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## Chapter 3 Exploratory data analysis

### *3.1 Introduction*

The data were first screened at the University of Reading. In particular, they were checked for consistency with the information in The Soil Geochemical Atlas (McGrath & Loveland, 1992). There were discrepancies at 21 sites in the original data set, and these were removed for subsequent analyses because the data at these sites were deemed unreliable. The remaining 5671 sampling points were included in the analyses. Of the original 127 variables, 80 were regarded as important. In many cases the variables removed were those for which there were few examples, e.g. top soils are not described at sites where only 'rock' was recorded. The variables selected are both quantitative and qualitative. An initial subset of quantitative variables was selected for the preliminary analyses, which comprised 31 quantitative soil variables plus altitude. Another subset comprised seven qualitative properties, such as the solid geology and land-use.

Several subsets of data were formed from the full data (data set I). A subset comprising 20 quantitative variables that excludes all extractable elements (data set II), and one comprising the quantitative variables, but excluding the corresponding total elements (data set III). Other data subsets comprise sub-samples of the full data: one sample in 4 providing a 10-km grid with 1433 sampling points (data set IV); one sample in 9 providing a 15-km grid with 637 sampling points (data set V); one sample in 16 providing a 20-km grid with 358 sampling points (data set VI). The full data set was also stratified to low and high rainfall strata, and to low and high altitude strata.

### *3.2 Summary statistics and the statistical distribution of the data*

We computed statistical summaries for the 31 quantitative variables of interest in the data, which comprises 5692 sites and up to 127 variables, and of subsets of these data. The statistics include the mean, maximum, minimum, variance, standard deviation, and skewness. The results are given in Tables 3.1 to 3.3. We also computed histograms and boxplots. Departures from normality affect some of the geostatistical and other analyses described later. Variances are unstable when data are highly skewed, and many subsequent analyses depend on the variogram (see Chapter 5).

Skewness can arise from a long tail in the distribution, or a few outliers, or both. A single outlier can have a serious effect on the variogram when the data set is fairly small (?150 sampling points). The NSI data set is large, and removing outliers for most variables had little effect on the information derived. However, much smaller subsets of the data sets are investigated later (Chapters 6 & 7). For some variables we normalized the data at the outset by removing an outlier(s), which was effective in removing skewness and avoided the need for further transformation. For other variables removing outlier(s) and subsequent transformation were both required to reduce skewness effectively. Table 3.4 shows how the data were handled in this respect. Outliers were returned to the data later for kriging. In this way we ensured that any potentially valuable information would not be lost.

**3.2.1** Summary of the treatment of outliers and transformations

Data that had skewness values greater than ?1 were evaluated in six ways to obtain a normal, or near normal distribution:

1) identification and removal of any false minima and true outliers,
2) transformation to common logarithms,
3) transformation to square roots,
4) logarithmic transformation with outliers removed,
5) square root transformation with outliers removed, and
6) 90%, 95% and 98% percentiles.

False minima may include values that have been set to zero because they were below the detection limit or those representing missing values.

**3.2.2** Results of the analysis of the statistical distribution

The following variables contained missing (m) or zero (z) values or both: Cd (z: 74) and extractable Cd (m: 25; z: 32), clay (m: 832; z: 3), ext. Co (m: 25; z: 51), and ext. Mn (m: 25; z: 1). The zero entries were treated in the same way as outliers; they were removed for computing the semivariances and returned to the data for kriging. Twenty-seven of the variables had skewness values that were more than 1 or less than –1. Their statistical distributions were examined further to assess the extent to which the non-normality arose from outliers. Figures 3.1 to 3.21, shows the histograms of the raw and transformed data (where applicable) for each of the quantitative variables after the outliers had been removed. Figures 3.1 and 3.4 give examples of boxplots for Cd and Cu, respectively. The statistical distributions of Al, K, pH and clay were close to normal, and data for these were analysed in their original form. A $\log_{10}$

transformation successfully reduced the skewness of 18 of the variables, such as Ca, ext. P and Zn (Tables 3.1 to 3.3). After transforming Cd, Cr, Fe, Mn, Na, Ni, Pb and altitude to $\log_{10}$, and Co to square roots, the skewness values still exceeded the threshold of ?1. For Cd, Na, Ni, Pb and altitude the skewness was reduced by removing some outliers and then transforming to common logarithms, and for Co by transforming to the square root. Extreme upper and lower values were treated as outliers and removed for Cd, Co and Ni, whereas for altitude the lower extreme values only were removed, and for Na and Pb the higher extreme values only. The number of sites and the limits of the data after outliers have been removed are given in Tables 3.1 to 3.3. For Cr and Fe taking the 90 percentile and then transforming to logarithms reduced skewness, and for Mn the 95 percentile was taken prior to transforming similarly. In all cases the number of sites analysed is given.

*3.3 Correlation analysis*

Correlation was included in the exploratory data analysis to identify which variables are strongly related, and therefore where there might be redundancy in the information. Missing values in the data and the gaps left by outliers that were removed were replaced by the Multmiss macro in Genstat, an iterarive regression technique. The Pearson product–moment correlation coefficient was computed between all pairs of:

1) the 31 quantitative variables for all sample locations (data set I),
2) 20 quantitative variables that exclude all extractable elements (data set II),
3) 20 quantitative variables that include all extractable elements, but exclude the corresponding total elements (data set III),
4) for all of the quantitative variables for a sub-sample of one in four sites from the original grid to give locations on a 10 km ? 10 km grid (data set IV).

Table 3.5 gives the correlation coefficients for data set I: correlations between 0.6 and 0.75 are shown in italic and those exceeding 0.75 are in bold. Correlations of ?0.75 are between Al and Cr, Al and Fe, Al and Mg, Al and Ni, Ca and Sr, Ca and pH, Cd and Zn, Co and Cr, Co and Fe, Co and Mn, Co and Ni, ext. Co and ext. Mn, Cr and Fe, Cr and Mg, Cr and Ni, Cu and ext. Cu, Fe and Ni, Mg and Ni, Mn and ext Mn, and Pb and ext. Pb. In general, there are few large correlations among the extractable and total concentrations for the same element. There are moderate correlations of

0.6?0.75 between Al and Ba, Al and Co, Al and K, Al and Mn, Ba and Cr, Ba and Fe, Ba and Mg, Ba and Ni, Ba and Zn, Cd and Ni, ext. Cd and ext. Zn, Co and ext. Co, Co and Mg, Co and ext. Mn, Co and Zn, ext. Co and ext. Ni, Cr and K, Cr and Mn, Cu and Zn, Fe and K, Fe and Mn, K and Mg, K and Ni, Mg and Mn, Mn and Ni, Ni and Zn, and ext. Pb and ext. Zn.

The correlation coefficients for data sets II and III are also incorporated in Table 3.5, and those for data set IV are given in Table 3.6. The pairs of elements with a correlation of ?0.75 for these data are more or less the same as those for data set I. The pairs of elements with correlations between 0.6 and 0.75 for data set IV are also similar to those of data set I, with the exception of ext. Cd and ext. Zn. In addition, there are moderate correlations between Al and Mg, Al and Ni, Cu and Ni, Fe and Mg, Fe and ext. Mn, and Fe and Zn.

In general, large correlations are few. These results confirm those given in McGrath & Loveland (1992).

*3.4 Principal component analysis (PCA)*

Principal component analysis was carried out on the correlation matrix. The analysis was applied to each of the four data subsets described above. For data sets I (all data) and IV (one in four subset) all of the quantitative variables, except for altitude, were analysed by PCA to provide an overall view of the relations among variables, and to assess how representative the subset of the sites is of the full data. The reason for analysing data sets II and III was to assess the effects on the analysis of the relations between the total and extractable values for the same elements, Table 3.5.

The results for PCA are in three parts. Each latent root (or *eigenvalue*) gives the amount of variance expressed by the principal axis. The larger the latent root the more variance a given component accounts for; the latent roots are ordered in descending value. The elements of the latent vectors (or *eigenvectors*) describe the contribution to the variation of each variable on each of the principal axes. Finally, the principal component scores are the co-ordinates of the sampling points with respect to the principal axes.

We examined the latent roots for all sets of data first. Only those that were ?1.0 and expressed at least 5% of the variation were extracted (Table 3.7). More than 72% of the variation was accounted for by the first five latent roots for data sets I, III and IV.

For data set II, four roots account for more than 85% of the variation. Table 3.7 gives the latent roots and the percentage variance accounted for by each principal axis.

The latent vectors of the principal components (PCs) whose latent roots account for more than 5% of the variance were examined to identify those variables that account for most of the variation (Tables 3.8 to 3.10). The larger the absolute values of the elements of the latent vectors, the greater the proportion of the variation a particular variable accounts for on a given axis. For data set I the metallic elements, Al, Co, Cr, Fe and Ni, with eigenvector values greater than 0.25, suggest that the first principal axis represents variation in some heavy metals. Component 2, with eigenvectors ?0.3 for ext. Cd, organic C, Pb, ext. Pb, and ext. Zn, seems to represent the geochemical mineralization of some heavy metals (e.g. in what are now or were mining areas). The variables with eigenvector values ?0.3 for PC 3, Ca, ext. P, pH and Sr, suggest that it represents variation in acidity. Extractable Co, ext. Mn, Na and organic C have the largest values (?0.3) on PC4, which suggest that this might represent gleying. Component 5 has large eigenvectors (?0.3) for clay, ext. K, Mg and ext. Mn (Table 3.8), which possibly reflects the effects of management.

For data set II, the variables that have the largest eigenvector values for the first four components are similar to those for data set I (Table 3.9), but without any extractable concentrations. These results suggest that the correlations among the total and extractable concentrations of the elements do not affect the analysis adversely.

For data set III, the variables with eigenvectors ?0.25 for PC 1 are Al, Ba, ext. Co, Cr, Fe, ext. Mn and ext. Ni. For PC 2 ext. Cd, ext. Pb and ext. Zn have eigenvector values ?0.3, suggesting that it is an axis of mineralization. Component 3 has large values for Ca, ext. P, pH and Sr, which is similar to PC 3 for the data sets above. The large eigenvector values (?0.3) for PC 4 are clay, organic C, ext. Co, ext. Mn and Na, suggesting that it might represent gleying, as for data set II. The variation on component 5 is accounted for by Ba, clay, ext. K, and ext. Mg, which is similar to PC 5 for data set I (Table 3.10).

The results for data set IV are almost identical to those for data set I (Table 3.8). This suggests that the data on the 10-km grid are representative of the full data with respect to the relations between variables.

The variables considered to account for most of the variation in these data are: clay, Al, organic C, Ca, ext. Cd, Co, Cr, Fe, K, ext.Mg, ext. Mn, Ni, ext. P, Pb, ext. Pb, pH, Sr, Zn and ext Zn. The variables considered significant by legislators for both agricultural and environmental protection are: altitude, pH, clay, organic C, total and extractable P, Mg, Ni, Co, K, Pb, Zn, Cu and Cd, and total Cr. Many of these variables (except altitude) also account for a large proportion of the variation on the first three principal axes from the principal component analyses. On the basis of considered opinion and these PCA results, the elements Cd, Cr, Cu, K, Mg, Ni, P, Pb and Zn were selected for the detailed analyses that are described in subsequent chapters.

The principal component scores were plotted in the projection of components 1 and 2 (Figure 3.22) to show how the sampling points relate to each other. This graph shows no evidence of clustering in this space and this has implications for deciding which methods of multivariate classification are likely to be profitable. We discuss this again at a later stage.

*3.5 Stratification*

The sites were stratified according to rainfall and altitude. Threshold values of 800 mm for rainfall and 300 m for altitude were chosen as the basis for subdivision. The threshold value for rainfall is close to the mean annual rainfall for England and Wales of about 770 mm. The rainfall data at 123 sites in England and Wales are mean values over 30 years between 1963 and 1993. They were plotted, and a line was drawn on the maps to subdivide England and Wales into two rainfall strata >800 mm and ?800 mm. The subsets for rainfall comprised 3398 sites for areas with ?800 mm of rainfall and 2273 those with >800 mm of rainfall. The threshold value for altitude is based on the conventional separation between lowland and upland in Britain. The resulting subsets comprised 5092 sites ? 300 m and only 579 sites > 300 m. The latter included 14 isolated sites (twelve in England and two in Wales), which were removed, resulting in a data subset with 565 sites.

**3.5.1** Summary statistics of the strata

The summary statistics are given in Tables 3.11 to 3.16 for the rainfall strata and Tables 3.17 to 3.22 for the elevation ones. The same criteria were used to reduce skewness as before (see section 3.2). Outliers were excluded for some variables from both strata (Tables 3.11 and 3.22) prior to transformation to $\log_{10}$. The tables show where sites were removed.

**3.5.2** Results for the rainfall strata

The mean for Na in the high rainfall stratum (412 mg $l^{-1}$) is much larger than that in the low rainfall stratum (278 mg $l^{-1}$), Table 3.15. This shows the effect of the prevailing south-westerly winds which deposit Na on the soil with the rainfall. The means for Ca, ext. K and Sr are smaller in the high rainfall stratum, suggesting that these elements are leached from the soil. Mean pH for the high rainfall stratum is 1.4 units less than that in the low rainfall stratum, which supports our interpretation of leaching. On the other hand, the mean organic C content is larger in the high rainfall stratum, which is associated with the accumulation of organic matter in the wetter areas. The larger mean concentrations of Pb and ext. Pb in the high rainfall stratum are related to mineral deposits in these areas, and accumulation in peat associated with atmospheric deposition from mining and smelting activities. Mean altitude for the two strata is different: 208 m for the high rainfall stratum and 78 m for the low one. This supports the effects of the prevailing winds and the orographic nature of much of the rainfall.

