An Overview on the Source Identification of Atmospheric Mercury using PCA

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Outline

- Why need PCA
- How to do PCA
- Who has done it
- What they have found
- Summary

Major Sources of Atmospheric Hg

- Coal-fired power plants
- Coke ovens
- Mining
- Metal processing
- Traffic emissions
- Forest fire and bio-burning
- Reemission of historical depositions

Atmospheric Hg at Receptor Site

- Local manmade sources
- Local reemissions
- Long term transport
- May not be able to differentiate by using Hg data alone
- Add other parameters: complex relationships
- Factor Analysis (FA) such as principal component analysis (PCA) may help
- Available in most statistical software: e.g. SPAA, SAS, Minitab, Matlab

Principal Component Analysis

- FA: data reduction
- Analyze the structure or the interrelationships among a large number of variables to determine a set of common underlying dimensions, i.e. a few “factors” or “components”; not based on correlation only
- Select factors to retain based on eigenvalues (>1)
- Rotate selected factors to increase interpretability
- Interpret the factors:
  - identify highest loadings across all factors for each variable, or in each factor
  - significant factor loading depends on sample size
  - name each factor

Samouel's Restaurant

Rotated Component Matrix –
Samouel's Customer Survey

Variables	*Components/Factors* 1	2	3	4
X_4 – Excellent Food Taste	.912	.134	.065	.056
X_9 – Wide Variety of Menu Items	.901	-.059	.045	.055
X_1 – Excellent Food Quality	.883	.141	.056	.093
X_6 – Friendly employees	.049	.892	-.109	.048
X_{11} – Courteous Employees	-.022	.850	.007	-.037
X_{12} – Competent Employees	.212	.800	-.107	.208
X_8 – Fun Place to Go	.007	-.086	.869	-.102
X_2 – Attractive Interior	.008	-.056	.854	.001
X_7 – Appears Clean and Neat	.049	-.040	.751	.133
X_3 – Generous Portions	.084	.116	.037	.896
X_5 – Good Value for the Money	.239	.146	.107	.775
X_{10} – Reasonable Prices	-.074	-.056	-.072	.754

Note: Loadings sorted by size.

Source: https://www.google.ca/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF-8#q=what%20is%20factor%20analysis%20ppt

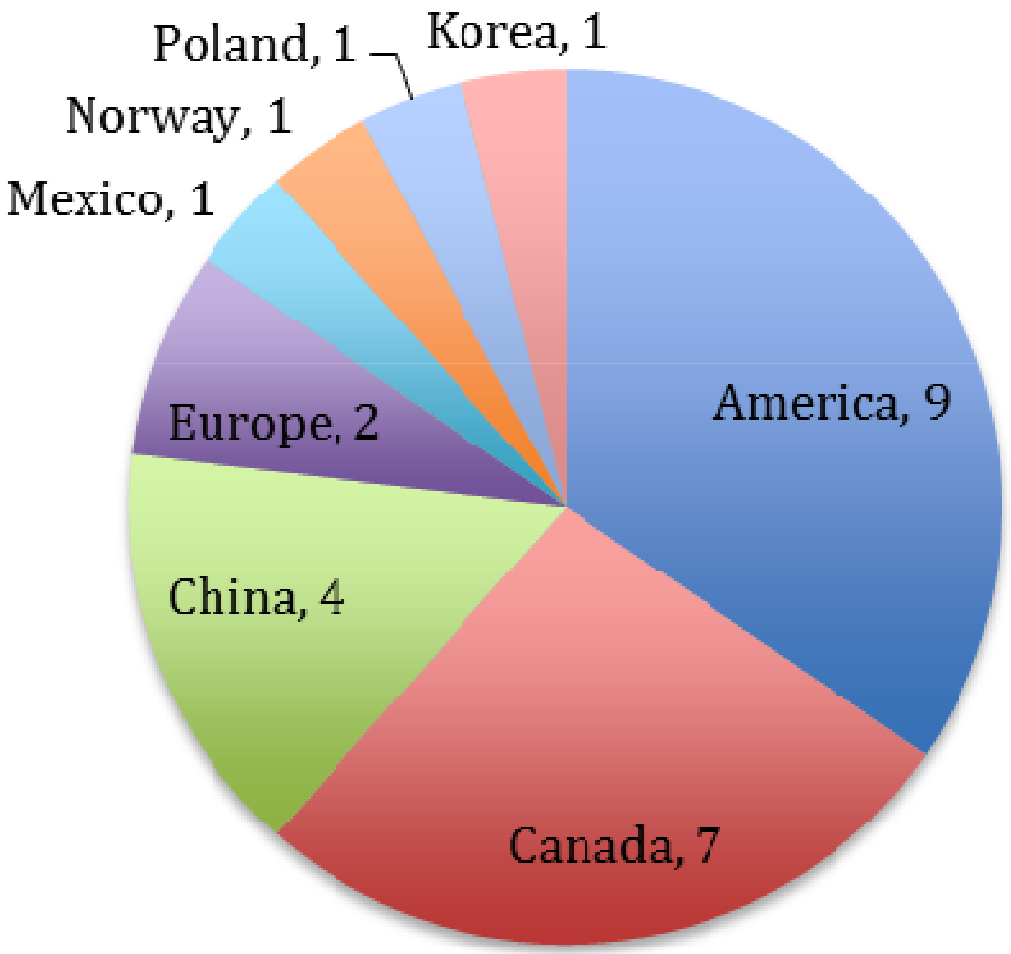
Objective

- To conduct a review of source identification of atmospheric mercury using PCA, by
  - study region
  - site: urban, rural, costal
  - study duration, short term, seasonal, multiple-year
  - TGM/GEM or with speciation
  - other parameters: air pollutants, weather conditions
  - major factors

