (castings), traffic and agricultural inputs.

Principal Component Analysis
Three major factors help explain observed spatial patterns:
Rare earth element component representing widespread dust derived from geological materials.
Co, Cr, Ni and Sc component derived from a restricted geological deposit.
Anthropogenic emission.

Overall:
A traditional gradient approach is unsatisfactory to explain complex atmospheric fallout pattern in Maricopa County.
Most elemental concentrations found in this study are within the range of values reported for unpolluted to slightly polluted areas.
Major air pollution sources in Maricopa County are: (1) traffic, (2) agriculture, (3) mining, and (4) industry

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