The skewness values are generally smaller for the low rainfall stratum data. However, there is a significant exception to this – Na – which has a much larger skewness value in the low rainfall stratum. This might be associated with the Na concentrations in the low-lying areas around the Wash.

**3.5.3** Results for the elevation strata

The mean for organic C, Pb and ext. Pb are larger for the high elevation stratum. The large value of organic C in this stratum can be explained as before. For Pb and ext. Pb the large values reflect the dispersion of Pb through smelting and mining associated with the mineralization in the rocks of the uplands, for example the Carboniferous strata of the Pennines. The means of Ba, Ca, K, ext. K, Mg, ext. Mn, Zn and pH (1.9 units more) are larger for the lowland stratum. This probably reflects greater inputs to the soil associated with the predominance of arable farming in this stratum and also the characteristics of the rocks and overlying drift, some of which are naturally calcareous. In general, the skewness values of the properties is greater in the lowland stratum than the upland one, which is surprising because the lowland has many more sites than the upland. In particular Na, Pb, ext. Pb and Zn have large skewness values.

**3.5.4** Principal component analysis of the rainfall strata

The results of the PCA for the rainfall strata are given in Tables 3.23 and 3.24. The first five latent roots explained over 73% of the variation in the low rainfall stratum. Overall, for PCs 1 to 3 the results are similar to those for data set I. The eigenvector values for PC1 are large (?0.25) for Al, Cr, Ni and Zn. For PC2, the main variables are Ca, ext. Pb, pH, Sr and ext. Zn, and for PC3 they are Ca, P and ext. Zn The large eigenvector elements (?0.3) for PCs 4 and 5 are Mn, ext. Mn, ext. P and organic C, and ext. K and ext. P, respectively.

For the high rainfall stratum the first five latent roots explained 70% of the variance in the data. For PC1, the variables that account for most of the variation are Co, Cr, Mn, and Ni. Extractable Cd, Pb, ext. Pb, and ext. Zn have large values (?0.3) for PC2, and Ca, ext. Mg, ext. P and pH for PC3. For PC4, Na, P, organic C and clay load heavily, and for PC5 it is Cu, ext. Cu, ext. Mg and ext. P. Although similar variables account for the variation expressed by PC 1 for both strata, these results suggest that there are also some differences in the important variables controlling the variation between the low and high rainfall areas.

**3.5.5** Principal component analysis of the elevation strata

The PCA results for the elevation strata are given in Tables 3.23 and 3.25. The first five latent roots from a PCA of the low-altitude stratum explained over 71% of the variation present. Components 1 to 3 are explained by more or less the same variables as for data set I and for the low rainfall stratum. Aluminium, Cr, Fe, NI and Zn account for most of the variation on PC1. The large eigenvector elements (?0.3) for PC2 are Pb, ext. Pb and ext. Zn, and for PC3 they are Ca, ext. P, Sr and pH. Exatractable Co, ext. Mn and organic C account for most of the variation on PC4, and ext. K, ext. Mg, Mn, ext. Ni and clay for PC5.

For the high-altitude stratum, the first five latent roots explained 71% of the variance in the data. For PC1, Al, Co, Cr, Fe, Mg, Mn, ext. Mn and Ni account for most of the variation. Extractable Cd, ext. Ni, Pb, and ext. Zn have large eigenvector values (?0.3) for PC2, and Ca, ext. Cu, ext. Mg and Sr for PC3. For PCs 4 and 5 the variables that account for most of the variation are ext. K, P and ext. P, and Na and clay, respectively. These results suggest, as for the rainfall strata, that there are some differences in the variables that account for most of the variation in the two strata. Nevertheless, the variables that load heavily on PCs 1 and 2 are similar to those for data set I.

### *3.6 Qualitative data*

The qualitative properties selected for analyses are given in Table 3.26. These properties were coded to indicate a particular state, such as the solid geology shown in Figure 3.23. The above analysis for the quantitative data cannot be applied to the qualitative data.

Table 3.1: Summary statistics for total and extractable (ext.) Chromium (Cr), Copper (Cu), Nickel (Ni), Lead (Pb) and Zinc (Zn) for England and Wales (mg kg$^{-1}$).

| Variable | *n* | Mean | Minimum | Maximum | Variance | Standard deviation | Skewness | Lower data limit* | Upper data limit* |
|---|---|---|---|---|---|---|---|---|---|
| Cd | 5671 | 0.8381 | 0.0 | 40.9 | 0.9503 | 0.9748 | 17.52 | | |
| Log$_{10}$Cd ( no outliers) | 5596 | -0.1867 | -1.0 | 1.283 | 0.1066 | 0.3265 | -0.6664 | 0.1 | 20.0 |
| ext. Cd | 5646 | 0.3280 | 0.0 | 17.8 | 0.2814 | 0.5305 | 16.67 | | |
| Log$_{10}$ext. Cd (no zeros) | 5614 | -0.5945 | -1.000 | 1.250 | 0.07093 | 0.2663 | 0.9953 | 0.1 | |
| Cr | 5671 | 41.20 | 0.2 | 837.8 | 798.4 | 28.26 | 9.458 | | |
| Log$_{10}$Cr ( 90% of data) | 5103 | 1.558 | 0.9395 | 1.863 | 0.03921 | 0.1980 | -0.8746 | 8.7 | 72.9 |
| Cu | 5671 | 23.01 | 1.2 | 1507.7 | 1365.7 | 36.96 | 21.28 | | |
| Log$_{10}$Cu | 5671 | 1.254 | 0.07918 | 3.178 | 0.07485 | 0.2736 | 0.4026 | | |
| ext. Cu | 5646 | 6.410 | 0.3 | 431.4 | 122.6 | 11.07 | 18.02 | | |
| Log$_{10}$ext. Cu | 5646 | 0.6560 | -0.5230 | 2.635 | 0.1126 | 0.3355 | 0.2187 | | |
| Ni | 5671 | 24.48 | 0.8 | 439.5 | 302.6 | 17.40 | 6.963 | 1.1 | 140.0 |
| Log$_{10}$Ni (no outliers) | 5634 | 1.298 | 0.04139 | 2.141 | 0.09211 | 0.3035 | -0.9482 | | |
| ext. Ni | 5646 | 1.648 | 0.1 | 73.20 | 4.017 | 2.004 | 13.87 | | |
| Log$_{10}$ext. Ni | 5646 | 0.07153 | -1.000 | 1.865 | 0.1198 | 0.3462 | 0.1502 | | |
| Pb | 5671 | 73.69 | 3.0 | 1.634 x $10^4$ | 7.125 x $10^4$ | 266.9 | 42.87 | | |
| Log$_{10}$Pb (no | 5661 | 1.654 | 0.4771 | 3.2167 | 0.1101 | 0.3319 | 0.8718 | | 1650.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| outliers) | | | | | | | |
| ext. Pb | 5646 | 27.85 | 1.2 | 6056.5 | 1.435 x $10^4$ | 119.8 | 32.74 |
| $Log_{10}$ext Pb | 5646 | 1.185 | 0.07918 | 3.782 | 0.1430 | 0.3781 | 0.9483 |
| Zn | 5671 | 96.82 | 5.0 | 3648.0 | 1.186 x $10^4$ | 108.9 | 13.71 |
| $Log_{10}$Zn | 5671 | 1.898 | 0.699 | 3.562 | 0.6675 | 0.2584 | 0.08434 |
| ext. Zn | 5646 | 9.680 | 0.5 | 712.0 | 604.7 | 24.59 | 16.67 |
| $Log_{10}$ext. Zn | 5646 | 0.7734 | -0.3010 | 2.852 | 0.1271 | 0.3565 | 0.9474 |

* Limits of the data before transformation
Note: Total concentration was obtained using digestion with *aqua regia* and extractable with EDTA.

Table 3.2: Summary statistics for Aluminium (Al), Barium (Ba), Calcium (Ca), Cobalt (Co), Iron (Fe), Manganese (Mn), Sodium (Na), Strontium (Sr) for England and Wales (mg $kg^{-1}$). Extractable concentration (ext.) measured for selected properties only.

| Variable | *n* | Mean | Minimum | Maximum | Variance | Standard deviation | Skewness | Lower data limit* | Upper data limit* |
|---|---|---|---|---|---|---|---|---|---|
| Al | 5671 | $2.792 \times 10^4$ | 491.0 | $7.936 \times 10^4$ | $1.654 \times 10^8$ | $1.286 \times 10^4$ | 0.1110 | | |
| Ba | 5671 | 140.7 | 11.0 | 2973.0 | $1.74 \times 10^4$ | 132.2 | 8.965 | | |
| $Log_{10}$Ba | 5671 | 2.059 | 1.041 | 3.473 | 0.07356 | 0.2712 | -0.07110 | | |
| Ca | 5671 | $1.385 \times 10^4$ | 50.0 | $3.396 \times 10^5$ | $1.376 \times 10^9$ | $3.710 \times 10^4$ | 4.946 | | |
| $Log_{10}$Ca | 5671 | 3.577 | 1.699 | 5.531 | 0.3980 | 0.6300 | 0.4633 | | |
| Co | 5671 | 10.59 | 0.2 | 321.8 | 82.39 | 9.077 | 14.47 | | |
| SqrtCo ( no outliers) | 5651 | 3.064 | 0.5477 | 8.161 | 1.078 | 1.038 | 0.0234 | 0.3 | 70.0 |
| ext. Co | 5646 | 1.063 | 0.0 | 26.5 | 1.450 | 1.204 | 4.570 | | |
| $Log_{10}$ext. Co (no zeros) | 5595 | -0.1774 | -1.000 | 1.423 | 0.1957 | 0.4424 | -0.1428 | 0.1 | |
| Fe | 5671 | $2.785 \times 10^4$ | 395.0 | $2.644 \times 10^5$ | $2.510 \times 10^8$ | $1.584 \times 10^4$ | 3.277 | | |
| $Log_{10}$Fe (90% of data) | 5103 | 4.394 | 3.796 | 4.697 | 0.03735 | 0.1933 | -0.8634 | 6250.0 | $4.975 \times 10^4$ |
| Mn | 5671 | 760.4 | 3.0 | $4.260 \times 10^4$ | $9.609 \times 10^5$ | 980.3 | 17.91 | | |
| $Log_{10}$Mn (95% of data) | 5387 | 2.702 | 1.398 | 3.382 | 0.1560 | 0.3950 | -0.9763 | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ext. Mn | 5646 | 159.36 | 0.0 | 3108.0 | 3.556 x $10^4$ | 188.6 | 4.572 | | |
| $Log_{10}$ext. Mn (no zeros) | 5645 | 1.956 | 0.0 | 3.492 | 0.2818 | 0.5309 | -0.9167 | 0.1 | |
| Na | 5671 | 331.68 | 31.0 | 2.515 x $10^4$ | 2.973 x $10^5$ | 545.3 | 25.16 | | |
| $Log_{10}$Na (no outliers) | 5667 | 2.413 | 1.491 | 3.962 | 0.06300 | 0.2510 | 0.8721 | | 1.000 x $10^4$ |
| Sr | 5671 | 45.23 | 3.0 | 1445.0 | 4564.6 | 67.56 | 6.832 | | |
| $Log_{10}$Sr | 5671 | 1.471 | 0.4770 | 3.160 | 0.1257 | 0.3546 | 0.7814 | | |

* Limits of the data before transformation

Note: Total concentration was obtained using digestion with *aqua regia* and extractable with EDTA.

Table 3.3: Summary statistics for the total and extractable (ext.) Potassium (K), Magnesium (Mg) and Phosphorus (P) concentration (mg $l^{-1}$), pH, organic C (%), clay (%), and altitude (m) for England and Wales.

| Variable | *n* | Mean | Minimum | Maximum | Variance | Standard deviation | Skewness | Lower data limit* |
|---|---|---|---|---|---|---|---|---|
| K | 5671 | 4923 | 60.0 | $2.044 \times 10^4$ | $7.138 \times 10^6$ | 2671.7 | 0.6747 | |
| ext. K | 5578 | 170.3 | 7.0 | 2776.0 | $1.981 \times 10^4$ | 140.7 | 3.844 | |
| $Log_{10}$ext. K | 5578 | 2.129 | 0.8451 | 3.443 | 0.085 | 0.2921 | 0.1518 | |
| Mg | 5671 | 3737.7 | 41.0 | $6.269 \times 10^4$ | $1.102 \times 10^7$ | 3320.3 | 4.870 | |
| $Log_{10}$Mg | 5671 | 3.437 | 1.613 | 4.797 | 0.1344 | 0.3666 | -0.6459 | |
| ext. Mg | 5578 | 141.1 | 1.0 | 1601.0 | $1.894 \times 10^4$ | 137.6 | 2.978 | |
| $Log_{10}$ext. Mg | 5578 | 2.006 | 0.0 | 3.204 | 0.1197 | 0.3460 | 0.1816 | |
| P | 5671 | 847.8 | 41.0 | 6273.0 | $1.978 \times 10^5$ | 444.8 | 2.225 | |
| $Log_{10}$P | 5671 | 2.876 | 1.613 | 3.797 | 0.04819 | 0.2195 | -0.5131 | |
| ext. P | 5574 | 26.05 | 1.0 | 337.0 | 562.5 | 23.72 | 3.146 | |
| $Log_{10}$ext. P | 5574 | 1.278 | 0.0 | 2.528 | 0.1240 | 0.3521 | -0.1968 | |
| pH | 5578 | 5.964 | 3.1 | 9.2 | 1.724 | 1.313 | -0.1631 | |
| Organic C | 5662 | 6.663 | 0.1 | 65.9 | 97.82 | 9.89 | 3.355 | |
| $Log_{10}$organic C | 5662 | 0.6006 | -1.0 | 1.819 | 0.1517 | 0.3895 | 0.8155 | |
| Clay | 4839 | 25.47 | 0.0 | 87.90 | 151.4 | 12.30 | 0.7745 | 0.2 |
| Clay (no | 4836 | 25.26 | 0.2 | 87.9 | 151.1 | 12.29 | 0.7788 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| zeros) | | | | | | | | |
| Altitude | 5671 | 129.9 | -1.0 | 1400.0 | $1.793 \times 10^4$ | 133.9 | 2.556 | |
| $Log_{10}$altitude (no outliers) | 5493 | 1.912 | 0.4771 | 3.146 | 0.2405 | 0.4904 | -0.7820 | 3.0 |

* Limits of the data before transformation

Note: Total concentration was obtained using digestion with *aqua regia*, extractable K and Mg with ammonium nitrate and extractable P with sodium bicarbonate (Olsen's P).