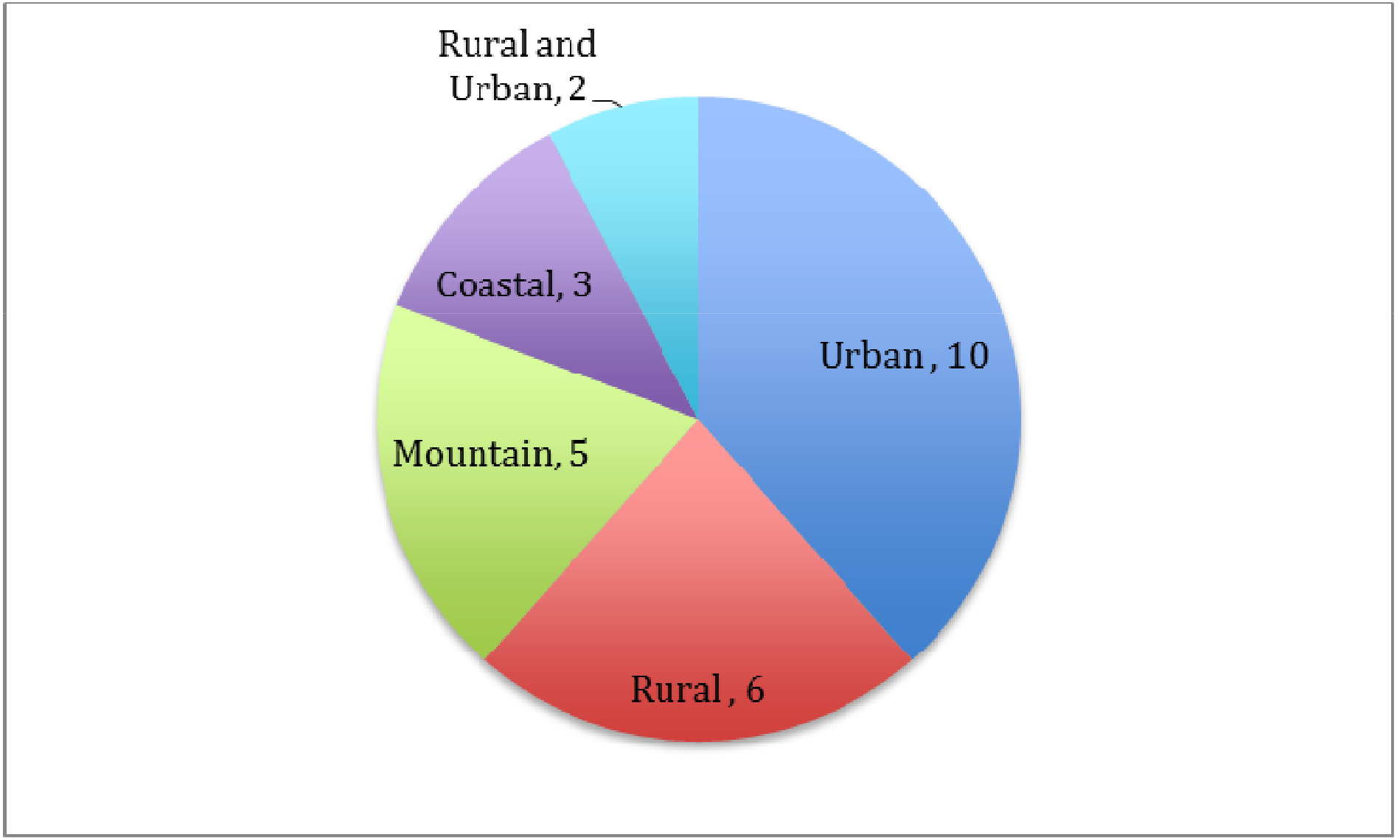
Literature Research

- Searched e-collections available at University of Windsor
- 24 journal papers and 2 thesis related to atmospheric Hg and PCA
- Details of each paper tabulated