Table 3.4: Outlier treatment and transformation. Acceptable levels of skewness are marked by *.

| | Skewness | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Stages in the transformation to a normal distribution | | | | | |
| Variable | Original data (OD) | $Log_{10}$ OD | Square root (Sqrt) OD | Outliers removed $Log_{10}$ | Outliers removed sqrt | 95%-tile $log_{10}$ | 90%-tile $log_{10}$ |
| Cd | 17.5 | -6.19 | 2.68 | *-0.666 | 1.95 | | |
| ext. Cd | 16.7 | *0.995 | | | | | |
| Cr | 9.46 | -1.61 | | -1.54 | | -1.10 | *-0.874 |
| Cu | 21.3 | *0.402 | | | | | |
| ext. Cu | 18.0 | *0.219 | | | | | |
| Ni | 6.96 | -1.09 | | *-0.948 | | | |
| ext. Ni | 13.9 | *0.150 | | | | | |
| Pb | 42.9 | 1.09 | | *0.872 | | | |
| ext. Pb | 32.7 | *0.948 | | | | | |
| Zn | 13.7 | *0.0843 | | | | | |
| ext. Zn | 16.7 | *0.947 | | | | | |
| Al | *0.111 | | | | | | |
| Ba | 8.97 | *0.0711 | | | | | |
| Ca | 4.95 | *0.463 | | | | | |
| Co | 14.5 | -1.30 | 1.02 | -1.25 | *0.0234 | | |
| ext. Co | 4.57 | *-0.143 | | | | | |
| Fe | 3.28 | -1.45 | | -1.52 | | -1.11 | *-0.863 |
| Na | 25.2 | 1.05 | | *0.842 | | | |
| Mn | 17.9 | -1.10 | | -1.13 | | *-0.976 | |
| Ext. Mn | 4.57 | *-0.916 | | | | | |
| Sr | 6.83 | *0.781 | | | | | |
| K | *0.675 | | | | | | |
| ext. K | 3.84 | *0.152 | | | | | |
| Mg | 4.87 | *-0.646 | | | | | |
| ext. Mg | 2.98 | *0.182 | | | | | |
| P | 2.23 | *-0.513 | | | | | |
| ext. P | 3.15 | *-0.197 | | | | | |
| pH | *-0.163 | | | | | | |
| Organic C | 3.36 | *0.815 | | | | | |
| Clay | *0.774 | | | | | | |
| Altitude | 2.56 | -1.29 | | *-0.782 | | | |

Table 3.5: Correlation matrix for data set I.

| | Al | Ba | org. C | Ca | Cd | ext. Cd | Co | ext. Co | Cr | Cu | ext. Cu | Fe | K | ext. K | Mg | ext. Mg | Mn | ext. Mn | Na | Ni | ext. Ni | P | ext.P | Pb | ext. Pb | Sr | Zn | ext. Zn | pH | Clay | Alt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Al | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ba | *0.69* | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| org. C | -0.24 | -0.15 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ca | 0.22 | 0.14 | -0.19 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cd | 0.54 | 0.55 | 0.16 | 0.32 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ext.Cd | 0.08 | 0.22 | 0.26 | 0.16 | 0.51 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Co | *0.72* | 0.59 | -0.28 | 0.30 | 0.59 | 0.09 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| ext.Co | 0.46 | 0.39 | -0.28 | -0.01 | 0.34 | 0.20 | *0.66* | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| Cr | **0.93** | *0.67* | -0.28 | 0.28 | 0.56 | 0.08 | **0.76** | 0.50 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| Cu | 0.39 | 0.48 | 0.15 | 0.20 | 0.55 | 0.33 | 0.46 | 0.28 | 0.41 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| ext.Cu | 0.34 | 0.44 | -0.08 | 0.09 | 0.33 | 0.37 | 0.34 | 0.43 | 0.36 | **0.80** | 1.00 | | | | | | | | | | | | | | | | | | | | |
| Fe | **0.83** | *0.63* | -0.23 | 0.19 | 0.58 | 0.04 | **0.81** | 0.54 | **0.87** | 0.46 | 0.36 | 1.00 | | | | | | | | | | | | | | | | | | | |
| K | *0.73* | 0.57 | -0.13 | 0.14 | 0.43 | -0.01 | 0.56 | 0.34 | *0.73* | 0.38 | 0.29 | *0.67* | 1.00 | | | | | | | | | | | | | | | | | | |
| ext.K | 0.29 | 0.10 | -0.10 | 0.36 | 0.17 | 0.11 | 0.28 | 0.21 | 0.31 | 0.22 | 0.21 | 0.27 | 0.40 | 1.00 | | | | | | | | | | | | | | | | | |
| Mg | **0.75** | *0.62* | -0.26 | 0.37 | 0.49 | 0.04 | *0.66* | 0.33 | 0.78 | 0.39 | 0.32 | *0.68* | *0.74* | 0.33 | 1.00 | | | | | | | | | | | | | | | | |
| ext.Mg | 0.33 | 0.36 | 0.07 | 0.19 | 0.30 | 0.20 | 0.27 | 0.33 | 0.36 | 0.25 | 0.30 | 0.29 | 0.42 | 0.36 | 0.47 | 1.00 | | | | | | | | | | | | | | | |
| Mn | *0.63* | 0.57 | -0.40 | 0.37 | 0.48 | 0.06 | **0.81** | 0.50 | *0.66* | 0.32 | 0.24 | *0.70* | 0.45 | 0.21 | *0.63* | 0.15 | 1.00 | | | | | | | | | | | | | | |
| ext.Mn | 0.54 | 0.53 | -0.46 | 0.18 | 0.35 | 0.13 | *0.70* | **0.77** | 0.58 | 0.24 | 0.37 | 0.59 | 0.38 | 0.20 | 0.51 | 0.27 | **0.83** | 1.00 | | | | | | | | | | | | | |
| Na | 0.51 | 0.46 | 0.04 | 0.12 | 0.38 | -0.05 | 0.40 | 0.15 | 0.46 | 0.36 | 0.19 | 0.49 | 0.57 | 0.16 | 0.51 | 0.25 | 0.36 | 0.22 | 1.00 | | | | | | | | | | | | |
| Ni | **0.75** | *0.62* | -0.27 | 0.45 | *0.64* | 0.18 | **0.86** | 0.52 | **0.83** | 0.58 | 0.45 | **0.80** | *0.60* | 0.34 | **0.75** | 0.35 | *0.70* | 0.59 | 0.39 | 1.00 | | | | | | | | | | | |
| ext.Ni | 0.38 | 0.36 | -0.06 | 0.20 | 0.39 | 0.44 | 0.43 | *0.66* | 0.44 | 0.43 | 0.58 | 0.39 | 0.34 | 0.36 | 0.33 | 0.53 | 0.21 | 0.43 | 0.07 | 0.55 | 1.00 | | | | | | | | | | |
| P | 0.32 | 0.29 | 0.23 | 0.40 | 0.49 | 0.28 | 0.36 | 0.11 | 0.35 | 0.48 | 0.31 | 0.40 | 0.22 | 0.33 | 0.30 | 0.17 | 0.37 | 0.20 | 0.33 | 0.41 | 0.24 | 1.00 | | | | | | | | | |
| ext.P | -0.05 | -0.01 | -0.16 | 0.22 | -0.07 | 0.12 | 0.00 | 0.02 | 0.00 | 0.17 | 0.30 | -0.04 | -0.02 | 0.41 | 0.04 | 0.06 | 0.05 | 0.10 | -0.04 | 0.05 | 0.13 | 0.46 | 1.00 | | | | | | | | |
| Pb | -0.08 | 0.19 | 0.57 | -0.19 | 0.35 | 0.42 | -0.01 | -0.03 | -0.09 | 0.45 | 0.29 | 0.00 | -0.07 | -0.12 | -0.11 | 0.04 | -0.10 | -0.12 | 0.07 | -0.01 | 0.06 | 0.27 | -0.05 | 1.00 | | | | | | | |
| ext.Pb | -0.17 | 0.10 | 0.41 | -0.33 | 0.13 | 0.45 | -0.16 | 0.08 | -0.18 | 0.31 | 0.37 | -0.14 | -0.14 | -0.11 | -0.21 | 0.06 | -0.25 | -0.09 | -0.12 | -0.15 | 0.18 | 0.03 | 0.02 | **0.82** | 1.00 | | | | | | |
| Sr | 0.33 | 0.23 | -0.08 | **0.82** | 0.42 | 0.12 | 0.39 | 0.05 | 0.34 | 0.27 | 0.08 | 0.32 | 0.25 | 0.34 | 0.36 | 0.17 | 0.37 | 0.13 | 0.37 | 0.49 | 0.19 | 0.43 | 0.09 | -0.10 | -0.31 | 1.00 | | | | | |
| Zn | 0.52 | *0.63* | 0.03 | 0.34 | **0.77** | 0.47 | *0.66* | 0.42 | 0.57 | *0.68* | 0.53 | *0.61* | 0.42 | 0.23 | 0.57 | 0.38 | 0.55 | 0.47 | 0.35 | *0.73* | 0.48 | 0.50 | 0.08 | 0.40 | 0.23 | 0.38 | 1.00 | | | | |
| ext.Zn | -0.18 | 0.09 | 0.34 | 0.00 | 0.24 | *0.60* | -0.05 | 0.12 | -0.15 | 0.39 | 0.45 | -0.12 | -0.07 | 0.16 | -0.08 | 0.26 | -0.10 | 0.02 | -0.07 | 0.00 | 0.37 | 0.24 | 0.24 | 0.54 | *0.60* | -0.01 | 0.46 | 1.00 | | | |
| pH | 0.25 | 0.14 | -0.50 | **0.78** | 0.13 | 0.00 | 0.32 | 0.17 | 0.30 | 0.10 | 0.18 | 0.23 | 0.17 | 0.38 | 0.35 | 0.14 | 0.37 | 0.32 | 0.06 | 0.43 | 0.22 | 0.18 | 0.26 | -0.39 | -0.37 | 0.58 | 0.20 | -0.14 | 1.00 | | |
| Clay | 0.49 | 0.30 | 0.17 | 0.25 | 0.46 | 0.16 | 0.37 | 0.26 | 0.49 | 0.29 | 0.18 | 0.43 | 0.54 | 0.32 | 0.40 | 0.41 | 0.16 | 0.12 | 0.31 | 0.43 | 0.39 | 0.26 | -0.10 | 0.07 | -0.03 | 0.37 | 0.35 | 0.01 | 0.12 | 1.00 | |
| Alt | -0.22 | -0.17 | 0.52 | -0.37 | 0.06 | 0.09 | -0.26 | -0.28 | -0.28 | -0.08 | -0.26 | -0.21 | -0.17 | -0.25 | -0.29 | -0.19 | -0.26 | -0.33 | -0.05 | -0.33 | -0.32 | 0.05 | -0.21 | 0.42 | 0.29 | -0.28 | -0.10 | 0.09 | -0.48 | -0.04 | 1.00 |

Note: Total concentration was obtained using digestion with *aqua regia* and extractable with EDTA, except extractable K and Mg where ammonium nitrate and extractable P where sodium bicarbonate (Olsen's P) was used.

Table 3.6: Correlation matrix for data set IV.

| | Al | Ba | org. C | Ca | Cd | ext. Cd | Co | ext. Co | Cr | Cu | ext. Cu | Fe | K | ext. K | Mg | ext. Mg | Mn | ext. Mn | Na | Ni | ext. Ni | P | ext. P | Pb | ext. Pb | Sr | Zn | ext. Zn | PH | clay | Alt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Al | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ba | *0.68* | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| org. C | -0.22 | -0.13 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ca | 0.24 | 0.16 | -0.20 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cd | 0.52 | 0.54 | 0.17 | 0.34 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ext.Cd | 0.07 | 0.20 | 0.26 | 0.18 | 0.52 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Co | *0.71* | 0.59 | -0.27 | 0.35 | 0.58 | 0.10 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| ext.Co | 0.45 | 0.37 | -0.29 | 0.05 | 0.33 | 0.23 | *0.66* | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| Cr | **0.93** | *0.66* | -0.28 | 0.30 | 0.53 | 0.07 | **0.76** | 0.50 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| Cu | 0.40 | 0.48 | 0.15 | 0.23 | 0.58 | 0.34 | 0.48 | 0.30 | 0.41 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| ext.Cu | 0.33 | 0.42 | -0.09 | 0.14 | 0.36 | 0.39 | 0.35 | 0.45 | 0.36 | **0.79** | 1.00 | | | | | | | | | | | | | | | | | | | | |
| Fe | **0.84** | *0.63* | -0.22 | 0.23 | 0.57 | 0.05 | **0.81** | 0.53 | **0.88** | 0.47 | 0.36 | 1.00 | | | | | | | | | | | | | | | | | | | |
| K | *0.74* | 0.58 | -0.10 | 0.14 | 0.44 | -0.01 | 0.57 | 0.33 | *0.74* | 0.41 | 0.30 | *0.68* | 1.00 | | | | | | | | | | | | | | | | | | |
| ext.K | 0.29 | 0.19 | -0.08 | 0.37 | 0.17 | 0.15 | 0.28 | 0.23 | 0.31 | 0.24 | 0.23 | 0.27 | 0.39 | 1.00 | | | | | | | | | | | | | | | | | |
| Mg | *0.74* | *0.62* | -0.23 | 0.38 | 0.49 | 0.05 | *0.67* | 0.34 | **0.78** | 0.41 | 0.32 | *0.69* | **0.76** | 0.34 | 1.00 | | | | | | | | | | | | | | | | |
| ext.Mg | 0.34 | 0.37 | 0.10 | 0.20 | 0.33 | 0.20 | 0.30 | 0.35 | 0.37 | 0.30 | 0.32 | 0.32 | 0.44 | 0.37 | 0.49 | 1.00 | | | | | | | | | | | | | | | |
| Mn | *0.62* | 0.56 | -0.39 | 0.39 | 0.46 | 0.05 | **0.81** | 0.49 | *0.66* | 0.34 | 0.24 | *0.71* | 0.46 | 0.21 | *0.63* | 0.16 | 1.00 | | | | | | | | | | | | | | |
| ext.Mn | 0.53 | 0.52 | -0.45 | 0.22 | 0.34 | 0.14 | *0.71* | **0.78** | 0.59 | 0.28 | 0.38 | *0.60* | 0.38 | 0.21 | 0.57 | 0.28 | **0.82** | 1.00 | | | | | | | | | | | | | |
| Na | 0.51 | 0.45 | 0.10 | 0.10 | 0.40 | -0.02 | 0.40 | 0.14 | 0.46 | 0.37 | 0.20 | 0.49 | 0.59 | 0.19 | 0.51 | 0.28 | 0.36 | 0.21 | 1.00 | | | | | | | | | | | | |
| Ni | *0.74* | *0.61* | -0.25 | 0.47 | *0.66* | 0.21 | **0.85** | 0.53 | **0.82** | *0.60* | 0.47 | **0.79** | *0.62* | 0.35 | **0.75** | 0.37 | *0.68* | 0.59 | 0.40 | 1.00 | | | | | | | | | | | |
| ext.Ni | 0.36 | 0.33 | -0.07 | 0.24 | 0.39 | 0.47 | 0.42 | *0.69* | 0.42 | 0.44 | *0.60* | 0.38 | 0.32 | 0.36 | 0.32 | 0.53 | 0.18 | 0.43 | 0.07 | 0.56 | 1.00 | | | | | | | | | | |
| P | 0.33 | 0.30 | 0.21 | 0.44 | 0.52 | 0.31 | 0.38 | 0.12 | 0.35 | 0.50 | 0.34 | 0.42 | 0.25 | 0.36 | 0.33 | 0.20 | 0.39 | 0.24 | 0.37 | 0.43 | 0.21 | 1.00 | | | | | | | | | |
| ext.P | -0.06 | 0.00 | -0.20 | 0.26 | -0.06 | 0.14 | 0.01 | 0.04 | 0.01 | 0.18 | 0.32 | -0.03 | 0.00 | 0.43 | 0.07 | 0.07 | 0.06 | 0.12 | -0.02 | 0.08 | 0.16 | 0.45 | 1.00 | | | | | | | | |
| Pb | -0.08 | 0.20 | 0.58 | -0.15 | 0.38 | 0.42 | -0.02 | -0.07 | -0.11 | 0.44 | 0.27 | -0.01 | -0.03 | -0.07 | -0.07 | 0.06 | -0.10 | -0.12 | 0.09 | 0.01 | 0.05 | 0.20 | -0.06 | 1.00 | | | | | | | |
| ext.Pb | -0.18 | 0.10 | 0.42 | -0.28 | 0.16 | 0.46 | -0.17 | 0.05 | -0.20 | 0.28 | 0.33 | -0.16 | -0.12 | -0.07 | -0.18 | 0.07 | -0.25 | -0.09 | -0.10 | -0.13 | 0.19 | 0.06 | 0.02 | **0.81** | 1.00 | | | | | | |
| Sr | 0.35 | 0.26 | -0.08 | **0.81** | 0.44 | 0.14 | 0.41 | 0.09 | 0.36 | 0.28 | 0.11 | 0.34 | 0.26 | 0.37 | 0.35 | 0.21 | 0.37 | 0.15 | 0.34 | 0.50 | 0.22 | 0.45 | 0.12 | -0.07 | -0.27 | 1.00 | | | | | |
| Zn | 0.51 | *0.63* | 0.04 | 0.37 | **0.77** | 0.47 | *0.66* | 0.41 | 0.56 | *0.67* | 0.51 | *0.62* | 0.46 | 0.26 | 0.58 | 0.41 | 0.54 | 0.47 | 0.37 | *0.74* | 0.47 | 0.52 | 0.09 | 0.42 | 0.24 | 0.40 | 1.00 | | | | |
| ext.Zn | -0.18 | 0.10 | 0.34 | 0.02 | 0.27 | *0.63* | -0.05 | 0.12 | -0.16 | 0.36 | 0.43 | -0.11 | -0.06 | 0.19 | -0.07 | 0.25 | -0.12 | 0.01 | -0.05 | 0.02 | 0.40 | 0.25 | 0.25 | 0.55 | *0.60* | 0.02 | 0.45 | 1.00 | | | |
| pH | 0.25 | 0.15 | -0.52 | **0.77** | 0.13 | 0.03 | 0.35 | 0.23 | 0.31 | 0.13 | 0.22 | 0.26 | 0.16 | 0.36 | 0.33 | 0.14 | 0.38 | 0.35 | 0.02 | 0.43 | 0.25 | 0.19 | 0.29 | -0.37 | -0.34 | 0.57 | 0.21 | -0.13 | 1.00 | | |
| Clay | 0.48 | 0.28 | 0.18 | 0.28 | 0.46 | 0.19 | 0.36 | 0.26 | 0.47 | 0.30 | 0.20 | 0.42 | 0.53 | 0.33 | 0.39 | 0.44 | 0.14 | 0.12 | 0.31 | 0.43 | 0.39 | 0.25 | -0.09 | 0.09 | 0.00 | 0.40 | 0.37 | 0.05 | 0.15 | 1.00 | |
| Alt | -0.23 | -0.19 | 0.53 | -0.37 | 0.03 | 0.07 | -0.29 | -0.32 | -0.31 | -0.01 | -0.28 | -0.24 | -0.16 | -0.25 | -0.29 | -0.20 | -0.26 | -0.34 | -0.03 | -0.36 | -0.35 | 0.02 | -0.26 | 0.40 | 0.28 | -0.28 | -0.13 | 0.08 | -0.48 | -0.06 | 1.00 |

Note: Total concentration was obtained using digestion with *aqua regia* and extractable with EDTA, except extractable K and Mg where ammonium nitrate and extractable P where sodium bicarbonate (Olsen's P) was used.

Table 3.7: Selected latent roots of the correlation matrix data sets I to IV.

| Latent Roots | Latent roots for all data sets | | | | % variance for all data sets | | | |
|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV |
| 1 | 11.07 | 9.374 | 6.284 | 11.22 | 36.93 | 46.74 | 31.42 | 37.40 |
| 2 | 4.354 | 2.734 | 3.148 | 4.337 | 14.51 | 13.67 | 15.74 | 14.46 |
| 3 | 2.585 | 2.030 | 2.347 | 2.591 | 8.62 | 10.95 | 11.74 | 8.64 |
| 4 | 2.130 | 1.220 | 1.796 | 1.996 | 7.10 | 10.15 | 8.98 | 7.14 |
| 5 | 1.577 | - | 1.063 | 1.552 | 5.26 | 6.10 | 5.32 | 5.17 |

Table 3.8: Comparison of the eigenvectors between data set I (5671 sites) and IV (one in four subset of 1433 sites).

| | Data set I | | | | | Data set IV | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Eigenvector | | | | | Eigenvector | | | | |
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Al | **–0.251** | –0.096 | –0.165 | –0.092 | –0.052 | **–0.246** | –0.110 | –0.186 | –0.055 | 0.057 |
| Ba | –0.223 | 0.047 | –0.167 | –0.017 | 0.089 | –0.217 | 0.035 | –0.176 | 0.029 | –0.104 |
| Ca | –0.132 | –0.118 | **0.465** | –0.107 | 0.111 | –0.142 | –0.090 | **0.423** | 0.220 | **–0.105** |
| Cd | –0.216 | 0.150 | –0.002 | –0.182 | 0.160 | –0.214 | 0.163 | –0.052 | –0.153 | –0.151 |
| ext. Cd | –0.082 | **0.307** | 0.142 | 0.083 | 0.047 | –0.089 | **0.314** | 0.149 | 0.081 | –0.035 |
| Co | **–0.258** | –0.072 | –0.097 | 0.060 | 0144 | **–0.257** | –0.088 | –0.072 | 0.079 | –0.139 |
| ext. Co | –0.183 | 0.017 | –0.154 | **0.372** | –0.092 | –0.182 | –0.009 | –0.036 | **0.413** | 0.121 |
| Cr | **–0.263** | –0.098 | –0.132 | –0.050 | –0.048 | **–0.257** | –0.120 | –0.142 | –0.013 | 0.048 |
| Cu | –0.189 | 0.233 | 0.044 | –0.030 | 0.097 | –0.194 | 0.218 | 0.011 | –0.011 | –0.108 |
| ext. Cu | –0.165 | 0.216 | 0.042 | 0.247 | –0.039 | –0.168 | 0.199 | 0.093 | 0.242 | 0.031 |
| Fe | **–0.256** | –0.069 | –0.167 | –0.045 | 0.053 | **–0.254** | –0.085 | –0.169 | –0.006 | –0.054 |
| K | –0.216 | –0.067 | –0.147 | –0.161 | –0.272 | –0.217 | –0.062 | –0.190 | –0.124 | 0.246 |
| ext. K | –0.129 | –0.026 | 0.277 | 0.032 | **–0.358** | –0.132 | 0.001 | 0.274 | –0.071 | **0.323** |
| Mg | –0.242 | –0.102 | –0.052 | –0.093 | –0.080 | **–0.241** | –0.096 | –0.086 | –0.081 | 0.070 |
| ext. Mg | –0.145 | –0.080 | 0.032 | 0.006 | **–0.469** | –0.152 | 0.088 | 0.013 | –0.013 | **0.460** |
| Mn | –0.227 | –0.135 | –0.053 | 0.102 | **0.318** | –0.223 | –0.151 | –0.032 | 0.093 | **–0.325** |
| ext. Mn | –0.206 | 0.082 | –0.112 | **0.347** | 0.140 | –0.205 | –0.100 | –0.017 | **0.355** | –0.137 |
| Na | –0.158 | –0.029 | –0.103 | **–0.310** | –0.003 | –0.157 | –0.010 | –0.184 | –0.279 | 0.009 |
| Ni | **–0.274** | –0.046 | 0.006 | 0.005 | 0.065 | **–0.272** | –0.043 | 0.004 | 0.009 | –0.050 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ext. Ni | –0.180 | 0.138 | 0.058 | 0.262 | –0.322 | –0.177 | 0.136 | 0.126 | 0.265 | **–0.336** |
| P | –0.154 | 0.123 | 0.244 | –0.165 | 0.172 | –0.162 | 0.130 | 0.182 | –0.224 | –0.218 |
| ext. P | –0.035 | 0.042 | **0.350** | 0.212 | –0.034 | –0.043 | 0.042 | **0.392** | 0.090 | –0.007 |
| Pb | –0.018 | **0.404** | –0.082 | –0.130 | 0.192 | –0.023 | **0.402** | –0.125 | –0.093 | –0.206 |
| ext. Pb | 0.020 | **0.405** | –0.101 | 0.095 | 0.024 | 0.016 | **0.401** | –0.080 | 0.131 | –0.042 |
| Sr | –0.152 | –0.093 | **0.359** | –0.248 | 0.110 | –0.157 | –0.067 | **0.292** | **–0.333** | –0.073 |
| Zn | –0.237 | 0.185 | 0.032 | –0.018 | 0.171 | **–0.238** | 0.178 | 0.001 | –0.021 | –0.165 |
| ext. Zn | –0.033 | **0.378** | 0.157 | 0.142 | –0.042 | –0.038 | **0.384** | 0.161 | 0.110 | 0.038 |
| pH | –0.123 | –0.209 | **0.377** | 0.119 | 0.044 | –0.128 | –0.192 | **0.399** | 0.021 | –0.038 |
| org. C | –0.065 | **0.306** | –0.016 | **–0.368** | –0.084 | 0.058 | **0.316** | –0.131 | **–0.325** | 0.085 |
| Clay | –0.158 | 0.034 | –0.002 | –0.268 | **–0.357** | –0.157 | 0.049 | –0.040 | –0.243 | **0.380** |

Vectors for important variables are in bold.