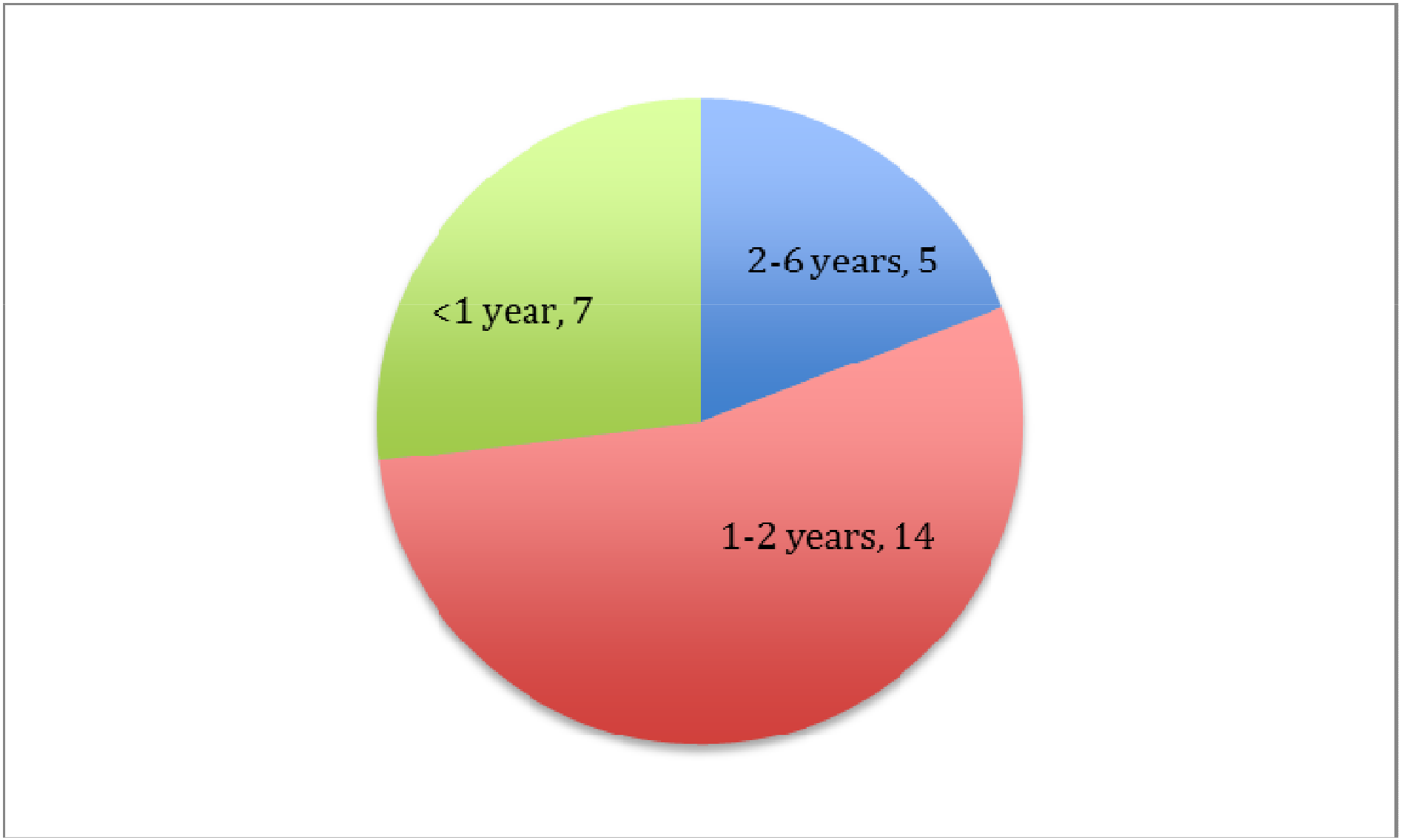
Country


Poland, 1
Korea, 1
Norway, 1
Mexico, 1
Europe, 2
America, 9
China, 4
Canada, 7

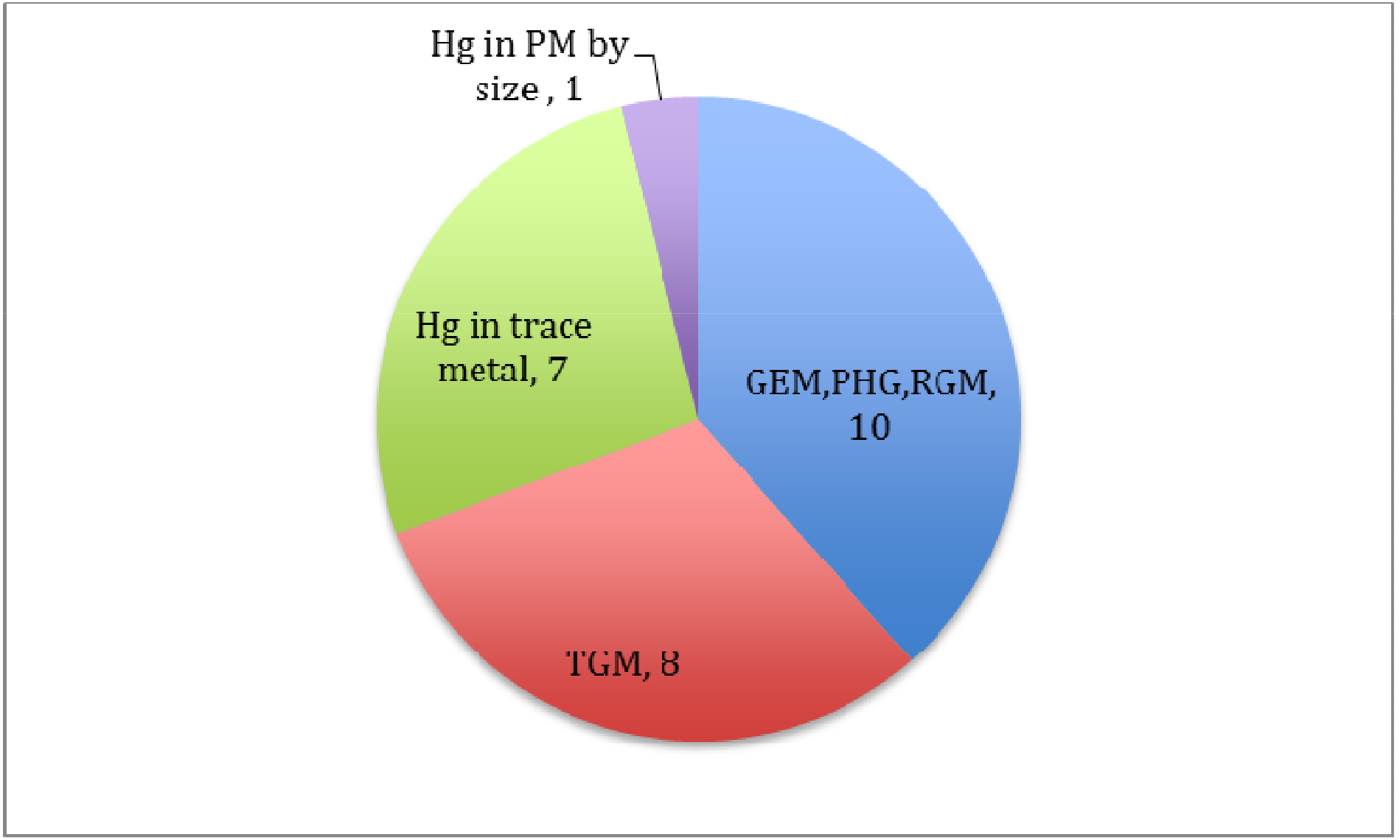
Site Classification