Table 3.9: Eigenvectors for data set II (major variables excluding all extractable elements).

| | Eigenvectors | | | |
|---|---|---|---|---|
| Variables | 1 | 2 | 3 | 4 |
| Al | **–0.282** | 0.031 | 0.218 | 0.117 |
| Ba | –0.244 | –0.102 | 0.158 | –0.131 |
| Ca | –0.152 | 0.264 | **–0.504** | 0.071 |
| Cd | –0.238 | –0.222 | –0.148 | –0.054 |
| Co | **–0.281** | 0.042 | 0.082 | –0.201 |
| Cr | **–0.291** | 0.052 | 0.190 | 0.060 |
| Cu | –0.116 | –0.290 | –0.034 | –0.210 |
| Fe | **–0.284** | –0.003 | 0.185 | –0.042 |
| K | –0.242 | –0.014 | 0.239 | **0.337** |
| Na | –0.188 | –0.099 | 0.074 | **0.328** |
| Ni | **–0.299** | 0.047 | –0.010 | –0.122 |
| Mg | **–0.271** | 0.080 | 0.120 | 0.089 |
| Mn | **–0.252** | 0.135 | 0.060 | **–0.312** |
| P | –0.170 | –0.174 | **–0.323** | –0.029 |
| Pb | –0.013 | **–0.512** | –0.139 | –0.202 |
| Sr | –0.181 | –0.158 | **–0.446** | 0.217 |
| Zn | **–0.252** | –0.199 | –0.137 | –0.263 |
| pH | –0.134 | **0.407** | **–0.308** | –0.043 |
| org. C | 0.068 | **–0.468** | –0.190 | 0.287 |
| Clay | –0.174 | –0.106 | –0.043 | **0.547** |

Vectors for important variables are in bold.

Table 3.10: Eigenvectors for data set III (major variables excluding some total elements).

| | Eigenvectors | | | | |
|---|---|---|---|---|---|
| Variables | 1 | 2 | 3 | 4 | 5 |
| Al | **–0.335** | 0.086 | 0.220 | –0.110 | 0.061 |
| Ba | **–0.286** | –0.070 | 0.196 | –0.052 | **0.326** |
| Ca | –0.182 | 0.202 | **–0.465** | –0.119 | 0.189 |
| ext. Cd | –0.100 | **–0.366** | –0.189 | –0.057 | 0.253 |
| ext. Co | **–0.264** | –0.132 | 0.151 | **0.302** | –0.202 |
| Cr | **–0.347** | 0.089 | 0.185 | –0.052 | 0.034 |
| ext. Cu | –0.221 | –0.284 | –0.055 | 0.173 | 0.193 |
| Fe | **–0.330** | 0.071 | 0.224 | –0.037 | 0.064 |
| ext. K | –0.193 | 0.005 | –0.294 | –0.020 | **–0.419** |
| Na | –0.194 | 0.071 | 0.150 | **–0.328** | 0.024 |
| ext. Ni | **–0.265** | –0.253 | –0.088 | 0.108 | –0.268 |
| ext. Mg | –0.211 | –0.157 | –0.061 | –0.142 | **–0.436** |
| ext. Mn | **–0.282** | 0.005 | 0.131 | **0.352** | 0.053 |
| ext. P | –0.059 | 0.056 | **–0.345** | 0.260 | –0.010 |
| ext. Pb | 0.043 | **–0.467** | 0.037 | –0.123 | 0.193 |
| Sr | –0.202 | 0.191 | **–0.336** | –0.286 | 0.227 |
| ext. Zn | –0.030 | **–0.452** | –0.229 | –0.004 | 0.130 |
| pH | –0.194 | 0.254 | **–0.370** | 0.155 | 0.099 |
| org. C | 0.122 | –0.284 | –0.003 | **–0.494** | –0.045 |
| Clay | –0.216 | –0.035 | 0.005 | **–0.402** | **–0.330** |

Vectors for important variables are in bold.

Table 3.11: Summary statistics for total and ext. Cr, Cu, Ni, Pb and Zn for England and Wales (mg $kg^{-1}$) with the data stratified according to rainfall ? 800mm.

| Variable | *n* | Mean | Minimum | Maximum | Variance | Standard deviation | Skewness | Lower data limit* | Upper data limit* |
|---|---|---|---|---|---|---|---|---|---|
| Cd | 3398 | 0.7947 | 0.0 | 19.2 | 0.5803 | 0.7618 | 9.786 | | |
| $Log_{10}$Cd ( no zeros) | 3352 | -0.2092 | -1.0 | 1.283 | 0.1134 | 0.3367 | -0.7032 | 0.1 | |
| ext. Cd | 3392 | 0.3180 | 0.0 | 15.7 | 0.2294 | 0.4790 | 17.15 | | |
| $Log_{10}$ext. Cd (no zeros) | 3382 | -0.5970 | -1.0 | 1.196 | 0.06437 | 0.2537 | 0.9449 | 0.1 | |
| Cr | 3398 | 42.45 | 0.2 | 837.8 | 870.1 | 29.50 | 10.04 | | |
| $Log_{10}$Cr (no outliers) | 3396 | 1.562 | 0.1139 | 2.923 | 0.06232 | 0.2496 | -0.9137 | 1.3 | |
| Cu | 3398 | 20.66 | 1.2 | 933.5 | 604.1 | 24.58 | 20.17 | | |
| $Log_{10}$Cu | 3398 | 1.231 | 0.07918 | 2.970 | 0.06324 | 0.2515 | 0.1406 | | |
| ext. Cu | 3392 | 6.329 | 0.3 | 203.0 | 74.10 | 8.608 | 11.78 | | |
| $Log_{10}$ext. Cu | 3392 | 0.6675 | -0.5229 | 2.307 | 0.1052 | 0.3244 | 0.03733 | | |
| Ni | 3398 | 26.04 | 0.8 | 243.0 | 225.8 | 15.03 | 2.802 | | |
| $Log_{10}$Ni (no outliers) | 3378 | 1.348 | 0.1461 | 2.386 | 0.07089 | 0.2662 | -0.9579 | 1.4 | |
| ext. Ni | 3392 | 1.931 | 0.1 | 73.2 | 4.410 | 2.100 | 14.42 | | |
| $Log_{10}$ext. Ni | 3392 | 0.1526 | -1.0 | 1.865 | 0.1181 | 0.3437 | -0.1342 | | |
| Pb | 3398 | 47.50 | 3.0 | 3264.0 | 6446.8 | 80.29 | 22.75 | | |
| $Log_{10}$Pb | 3398 | 1.556 | 0.4771 | 3.514 | 0.07799 | 0.2793 | 0.8397 | | |
| ext. Pb | 3392 | 18.65 | 1.2 | 1276.6 | 1172.8 | 34.25 | 18.65 | | |
| $Log_{10}$ext Pb | 3392 | 1.108 | 0.07918 | 3.106 | 0.1085 | 0.3295 | 0.7069 | | |
| Zn | 3398 | 93.17 | 5.0 | 1985.0 | 6487.2 | 80.54 | 9.641 | | |
| $Log_{10}$Zn | 3398 | 1.231 | 0.07918 | 2.970 | 0.06324 | 0.2515 | 0.1406 | | |
| ext. Zn | 3392 | 9.308 | 0.5 | 681.2 | 74.10 | 8.608 | 11.78 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $Log_{10}$ext. Zn (no outliers) | 3388 | 0.7668 | -0.3010 | 2.465 | 0.1139 | 0.3375 | 0.9003 | 291.5 |

* Limits of the data before transformation

Note: Total concentration was obtained using digestion with *aqua regia* and extractable with EDTA.

Table 3.12: Summary statistics for Al, Ba, Ca, Co, ext. Co, Fe, Na, Mn, ext. Mn and Sr for England and Wales (mg $kg^{-1}$) with the data stratified according to rainfall ? 800mm.

| Variable | *n* | Mean | Minimum | Maximum | Variance | Standard deviation | Skewness | Lower data limit* | Upper data limit* |
|---|---|---|---|---|---|---|---|---|---|
| Al | 3398 | 2.781 x $10^4$ | 491.0 | 7.936 x $10^4$ | 1.656 x $10^8$ | 1.287 x $10^4$ | 0.3625 | | |
| Ba | 3398 | 129.2 | 11.0 | 2416.0 | 1.050 x $10^4$ | 102.5 | 7.549 | | |
| $Log_{10}$Ba | 3398 | 2.039 | 1.041 | 3.383 | 0.05964 | 0.2442 | -0.03149 | | |
| Ca | 3398 | 2.078 x $10^4$ | 50.0 | 3.396 x $10^5$ | 2.131 x $10^9$ | 4.616 x $10^4$ | 3.811 | | |
| $Log_{10}$Ca | 3398 | 3.791 | 1.699 | 5.531 | 0.3921 | 0.6262 | 0.4909 | | |
| Co | 3398 | 10.92 | 0.2 | 66.6 | 38.83 | 6.231 | 1.748 | | |
| $Log_{10}$Co ( no outliers) | 3364 | 0.9725 | -0.1549 | 1.823 | 0.07099 | 0.2664 | -0.9538 | 0.7 | |
| ext. Co | 3392 | 1.213 | 0.0 | 15.7 | 1.534 | 1.239 | 2.912 | | |
| $Log_{10}$ext. Co (no zeros) | 3376 | -0.1108 | -1.0 | 1.196 | 0.1924 | 0.4387 | -0.2645 | | |
| Fe | 3398 | 2.788 x $10^4$ | 430.0 | 2.644 x $10^5$ | 2.574 x $10^8$ | 1.605 x $10^4$ | 4.472 | | |
| $Log_{10}$Fe (no outliers) | 3385 | 4.391 | 3.168 | 5.422 | 0.05279 | 0.2298 | -0.8751 | 1471.0 | |
| Mn | 3398 | 703.7 | 3.0 | 5338.0 | 2.986 x $10^5$ | 546.5 | 2.230 | | |
| $Log_{10}$Mn (no outliers) | 3386 | 2.725 | 1.114 | 3.727 | 0.1281 | 0.3579 | -0.8978 | 12.0 | |
| ext. Mn | 3392 | 160.62 | 0.0 | 2442.0 | 2.868 x $10^4$ | 169.36 | 3.874 | | |
| $Log_{10}$ext. Mn (no zeros) | 3391 | 2.018 | 0.0 | 3.388 | 0.1931 | 0.4395 | -0.7853 | | |
| Na | 3398 | 278.2 | 31.0 | 2.515 x $10^4$ | 3.675 x $10^5$ | 606.2 | 28.54 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $Log_{10}Na$ (no outliers) | 3396 | 2.362 | 1.494 | 4.123 | 0.04030 | 0.2007 | 0.8838 | $1.327 \times 10^4$ |
| Sr | 3398 | 56.00 | 3.0 | 1445.0 | 6105.1 | 78.14 | 5.533 | |
| $Log_{10}Sr$ | 3398 | 1.556 | 0.4771 | 3.160 | 0.1373 | 0.3705 | 0.6779 | |

* Limits of the data before transformation
Note: Total concentration was obtained using digestion with *aqua regia* and extractable with EDTA.

Table 3.13: Summary statistics for the total and ext. K, Mg and P concentration (mg $l^{-1}$), pH, organic C (%), clay (%), and altitude (m) for England and Wales with the data stratified according to rainfall ? 800mm.

| Variable | *n* | Mean | Minimum | Maximum | Variance | Standard deviation | Skewness | Lower data limit* |
|---|---|---|---|---|---|---|---|---|
| K | 3398 | 4830.0 | 60.0 | 1.733 x $10^4$ | 6.887 x $10^6$ | 2624.3 | 0.8579 | |
| ext. K | 3357 | 201.77 | 14.0 | 2776.0 | 2.564 x $10^4$ | 160.12 | 3.631 | |
| $Log_{10}$ext. K | 3357 | 2.206 | 1.145 | 3.443 | 0.08349 | 0.2889 | 0.1104 | |
| Mg | 3398 | 3828.6 | 41.0 | 6.269 x $10^4$ | 1.280 x $10^7$ | 3578.0 | 5.836 | |
| $Log_{10}$Mg | 3398 | 3.460 | 1.613 | 4.797 | 0.1170 | 0.3420 | -0.6769 | |
| ext. Mg | 3357 | 159.5 | 5.0 | 1601.0 | 2.402 x $10^4$ | 154.97 | 2.660 | |
| $Log_{10}$ext. Mg | 3357 | 2.047 | 0.6990 | 3.204 | 0.1347 | 0.3671 | 0.1008 | |
| P | 3398 | 818.7 | 41.0 | 6273.0 | 2.139 x $10^5$ | 462.5 | 2.700 | |
| $Log_{10}$P | 3398 | 2.856 | 1.613 | 3.797 | 0.05122 | 0.2263 | -0.5169 | |
| ext. P | 3353 | 29.27 | 1.0 | 337.0 | 683.4 | 26.14 | 2.939 | |
| $Log_{10}$ext. P | 3353 | 1.328 | 0.0 | 2.528 | 0.1287 | 0.3588 | -0.3049 | |
| pH | 3357 | 6.532 | 3.1 | 9.0 | 1.335 | 1.156 | -0.6919 | |
| Organic C | 3392 | 4.088 | 0.1 | 56.4 | 23.65 | 4.864 | 5.479 | |
| $Log_{10}$organic C | 3392 | 0.4744 | -1.0 | 1.751 | 0.1007 | 0.3173 | 0.5081 | |
| Clay | 3106 | 26.09 | 0.0 | 87.9 | 179.26 | 13.39 | 0.6919 | |
| Altitude | 3398 | 77.37 | -1.0 | 1050.0 | 4438.7 | 66.62 | 2.746 | |
| $Log_{10}$altitude (no outliers) | 3144 | 1.779 | 0.6021 | 3.021 | 0.1567 | 0.3958 | -0.8726 | 4.0 |

* Limits of the data before transformation

Note: Total concentration was obtained using digestion with *aqua regia*, extractable K and Mg with ammonium nitrate and extractable P with sodium bicarbonate (Olsen's P).

Table 3.14: Summary statistics for total and ext. Cr, Cu, Ni, Pb, and Zn for England and Wales (mg $kg^{-1}$) with the data stratified according to rainfall > 800mm.

| Variable | *n* | Mean | Minimum | Maximum | Variance | Standard deviation | Skewness | Lower data limit* | Upper data limit* |
|---|---|---|---|---|---|---|---|---|---|
| Cd | 2273 | 0.9026 | 0.0 | 40.9 | 1.497 | 1.223 | 18.50 | | |
| $Log_{10}$Cd ( no zeros) | 2245 | -0.1524 | -1.0 | 1.612 | 0.09599 | 0.3098 | -0.4596 | | |
| ext. Cd | 2254 | 0.3436 | 0.0 | 17.8 | 0.3594 | 0.5995 | 15.77 | | |
| $Log_{10}$ext. Cd (no outliers) | 2231 | 0.5916 | -1.0 | 1.004 | 0.7940 | 0.2818 | 0.9458 | 0.1 | 10.1 |
| Cr | 2273 | 39.32 | 0.2 | 692.9 | 685.9 | 26.19 | 8.168 | | |
| Cr (no outliers) | 2270 | 38.79 | 0.2 | 170.8 | 427.3 | 20.67 | 0.4342 | | 170.8 |
| Cu | 2273 | 26.52 | 1.9 | 1507.7 | 2484.4 | 49.84 | 17.88 | | |
| $Log_{10}$Cu | 2273 | 1.287 | 0.2788 | 3.178 | 0.09038 | 0.3006 | 0.5336 | | |
| ext. Cu | 2254 | 6.579 | 0.3 | 431.4 | 195.7 | 13.99 | 18.26 | | |
| $Log_{10}$ext. Cu | 2254 | 0.6387 | -0.5229 | 2.635 | 0.1231 | 0.3509 | 0.4564 | | |
| Ni | 2273 | 22.15 | 0.8 | 439.5 | 408.6 | 20.21 | 9.519 | | |
| $Log_{10}$Ni | 2273 | 1.221 | -0.09691 | 2.643 | 0.1254 | 0.3541 | -0.7088 | | |
| ext. Ni | 2254 | 1.221 | 0.1 | 49.2 | 3.126 | 1.768 | 14.03 | | |
| $Log_{10}$ext. Ni | 2254 | -0.05040 | -1.0 | 1.692 | 0.09777 | 0.3127 | 0.5690 | | |
| Pb | 2273 | 112.8 | 3.0 | $1.634 \times 10^4$ | $1.656 \times 10^5$ | 407.0 | 29.67 | | |
| $Log_{10}$Pb (no outliers) | 2272 | 1.809 | 0.4771 | 3.661 | 0.1325 | 0.3640 | 0.9707 | | 4578.0 |
| ext. Pb | 2254 | 41.69 | 1.8 | 6056.5 | $3.386 \times 10^4$ | 184.0 | 22.24 | | |
| $Log_{10}$ext. Pb | 2254 | 1.301 | 0.2553 | 3.782 | 0.1724 | 0.4152 | 0.9406 | | |
| Zn | 2273 | 102.3 | 10.0 | 3648.0 | $1.984 \times 10^4$ | 140.85 | 13.05 | | |
| $Log_{10}$Zn | 2273 | 1.898 | 1.0 | 3.562 | 0.08023 | 0.2833 | 0.3488 | | |
| ext. Zn | 2254 | 10.24 | 0.8 | 712.0 | 760.6 | 27.58 | 16.24 | | |
| $Log_{10}$ext. Zn | 2254 | 0.7800 | -0.09691 | 2.852 | 0.1408 | 0.3752 | 0.8325 | | |

* Limits of the data before transformation; Note: Total concentration was obtained using digestion with *aqua regia* and extractable with EDTA.

Table 3.15: Summary statistics for Al, Ba, Ca, Co, ext. Co, Fe, Mn, ext. Mn, Na, and Sr for England and Wales (mg $kg^{-1}$) with the data stratified according to rainfall > 800mm.

| Variable | *n* | Mean | Minimum | Maximum | Variance | Standard deviation | Skewness | Lower data limit* |
|---|---|---|---|---|---|---|---|---|
| Al | 2273 | $2.810 \times 10^4$ | 880.0 | $6.766 \times 10^4$ | $1.652 \times 10^8$ | $1.285 \times 10^4$ | -0.2656 | |
| Ba | 2273 | 158.00 | 11.0 | 2973.0 | $2.741 \times 10^4$ | 165.6 | 8.527 | |
| $Log_{10}$Ba | 2273 | 2.089 | 1.041 | 3.473 | 0.09285 | 0.3047 | -0.2088 | |
| Ca | 2273 | 3494.1 | 71.0 | $1.730 \times 10^5$ | $6.956 \times 10^7$ | 8340.0 | 11.35 | |
| $Log_{10}$Ca | 2273 | 3.256 | 1.851 | 5.238 | 0.2352 | 0.4850 | -0.1991 | |
| Co | 2273 | 10.10 | 0.2 | 321.8 | 147.2 | 12.13 | 14.88 | |
| $Log_{10}$Co | 2273 | 0.8291 | -0.6990 | 2.508 | 0.1932 | 0.4396 | -0.8399 | |
| ext. Co | 2254 | 0.8369 | 0.0 | 26.5 | 1.239 | 1.113 | 8.321 | |
| $Log_{10}$ext. Co (no zeros) | 2219 | -0.2788 | -1.0 | 1.423 | 0.1837 | 0.4287 | 0.009183 | |
| Fe | 2273 | $2.780 \times 10^4$ | 395.0 | $2.052 \times 10^5$ | $2.414 \times 10^8$ | $1.554 \times 10^4$ | 1.308 | |
| $Log_{10}$Fe (no outliers) | 2141 | 4.403 | 3.652 | 5.312 | 0.06698 | 0.2588 | -0.9620 | 486.0 |
| Mn | 2273 | 845.2 | 3.0 | $4.260 \times 10^4$ | $1.940 \times 10^6$ | 1392.6 | 15.24 | |
| $Log_{10}$Mn | 2273 | 2.635 | 0.4771 | 4.629 | 0.3459 | 0.5882 | -0.8297 | |
| ext. Mn | 2254 | 157.5 | 1.0 | 3108.0 | $4.591 \times 10^4$ | 214.3 | 4.945 | |
| $Log_{10}$ext. Mn | 2254 | 1.863 | 0.0 | 3.492 | 0.4008 | 0.6331 | -0.7279 | |
| Na | 2273 | 411.6 | 52.0 | $1.111 \times 10^4$ | $1.819 \times 10^5$ | 426.46 | 9.338 | |
| $Log_{10}$Na | 2273 | 2.498 | 1.716 | 4.046 | 0.08825 | 0.2971 | 0.5913 | |
| Sr | 2273 | 29.12 | 3.0 | 1229.0 | 1830.2 | 42.78 | 14.19 | |
| $Log_{10}$Sr | 2273 | 1.344 | 0.4771 | 3.090 | 0.08161 | 0.2857 | 0.6568 | |

* Limits of the data before transformation

Note: Total concentration was obtained using digestion with *aqua regia* and extractable with EDTA.

Table 3.16 Summary statistics for the total and ext. K, Mg and P concentration (mg $l^{-1}$), pH, organic C (%), clay (%), and altitude (m) for England and Wales with the data stratified according to rainfall > 800mm.

| Variable | *n* | Mean | Minimum | Maximum | Variance | Standard deviation | Skewness | Lower data limit* |
|---|---|---|---|---|---|---|---|---|
| K | 2273 | 5063.0 | 104.0 | 2444.0 | $7.483 \times 10^6$ | 2735.5 | 0.4243 | |
| ext. K | 2221 | 122.7 | 7.0 | 1066.0 | 7238.2 | 85.08 | 2.983 | |
| $Log_{10}$ext. K | 2221 | 2.012 | 0.8451 | 3.028 | 0.06531 | 0.2556 | -0.0004882 | |
| Mg | 2273 | 3601.8 | 62.0 | $3.166 \times 10^4$ | $8.341 \times 10^6$ | 2888.0 | 1.809 | |
| $Log_{10}$Mg | 2273 | 3.404 | 1.792 | 4.501 | 0.1586 | 0.3982 | -0.5501 | |
| ext. Mg | 2221 | 113.2 | 1.0 | 981.0 | 9988.9 | 99.94 | 3.394 | |
| $Log_{10}$ext. Mg | 2221 | 1.944 | 0.0 | 2.992 | 0.09057 | 0.3010 | 0.1197 | |
| P | 2273 | 891.2 | 84.0 | 4529.0 | $1.707 \times 10^5$ | 413.1 | 1.347 | |
| $Log_{10}$P | 2273 | 2.904 | 1.924 | 3.656 | 0.04232 | 0.2057 | -0.4414 | |
| ext. P | 2221 | 21.19 | 1.0 | 280.0 | 340.9 | 18.46 | 3.367 | |
| $Log_{10}$ext. P | 2221 | 1.204 | 0.0 | 2.447 | 0.1078 | 0.3283 | -0.1343 | |
| pH | 2221 | 5.106 | 0.0 | 1400.0 | $2.779 \times 10^4$ | 166.7 | 1.798 | |
| Organic C | 2270 | 10.51 | 0.1 | 65.9 | 184.0 | 13.56 | 2.115 | |
| $Log_{10}$organic C | 2270 | 0.7892 | -1.0 | 1.819 | 0.1686 | 0.4107 | 0.7779 | |
| Clay | 1733 | 23.74 | 0.0 | 73.3 | 97.94 | 9.897 | 0.7093 | |
| Altitude | 2273 | 208.5 | 0.0 | 1400.0 | $2.779 \times 10^4$ | 166.7 | 1.798 | |
| $Log_{10}$altitude (no outliers) | 2236 | 2.169 | 0.7782 | 3.146 | 0.1807 | 0.4251 | -0.9974 | 6.0 |

* Limits of the data before transformation

Note: Total concentration was obtained using digestion with *aqua regia*, extractable K and Mg with ammonium nitrate and extractable P with sodium bicarbonate (Olsen's P).

Table 3.17: Summary statistics for total and ext. Cr, Cu, Ni, Pb, and Zn for England and Wales (mg kg$^{-1}$) with the data stratified according to altitude ? 300m.

| Variable | *n* | Mean | Minimum | Maximum | Variance | Standard deviation | Skewness | Lower data limit* | Upper data limit* |
|---|---|---|---|---|---|---|---|---|---|
| Cd | 5062 | 0.8392 | 0.1 | 65.9 | 32.55 | 5.705 | 5.018 | | |
| $Log_{10}$Cd ( no zeros) | 5027 | -0.1850 | -1.0 | 1.612 | 0.1070 | 0.3271 | -0.6736 | | |
| ext. Cd | 5068 | 0.3234 | 0.0 | 17.8 | 0.2987 | 0.5465 | 16.82 | | |
| $Log_{10}$ext. Cd (no outliers) | 5036 | -0.6039 | -1.0 | 0.9638 | 0.06887 | 0.2624 | 0.9638 | 0.1 | 9.2 |
| Cr | 5092 | 43.02 | 0.2 | 837.8 | 807.0 | 28.41 | 10.26 | | |
| Cr (no outliers) | 5066 | 41.78 | 0.2 | 149.7 | 359.8 | 18.97 | 0.7811 | | |
| Cu | 5092 | 23.32 | 1.2 | 507.7 | 1447.8 | 38.05 | 21.36 | | |
| $Log_{10}$Cu | 5092 | 1.260 | 0.07918 | 3.178 | 0.07377 | 0.2716 | 0.3906 | | |
| ext. Cu | 5068 | 3.722 | 0.3 | 431.4 | 133.3 | 11.55 | 17.59 | | |
| $Log_{10}$ext. Cu | 5068 | 0.6790 | -0.5229 | 2.635 | 0.1088 | 0.3299 | 0.2275 | | |
| Ni | 5092 | 25.80 | 0.8 | 439.5 | 302.6 | 17.40 | 7.578 | | |
| SqrtNi | 5092 | 4.866 | 0.8944 | 20.96 | 2.119 | 1.456 | 0.9175 | | |
| ext. Ni | 5068 | 1.734 | 0.1 | 73.2 | 4.325 | 2.080 | 13.72 | | |
| $Log_{10}$ext. Ni | 5068 | 0.09792 | -1.0 | 18.65 | 0.1171 | 0.3422 | 0.1116 | | |
| Pb | 5092 | 62.52 | 3.0 | $1.634 \times 10^4$ | $6.925 \times 10^4$ | 263.2 | 48.56 | | |
| $Log_{10}$Pb (no outliers) | 5084 | 1.611 | 0.4771 | 3.215 | 0.08902 | 0.2984 | 0.8173 | | 1640 |
| ext. Pb | 5068 | 24.37 | 1.2 | 6056.5 | $1.292 \times 10^4$ | 113.7 | 36.65 | | |
| $Log_{10}$ext Pb (no outliers) | 5060 | 1.142 | 0.07918 | 2.921 | 0.1182 | 0.3437 | 0.7618 | | 832.8 |
| Zn | 5092 | 99.22 | 5.0 | 3648.0 | $1.256 \times 10^4$ | 112.1 | 13.83 | | |
| $Log_{10}$Zn | 5092 | 1.912 | 0.6990 | 3.562 | 0.06349 | 0.2520 | 0.08899 | | |
| ext. Zn | 5068 | 9.531 | 0.5 | 712.0 | 660.1 | 25.69 | 16.26 | | |
| $Log_{10}$ext. Zn (no outliers) | 5058 | 0.7541 | -0.3010 | 2.447 | 0.1198 | 0.3461 | 0.8607 | | 280.2 |

Limits of the data before transformation; Note: Total concentration was obtained using digestion with *aqua regia* and extractable with EDTA.