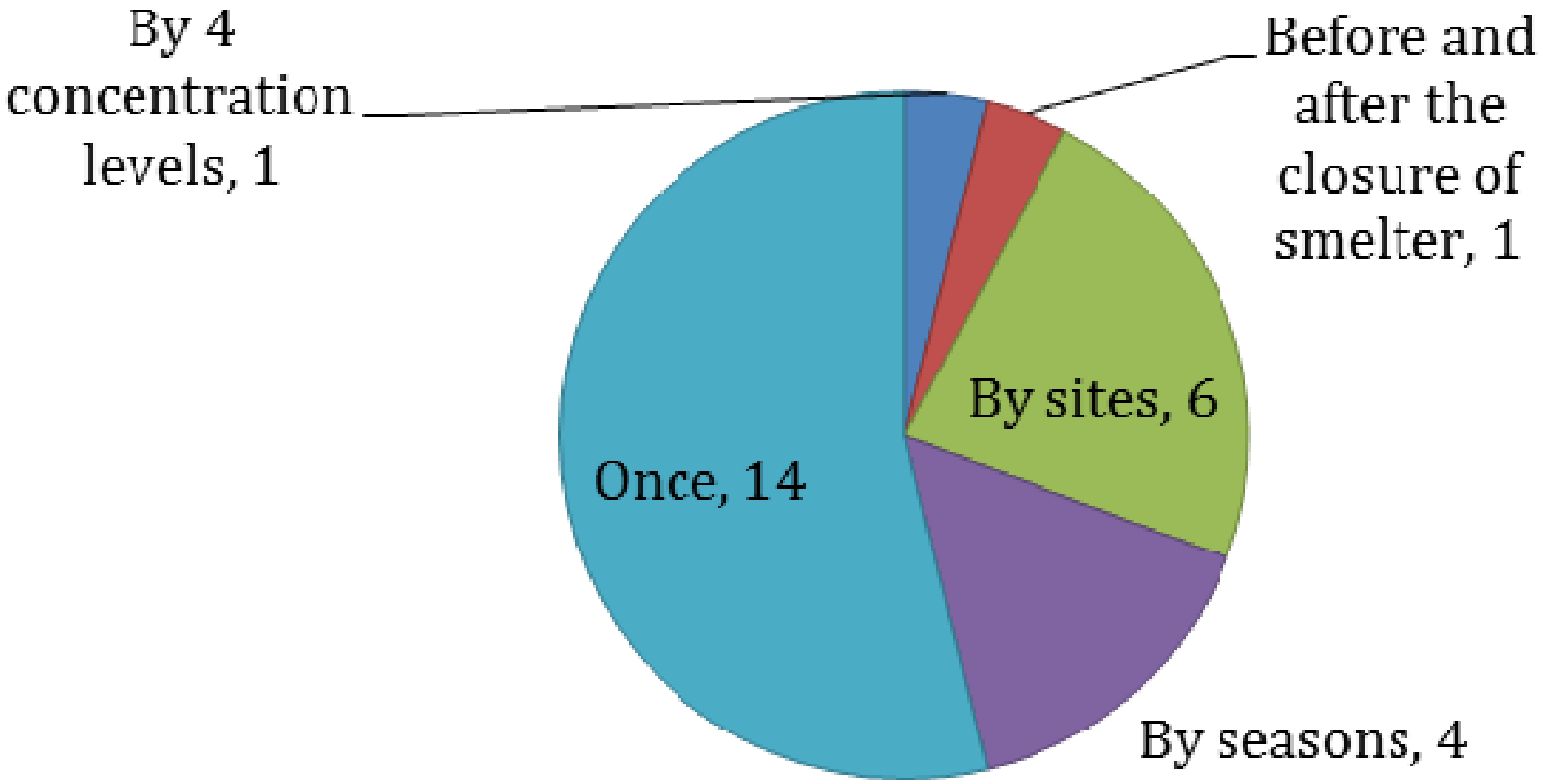
Study Duration



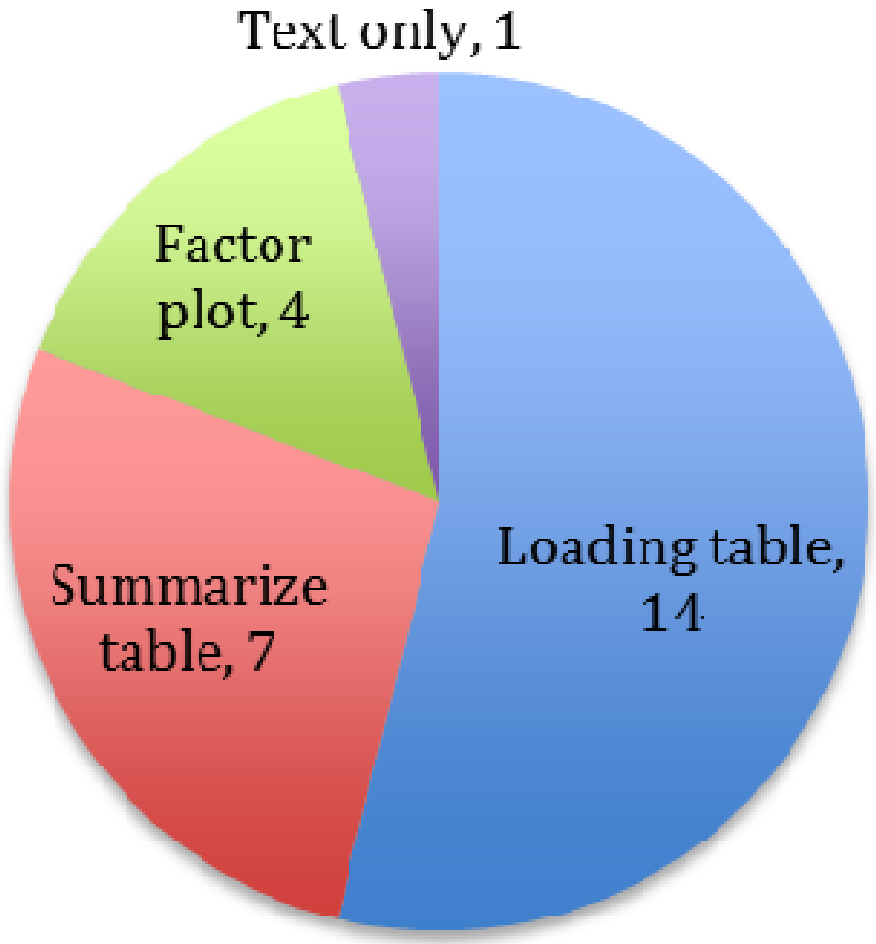
Hg Compounds



Run PCA


By 4 concentration levels, 1
Before and after the closure of smelter, 1
By sites, 6
Once, 14
By seasons, 4

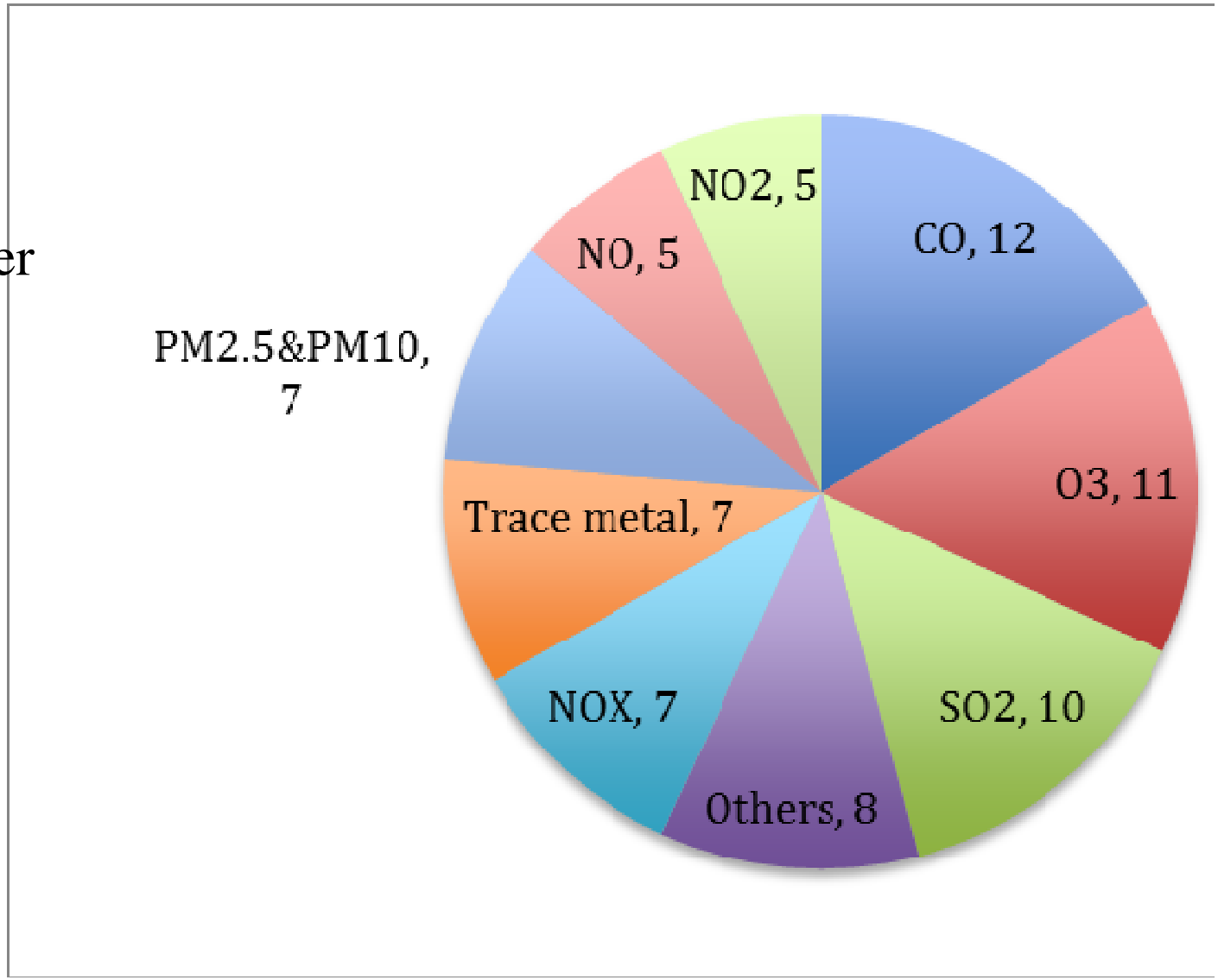
Presentation of PCA Results



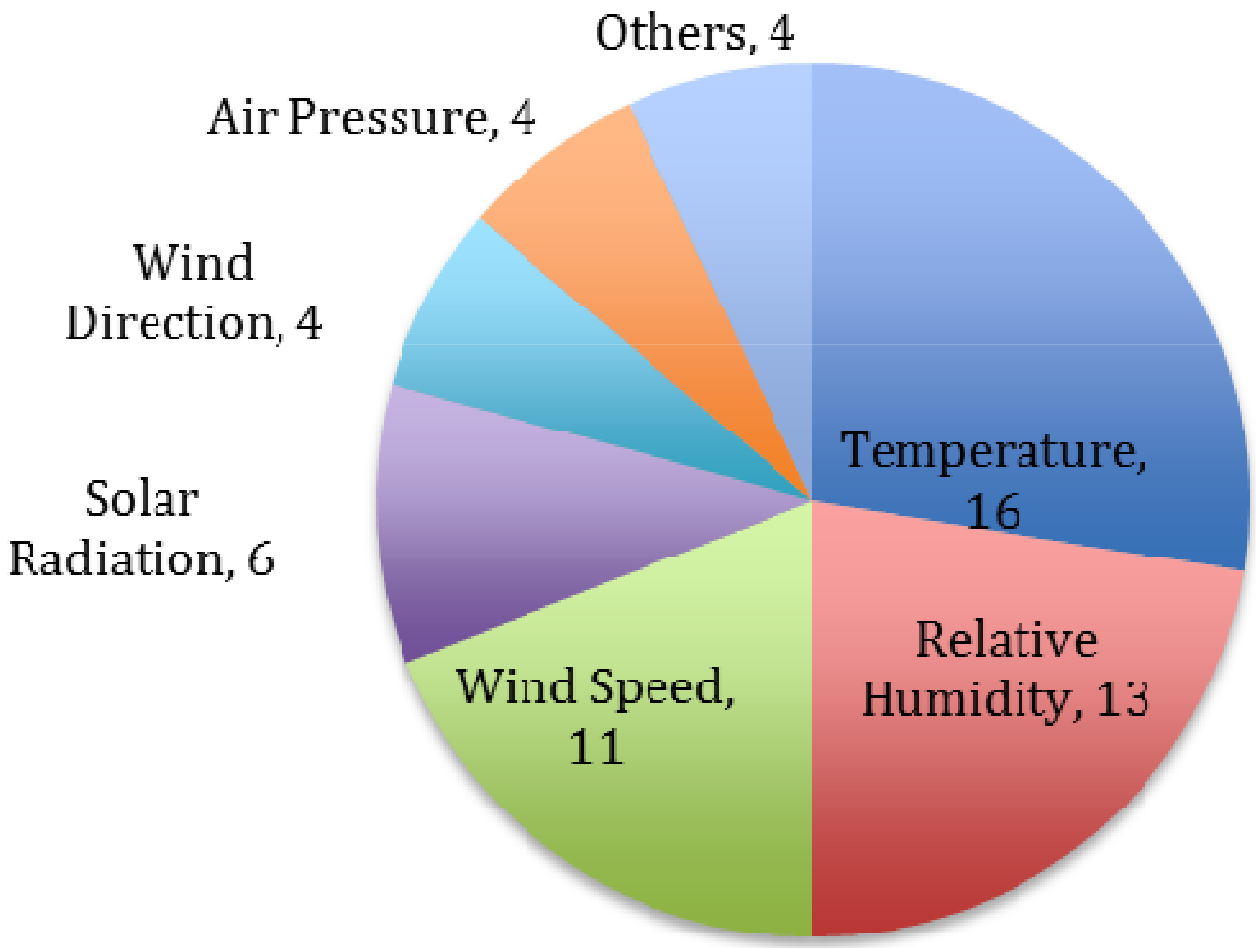
Other Air Pollutants

Others:

- VOCs