Table 3.18: Summary statistics for Al, Ba, Ca, Co, ext. Co, Fe, Mn, ext. Mn, Na and Sr for England and Wales (mg $kg^{-1}$) with the data stratified according to altitude ? 300m.

| Variable | *n* | Mean | Minimum | Maximum | Variance | Standard deviation | Skewness | Upper data limit* |
|---|---|---|---|---|---|---|---|---|
| Al | 5092 | $2.887 \times 10^4$ | 491.0 | $7.936 \times 10^4$ | $1.536 \times 10^8$ | $1.239 \times 10^4$ | 0.1726 | |
| Ba | 5092 | 144.8 | 11.0 | 2973.0 | $1.813 \times 10^4$ | 134.6 | 9.249 | |
| $Log_{10}$Ba | 5092 | 2.079 | 1.041 | 3.473 | 0.06493 | 0.2548 | 0.07746 | |
| Ca | 5092 | $1.518 \times 10^4$ | 50.0 | $3.396 \times 10^5$ | $1.507 \times 10^9$ | $3.382 \times 10^4$ | 4.694 | |
| $Log_{10}$Ca | 5092 | 3.649 | 1.699 | 5.531 | 0.3623 | 0.6019 | 0.5928 | |
| Co | 5092 | 11.05 | 0.2 | 161.4 | 48.84 | 6.988 | 4.451 | |
| SqrtCo | 5092 | 3.177 | 0.4472 | 12.70 | 0.9543 | 0.9769 | 0.4254 | |
| ext. Co | 5068 | 1.125 | 0.0 | 15.7 | 1.379 | 1.174 | 3.241 | |
| $Log_{10}$ext. Co (no zeros) | 5040 | -0.131 | -1.0 | 1.196 | 0.1807 | 0.4251 | -0.2015 | |
| Fe | 5092 | $2.879 \times 10^4$ | 430.0 | $2.644 \times 10^5$ | $2.358 \times 10^8$ | $1.536 \times 10^4$ | 3.612 | |
| SqrtFe | 5092 | 164.4 | 20.74 | 514.2 | 1746.3 | 41.79 | 0.5479 | |
| Mn | 5092 | 783.4 | 3.0 | $1.793 \times 10^4$ | $6.380 \times 10^5$ | 798.7 | 8.169 | |
| $Log_{10}$Mn | 5092 | 2.744 | 0.4771 | 4.253 | 0.1571 | 0.3964 | -0.9826 | |
| ext. Mn | 5068 | 168.8 | 0.0 | 3108.0 | $3.463 \times 10^4$ | 186.1 | 4.308 | |
| $Log_{10}$ext. Mn (no zeros) | 5067 | 2.028 | 0.0 | 3.492 | 0.2089 | 0.4571 | -0.7970 | |
| Na | 5092 | 333.9 | 31.0 | $2.515 \times 10^4$ | $3.202 \times 10^5$ | 565.9 | 25.02 | |
| $Log_{10}$Na (no outliers) | 5087 | 2.421 | 1.491 | 3.770 | 0.06011 | 0.2452 | 0.8266 | 5940 |
| Sr | 5092 | 48.12 | 3.0 | 1445.0 | 4962.8 | 70.45 | 6.591 | |
| $Log_{10}$Sr | 5092 | 1.502 | 0.4771 | 3.160 | 0.1226 | 0.3502 | 0.8244 | |

* Limits of the data before transformation; Note: Total concentration using digestion with *aqua regia* and extractable with EDTA.

Table 3.19: Summary statistics for the total and ext. K, Mg and P concentration (mg $l^{-1}$), pH, organic C (%), clay (%), and altitude (m) for England and Wales with the data stratified according to altitude ? 300m.

| Variable | *n* | Mean | Minimum | Maximum | Variance | Standard deviation | Skewness |
|---|---|---|---|---|---|---|---|
| K | 5092 | 5085.9 | 60.0 | $2.044 \times 10^4$ | $6.893 \times 10^6$ | 2625.5 | 0.7324 |
| ext. K | 5015 | 177.4 | 12.0 | 2776.0 | $2.109 \times 10^4$ | 145.2 | 3.764 |
| $Log_{10}$ext. K | 5015 | 2.147 | 1.079 | 3.443 | 0.08422 | 0.2902 | 0.1962 |
| Mg | 5092 | 3934.2 | 41.0 | $6.269 \times 10^4$ | $1.138 \times 10^7$ | 3372.8 | 5.031 |
| $Log_{10}$Mg | 5092 | 3.477 | 1.613 | 4.797 | 0.1139 | 0.3375 | -0.6551 |
| ext. Mg | 5015 | 146.1 | 5.0 | 1601.0 | $1.986 \times 10^4$ | 140.94 | 2.911 |
| $Log_{10}$ext. Mg | 5015 | 2.022 | 0.6990 | 3.204 | 0.1190 | 0.3450 | 0.19337 |
| P | 5092 | 847.8 | 41.0 | 6273.0 | $2.024 \times 10^5$ | 449.87 | 2.299 |
| $Log_{10}$P | 5092 | 2.875 | 1.613 | 3.797 | 0.04875 | 0.2208 | -0.5268 |
| ext. P | 5011 | 27.09 | 1.0 | 337.0 | 593.1 | 24.35 | 3.073 |
| $Log_{10}$ext. P | 5011 | 1.297 | 0.0 | 2.528 | 0.1224 | 0.3499 | -0.1912 |
| pH | 5015 | 6.150 | 3.2 | 9.2 | 1.477 | 1.215 | -0.2088 |
| Organic C | 5083 | 4.723 | 0.1 | 65.9 | 32.55 | 5.705 | 5.018 |
| $Log_{10}$organic C | 5083 | 0.5333 | -1.0 | 1.819 | 0.1031 | 0.3211 | 0.4737 |
| Clay | 4588 | 25.37 | 0.0 | 87.9 | 153.7 | 12.40 | 0.7840 |
| Altitude | 5092 | 94.88 | -1.0 | 300.0 | 5250.5 | 72.46 | 0.8022 |

Note: Total concentration was obtained using digestion with *aqua regia*, extractable K and Mg with ammonium nitrate and extractable P with sodium bicarbonate (Olsen's P).

Table 3.20: Summary statistics for total and ext. Cr, Cu, Ni, Pb, and Zn for England and Wales (mg $kg^{-1}$) with the data stratified according to altitude > 300m.

| Variable | *n* | Mean | Minimum | Maximum | Variance | Standard deviation | Skewness |
|---|---|---|---|---|---|---|---|
| Cd | 565 | 0.8267 | 0.0 | 21.1 | 0.7281 | 0.8533 | 6.015 |
| $Log_{10}$Cd ( no zeros) | 556 | -0.2009 | -1.0 | 1.083 | 0.1103 | 0.3322 | -0.2800 |
| ext. Cd | 564 | 0.3720 | 0.0 | 4.8 | 0.1310 | 0.3620 | 5.847 |
| $Log_{10}$ext. Cd (no zeros) | 561 | -0.5201 | -1.0 | 0.6812 | 0.06809 | 0.2609 | 0.5986 |
| Cr | 565 | 24.58 | 0.2 | 131.7 | 429.5 | 20.73 | 1.069 |
| $Log_{10}$Cr | 565 | 1.198 | -0.6990 | 2.120 | 0.2097 | 0.4579 | -0.6377 |
| Cu | 565 | 19.93 | 1.9 | 457.9 | 599.5 | 24.48 | 11.14 |
| $Log_{10}$Cu | 565 | 1.189 | 0.2788 | 2.661 | 0.07939 | 0.2818 | 0.5471 |
| ext. Cu | 564 | 3.767 | 0.3 | 75.4 | 20.84 | 4.565 | 8.482 |
| $Log_{10}$ext. Cu | 564 | 0.4462 | -0.5229 | 1.877 | 0.09817 | 0.3133 | 0.3846 |
| Ni | 565 | 12.57 | 0.8 | 92.5 | 148.7 | 12.20 | 2.57 |
| $Log_{10}$Ni | 565 | 0.9401 | -0.09691 | 1.966 | 0.1397 | 0.3737 | 0.02478 |
| ext. Ni | 564 | 0.8697 | 0.1 | 7.5 | 0.6531 | 0.8082 | 3.592 |
| $Log_{10}$ext. Ni | 564 | -0.1676 | -1.0 | 0.8751 | 0.08188 | 0.2861 | 0.4625 |
| Pb | 565 | 175.0 | 13.0 | 4578.0 | $7.979 \times 10^4$ | 282.5 | 9.228 |
| $Log_{10}$Pb | 565 | 2.055 | 1.114 | 3.661 | 0.1376 | 0.3710 | 0.4957 |
| ext. Pb | 564 | 59.47 | 3.1 | 3572.9 | $2.643 \times 10^4$ | 162.6 | 18.30 |
| $Log_{10}$ext Pb | 564 | 1.544 | 0.4914 | 3.553 | 0.1615 | 0.4019 | 0.2848 |
| Zn | 565 | 74.95 | 10.0 | 753.0 | 5037.9 | 70.98 | 4.586 |
| $Log_{10}$Zn | 565 | 1.773 | 1.0 | 2.877 | 0.07845 | 0.2801 | 0.4147 |
| ext. Zn | 564 | 11.10 | 0.8 | 109.1 | 118.7 | 10.89 | 4.441 |
| $Log_{10}$ext. Zn | 564 | 0.9148 | -0.09691 | 2.038 | 0.1102 | 0.3319 | 0.07338 |

Note: Total concentration was obtained using digestion with *aqua regia* and extractable with EDTA.

Table 3.21: Summary statistics for Al, Ba, Ca, Co, ext. Co, Fe, Mn, ext. Mn, Na and Sr for England and Wales (mg $kg^{-1}$) with the data stratified according to altitude > 300m.

| Variable | *n* | Mean | Minimum | Maximum | Variance | Standard deviation | Skewness | Upper data limit* |
|---|---|---|---|---|---|---|---|---|
| Al | 565 | $1.925 \times 10^4$ | 880.0 | $6.087 \times 10^4$ | $1.893 \times 10^8$ | $1.376 \times 10^4$ | -0.975 | |
| Ba | 565 | 104.2 | 11.0 | 967.0 | $1.033 \times 10^4$ | 101.6 | 3.459 | |
| $Log_{10}$Ba | 565 | 1.879 | 1.041 | 2.985 | 0.1163 | 0.3411 | 0.1883 | |
| Ca | 565 | 1533.7 | 71.0 | $3.867 \times 10^4$ | $5.937 \times 10^6$ | 2436.5 | 7.637 | |
| $Log_{10}$Ca | 565 | 2.913 | 1.851 | 4.587 | 0.2298 | 0.4794 | 0.1925 | |
| Co | 565 | 6.443 | 0.2 | 321.8 | 366.1 | 19.13 | 14.19 | |
| $Log_{10}$Co | 565 | 0.4661 | -0.6990 | 2.508 | 0.2569 | 0.5068 | 0.3906 | |
| ext. Co | 564 | 0.5106 | 0.0 | 26.5 | 1.768 | 1.329 | 14.33 | |
| $Log_{10}$ext. Co (no zeros) | 542 | -0.5528 | -1.0 | 1.423 | 0.1787 | 0.4228 | 0.8953 | |
| Fe | 565 | $1.937 \times 10^4$ | 395.0 | $2.052 \times 10^5$ | $3.107 \times 10^8$ | $1.763 \times 10^4$ | 2.830 | |
| $Log_{10}$Fe | 565 | 4.099 | 2.597 | 5.312 | 0.1907 | 0.4367 | -0.3004 | |
| Mn | 565 | 522.4 | 3.0 | $4.260 \times 10^4$ | $3.844 \times 10^6$ | 1960.7 | 17.85 | |
| $Log_{10}$Mn | 565 | 2.157 | 0.4771 | 4.629 | 0.5165 | 0.7187 | 0.2723 | |
| Ext. Mn | 564 | 75.14 | 1.0 | 2933.0 | $3.664 \times 10^4$ | 191.4 | 8.384 | |
| $Log_{10}$ext. Mn | 564 | 1.317 | 0.0 | 3.467 | 0.4834 | 0.6952 | 0.2938 | |
| Na | 565 | 310.4 | 52.0 | 2259.0 | $9.604 \times 10^4$ | 309.9 | 3.079 | |
| $Log_{10}$Na (no outliers) | 561 | 2.366 | 1.716 | 3.240 | 0.07700 | 0.2775 | 0.9738 | 1737.0 |
| Sr | 565 | 18.60 | 3.0 | 120.0 | 185.0 | 13.60 | 3.150 | |
| $Log_{10}$Sr | 565 | 1.189 | 0.4771 | 2.079 | 0.06569 | 0.2563 | 0.2600 | |

* Limits of the data before transformation

Note: Total concentration was obtained using digestion with *aqua regia* and extractable with EDTA.