- aerosol scatter
- black carbon
- HNO3
- THC
- TRS
- NH3
- CH4



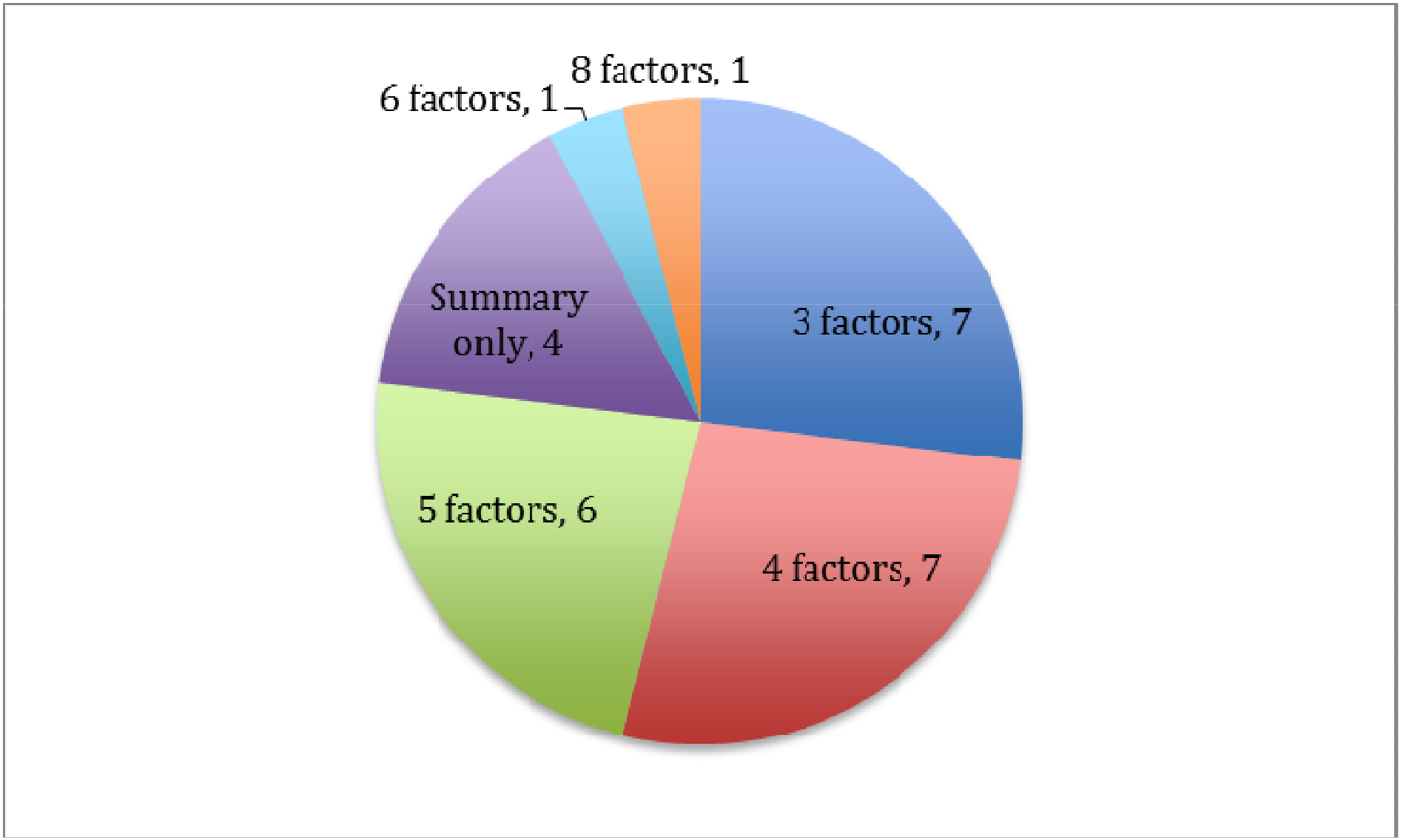
Meteorological Parameters



Others:

- UV radiation
- Cumulative precipitation
- Mixing height

Number of Factors



Samouel's Restaurant

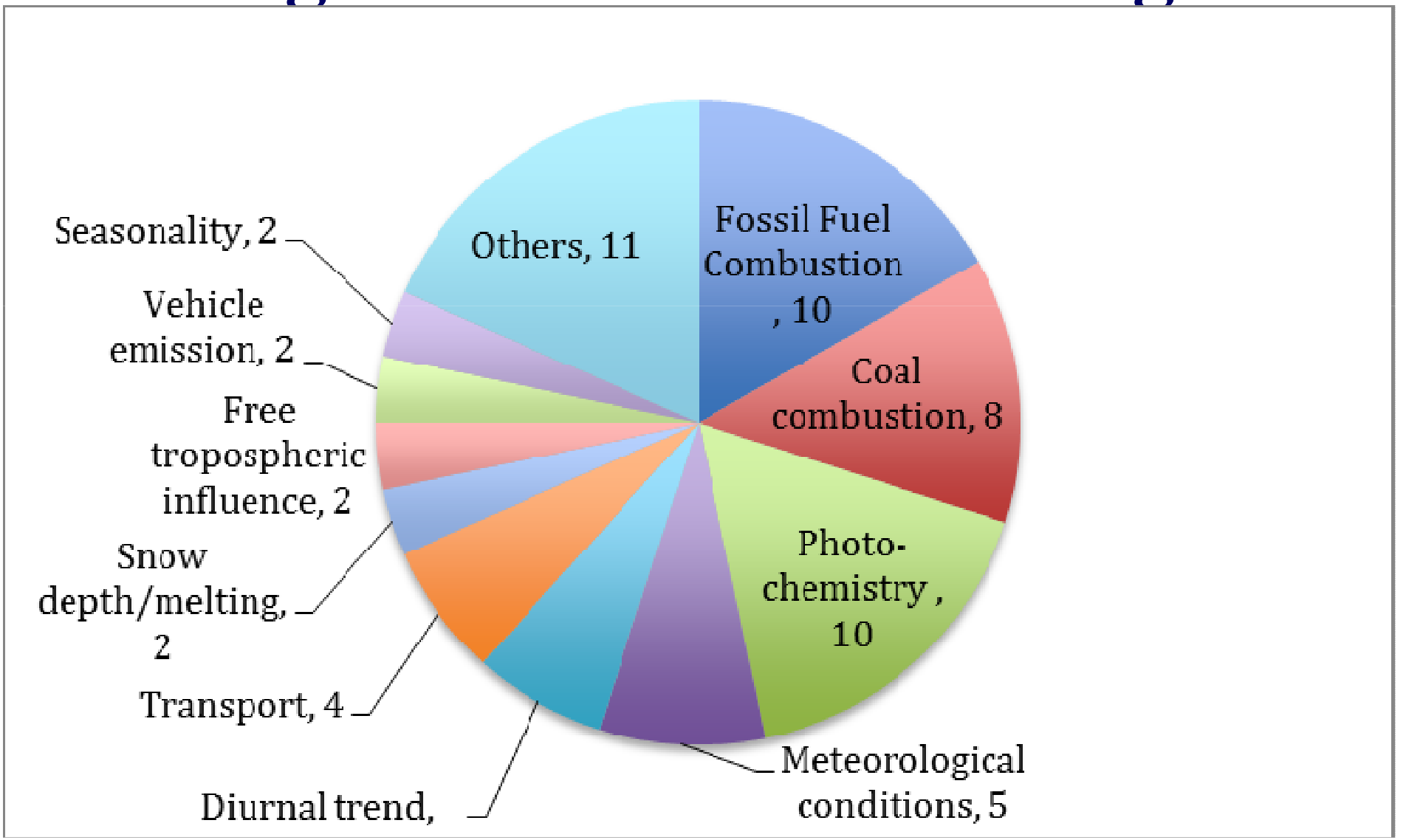
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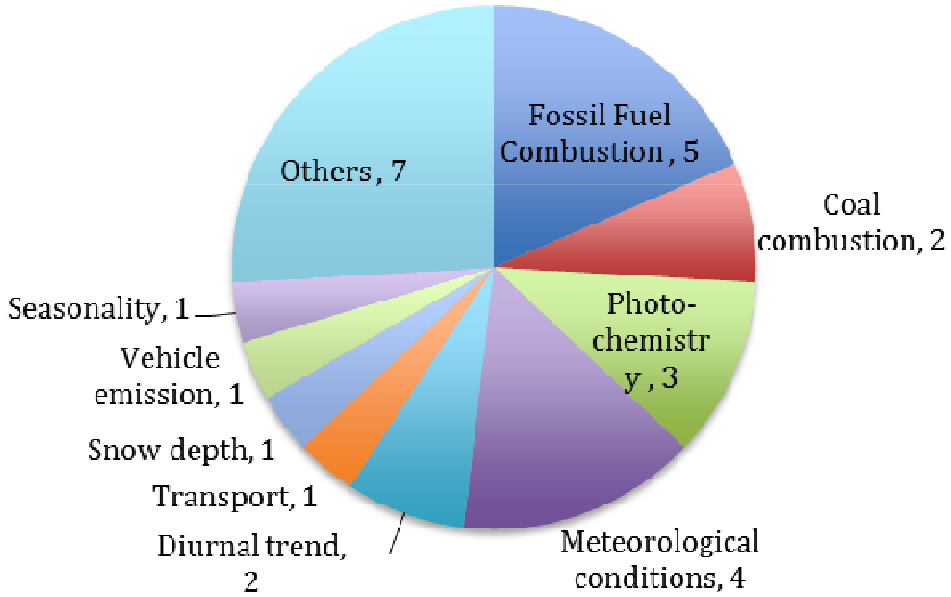
Source: https://www.google.ca/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF-8#q=what%20is%20factor%20analysis%20ppt