Table 3.22: Summary statistics for the total and ext. K, Mg and P concentration (mg $l^{-1}$), pH, organic C (%), clay (%), and altitude (m) for England and Wales with the data stratified according to altitude > 300m.

| Variable | *n* | Mean | Minimum | Maximum | Variance | Standard deviation | Skewness | Upper data limit* |
|---|---|---|---|---|---|---|---|---|
| K | 565 | 3443.6 | 104.0 | $1.357 \times 10^4$ | $6.977 \times 10^6$ | 2641.4 | 0.7206 | |
| ext. K | 549 | 105.3 | 7.0 | 563.0 | 3759.0 | 61.31 | 2.223 | |
| $Log_{10}$ext. K | 549 | 1.956 | 0.8451 | 2.751 | 0.06332 | 0.2516 | -0.6997 | |
| Mg | 565 | 1978.2 | 142.0 | $1.199 \times 10^4$ | $4.652 \times 10^6$ | 2156.8 | 1.979 | |
| $Log_{10}$ Mg | 565 | 3.083 | 2.152 | 4.079 | 0.1818 | 0.4264 | 0.3105 | |
| ext. Mg | 549 | 95.84 | 1.0 | 845.0 | 8661.3 | 93.07 | 3.695 | |
| $Log_{10}$ext. Mg | 549 | 1.856 | 0.0 | 2.927 | 0.1033 | 0.3214 | -0.009633 | |
| P | 565 | 837.7 | 142.0 | 2393.0 | $1.435 \times 10^5$ | 378.9 | 0.8466 | |
| ext. P | 549 | 16.57 | 1.0 | 157.0 | 186.8 | 13.67 | 3.923 | |
| $Log_{10}$ext. P | 549 | 1.107 | 0.0 | 2.196 | 0.1055 | 0.3248 | -0.4492 | |
| pH | 549 | 4.253 | 3.1 | 7.5 | 0.7409 | 0.8608 | 1.363 | |
| Organic C | 565 | 24.16 | 0.5 | 57.6 | 347.5 | 18.64 | 0.3627 | |
| Clay | 238 | 22.52 | 2.8 | 46.4 | 101.5 | 10.08 | 0.1526 | |
| Altitude | 565 | 438.6 | 302.0 | 1400.0 | $2.391 \times 10^4$ | 154.6 | 3.192 | |
| $Log_{10}$altitude (no outliers) | 554 | 2.615 | 2.480 | 3.002 | 0.009589 | 0.09792 | 0.9319 | 1005.0 |

* Limits of the data before transformation

Note: Total concentration was obtained using digestion with *aqua regia*, extractable K and Mg with ammonium nitrate and extractable P with sodium bicarbonate (Olsen's P).

Table 3.23: Selected latent roots of the correlation matrix for the stratified data.

| | Latent roots | | | | % variance | | | |
|---|---|---|---|---|---|---|---|---|
| | Rainfall | | Altitude | | Rainfall | | Altitude | |
| Root | ?800mm | >800mm | ?300m | >300m | ?800mm | >800mm | ?300m | >300m |
| 1 | 11.51 | 11.24 | 11.04 | 10.79 | 38.38 | 37.45 | 36.78 | 35.96 |
| 2 | 3.838 | 4.634 | 3.828 | 4.683 | 12.79 | 15.78 | 12.76 | 15.61 |
| 3 | 2.938 | 2.001 | 2.833 | 2.373 | 9.79 | 6.67 | 9.44 | 7.91 |
| 4 | 1.030 | 1.767 | 2.109 | 1.897 | 6.77 | 5.89 | 7.03 | 6.32 |
| 5 | 1.745 | 1.409 | 1.73 | 1.667 | 5.82 | 4.70 | 5.77 | 5.56 |

Table 3.24: Eigenvectors for data stratified according to rainfall ?800 mm and >800mm.

| | Data ?800 mm | | | | | Data >800 mm | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Eigenvector | | | | | Eigenvector | | | | |
| Variable | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Al | **–0.250** | 0.076 | 0.169 | –0.079 | 0.003 | –0.244 | –0.124 | 0.100 | –0.007 | –0.090 |
| Ba | –0.223 | –0.079 | 0.069 | –0.003 | 0.046 | –0.233 | –0.017 | 0.082 | –0.053 | 0.006 |
| Ca | –0.098 | **0.359** | **–0.314** | 0.025 | 0.053 | –0.170 | –0.079 | **–0.363** | 0.048 | 0.173 |
| Cd | –0.237 | 0.059 | –0.071 | –0.029 | 0.253 | –0.184 | –0.214 | 0.239 | 0.067 | 0.117 |
| ext. Cd | –0.123 | –0.173 | –0.273 | 0.001 | 0.167 | –0.026 | **–0.349** | –0.031 | –0.112 | 0.160 |
| Co | –0.222 | 0.037 | 0.154 | 0.140 | 0.224 | **–0.264** | 0.031 | 0.112 | –0.083 | –0.013 |
| ext. Co | –0.150 | –0.213 | 0.251 | 0.249 | –0.015 | –0.211 | –0.059 | 0.013 | –0.200 | 0.121 |
| Cr | **–0.250** | 0.061 | 0.186 | –0.090 | 0.011 | **–0.264** | 0.099 | 0.067 | –0.027 | –0.075 |
| Cu | –0.232 | –0.095 | –0.161 | 0.019 | –0.062 | –0.142 | –0.256 | 0.091 | 0.027 | **–0.369** |
| ext. Cu | –0.174 | –0.250 | –0.092 | 0.127 | –0.257 | –0.147 | –0.239 | –0.073 | –0.140 | **–0.370** |
| Fe | –0.232 | 0.024 | 0.185 | 0.001 | 0.080 | –0.206 | 0.037 | 0.290 | 0.112 | 0.049 |
| K | –0.216 | 0.062 | 0.168 | –0.187 | –0.244 | –0.224 | 0.114 | 0.102 | 0.158 | 0.006 |
| ext. K | –0.141 | 0.099 | –0.118 | 0.017 | **–0.421** | –0.086 | –0.052 | –0.223 | 0.290 | 0.040 |
| Mg | –0.231 | 0.116 | 0.067 | –0.104 | –0.127 | –0.246 | 0.109 | –0.001 | –0.022 | –0.042 |
| ext. Mg | –0.179 | –0.091 | 0.085 | –0.233 | –0.242 | –0.100 | –0.107 | **–0.336** | 0.148 | **0.435** |
| Mn | –0.177 | 0.111 | –0.032 | **0.353** | 0.278 | **–0.259** | 0.089 | 0.036 | –0.116 | –0.030 |
| ext. Mn | –0.155 | –0.127 | 0.180 | **0.429** | 0.066 | –0.246 | 0.044 | –0.081 | –0.208 | 0.062 |
| Na | –0.190 | 0.115 | 0.008 | –0.136 | –0.170 | –0.165 | –0.094 | 0.148 | **0.388** | 0.001 |
| Ni | **–0.253** | 0.113 | 0.066 | 0.033 | 0.098 | **–0.267** | –0.033 | 0.065 | –0.109 | –0.065 |
| ext. Ni | –0.199 | –0.176 | 0.075 | –0.004 | –0.191 | –0.138 | –0.256 | –0.160 | –0.190 | 0.158 |
| P | –0.173 | 0.098 | **–0.315** | 0.132 | 0.007 | –0.124 | –0.153 | –0.105 | **0.395** | –0.287 |
| ext. P | –0.017 | –0.037 | –0.291 | **0.304** | **–0.390** | –0.041 | –0.090 | **–0.416** | 0.218 | **–0.421** |
| Pb | –0.126 | –0.271 | –0.218 | –0.093 | 0.236 | 0.066 | **–0.365** | 0.243 | 0.018 | –0.053 |
| ext. Pb | –0.063 | **–0.413** | –0.120 | –0.042 | 0.018 | 0.087 | **–0.358** | 0.125 | –0.137 | –0.023 |
| Sr | –0.126 | **0.334** | –0.265 | –0.065 | 0.117 | –0.180 | –0.037 | –0.073 | 0.252 | 0.174 |
| Zn | **–0.255** | –0.066 | –0.126 | 0.033 | 0.147 | –0.209 | –0.232 | 0.089 | –0.049 | 0.053 |
| ext. Zn | –0.097 | **–0.306** | **–0.310** | 0.000 | –0.050 | 0.038 | **–0.381** | –0.088 | –0.047 | 0.098 |
| pH | –0.070 | **0.317** | –0.156 | 0.252 | –0.156 | –0.185 | 0.051 | **–0.335** | –0.096 | 0.061 |
| org. C | –0.074 | –0.091 | –0.209 | **–0.439** | 0.187 | 0.180 | –0.219 | 0.145 | **0.312** | 0.074 |
| Clay | –0.193 | 0.099 | 0.082 | –0.276 | 0.058 | –0.099 | –0.062 | 0.184 | **0.345** | 0.294 |

Vectors for important variables are in bold.

Table 3.25: Eigenvectors for data stratified according to altitude ?300 m and >300m.

| | Data ?300 m | | | | | Data >300 m | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Eigenvector | | | | | Eigenvector | | | | |
| Variable | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Al | **–0.251** | 0.123 | –0.152 | –0.118 | –0.056 | **0.257** | –0.095 | 0.139 | 0.144 | –0.049 |
| Ba | –0.220 | –0.050 | –0.141 | –0.066 | 0.087 | 0.244 | 0.056 | 0.004 | –0.019 | 0.030 |
| Ca | –0.098 | 0.187 | **0.466** | –0.028 | 0.081 | 0.091 | 0.218 | **–0.356** | –0.134 | –0.138 |
| Cd | –0.244 | –0.026 | 0.040 | –0.124 | 0.147 | 0.143 | 0.283 | 0.001 | –0.107 | 0.250 |
| ext. Cd | –0.114 | –0.279 | 0.184 | 0.040 | 0.020 | 0.001 | **0.309** | 0.106 | 0.059 | –0.142 |
| Co | –0.249 | 0.099 | –0.106 | 0.110 | 0.154 | **0.271** | 0.026 | 0.027 | –0.106 | 0.080 |
| ext. Co | –0.166 | –0.073 | –0.200 | **0.387** | –0.101 | 0.207 | 0.112 | 0.012 | –0.091 | –0.126 |
| Cr | **–0.257** | 0.123 | –0.130 | –0.062 | –0.063 | **0.278** | –0.052 | 0.128 | 0.075 | –0.036 |
| Cu | –0.216 | –0.183 | 0.080 | –0.066 | 0.091 | 0.050 | 0.271 | 0.296 | 0.124 | 0.218 |
| ext. Cu | –0.167 | –0.269 | 0.054 | 0.158 | –0.064 | 0.101 | 0.215 | **0.377** | 0.180 | 0.023 |
| Fe | **–0.252** | 0.102 | –0.158 | –0.017 | 0.055 | **0.265** | –0.040 | 0.064 | 0.016 | 0.150 |
| K | –0.211 | 0.116 | –0.126 | –0.133 | –0.265 | 0.248 | –0.146 | 0.040 | 0.094 | 0.084 |
| ext. K | –0.116 | 0.053 | 0.255 | 0.101 | **–0.346** | 0.074 | 0.000 | –0.091 | **–0.487** | –0.197 |
| Mg | –0.229 | 0.138 | –0.042 | –0.084 | –0.097 | **0.266** | –0.067 | –0.018 | –0.039 | 0.014 |
| ext. Mg | –0.157 | –0.048 | –0.004 | –0.007 | **–0.443** | –0.006 | 0.178 | **–0.436** | 0.018 | –0.262 |
| Mn | –0.206 | 0.133 | –0.062 | 0.167 | **0.366** | **0.275** | –0.015 | –0.038 | –0.051 | –0.050 |
| ext. Mn | –0.178 | 0.009 | –0.174 | **0.406** | 0.156 | **0.255** | 0.045 | –0.076 | –0.072 | –0.189 |
| Na | –0.166 | 0.106 | –0.074 | –0.249 | 0.021 | 0.159 | –0.073 | –0.229 | 0.097 | **0.392** |
| Ni | **–0.269** | 0.095 | 0.010 | 0.028 | 0.053 | **0.254** | 0.129 | 0.143 | –0.047 | –0.001 |
| ext. Ni | –0.179 | –0.151 | 0.032 | 0.228 | **–0.341** | 0.076 | **0.311** | 0.116 | 0.037 | –0.278 |
| P | –0.177 | –0.032 | 0.264 | –0.075 | 0.193 | 0.065 | 0.136 | –0.176 | **0.494** | 0.116 |
| ext. P | –0.019 | –0.086 | **0.311** | 0.238 | –0.036 | –0.017 | 0.067 | –0.132 | **0.520** | –0.086 |
| Pb | –0.111 | **–0.357** | –0.020 | –0.194 | 0.227 | –0.132 | **0.326** | 0.099 | –0.026 | 0.188 |
| ext. Pb | –0.045 | **–0.432** | –0.059 | –0.003 | 0.016 | –0.128 | 0.291 | 0.205 | 0.008 | 0.006 |
| Sr | –0.131 | 0.189 | **0.371** | –0.149 | 0.093 | 0.123 | 0.137 | **–0.340** | –0.092 | 0.270 |
| Zn | **–0.255** | –0.129 | 0.055 | –0.026 | 0.158 | 0.141 | 0.297 | –0.128 | –0.233 | 0.010 |
| ext. Zn | –0.080 | **0.381** | 0.183 | 0.074 | –0.058 | –0.146 | **0.322** | –0.085 | –0.057 | –0.091 |
| pH | –0.066 | 0.226 | **0.363** | 0.223 | 0.004 | 0.204 | 0.043 | –0.129 | –0.016 | –0.289 |
| org. C | –0.038 | –0.220 | 0.054 | **–0.458** | –0.053 | –0.236 | 0.154 | –0.142 | 0.105 | 0.182 |
| Clay | –0.177 | 0.074 | 0.016 | –0.199 | **–0.322** | 0.076 | 0.018 | –0.147 | 0.109 | **0.401** |

Vectors for important variables are marked by *.

Table 3.26: Qualitative variables

| |
|---|
| Coded pH |
| Carbonates |
| Ped Shape |
| Particle size class |
| Stone type |
| Solid geology |
| Land use |