Significant Factors for Hg

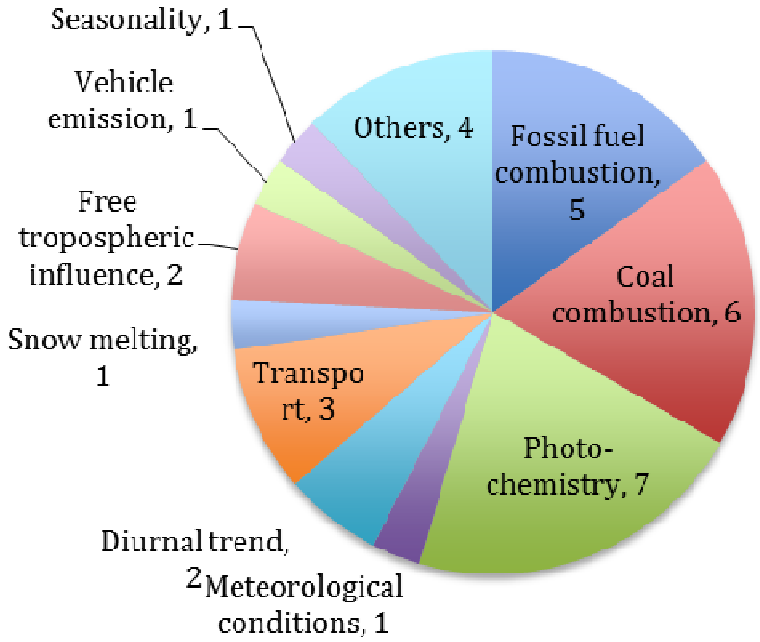


Significant Factors

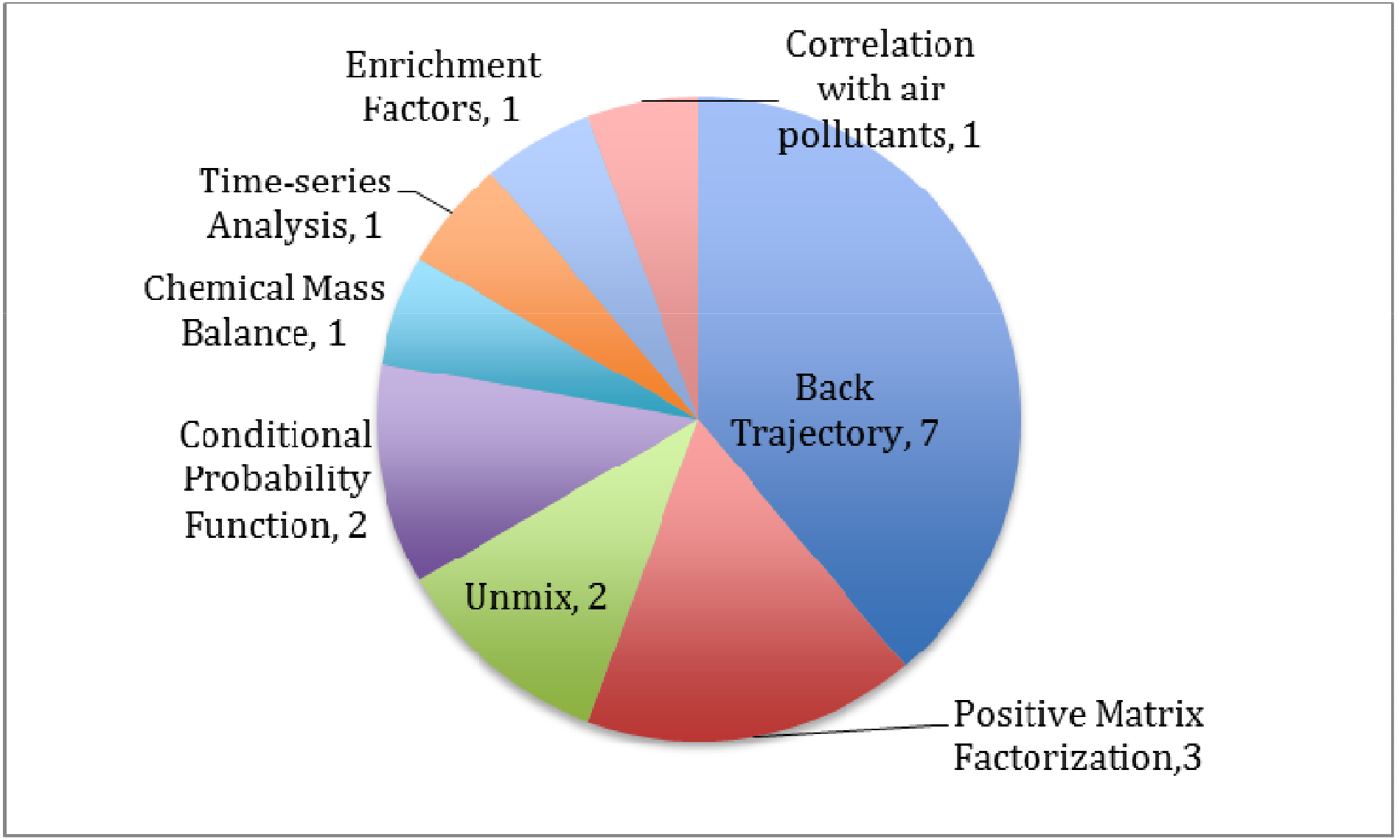
TGM



GEM, RGM, PHG



Other Analysis



Summary

- Most studies
  - ✓conducted in US or Canada
  - ✓in urban settings
  - ✓long term monitoring
  - ✓with speciated Hg
  - ✓had either meteorological parameters, or other air pollutants, or both
  - ✓ran PCA once
  - ✓provided PCA loading tables
  - ✓complemented by other analysis (e.g. HYSPLIT)

Summary

- Meteorological parameters
  - ✓Temperature
  - ✓Relative humidity
  - ✓Wind speed
  - ✓Solar radiations
- Other air pollutants
  - ✓CO
  - ✓O_3
  - ✓SO_2
  - ✓NOx
  - ✓PM

Summary

- Significant factors by PCA: 3-5
- Significant factors for Hg
  - ✓Fossil fuel combustion
  - ✓Coal combustion
  - ✓Photo-chemistry
  - ✓Mete conditions

Future Work

- Include more papers (send us the papers!)
- Further investigate the factors unique to certain sites, e.g. coastal, high elevation, near major sources
- How other approaches (e.g. HYSPLIT) aid source identification

Acknowledgements

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