**Supplemental Material**

**Contamination characteristics of PM2.5, mass concentration and source analysis of metal elements in PM2.5 in Lanzhou, China**

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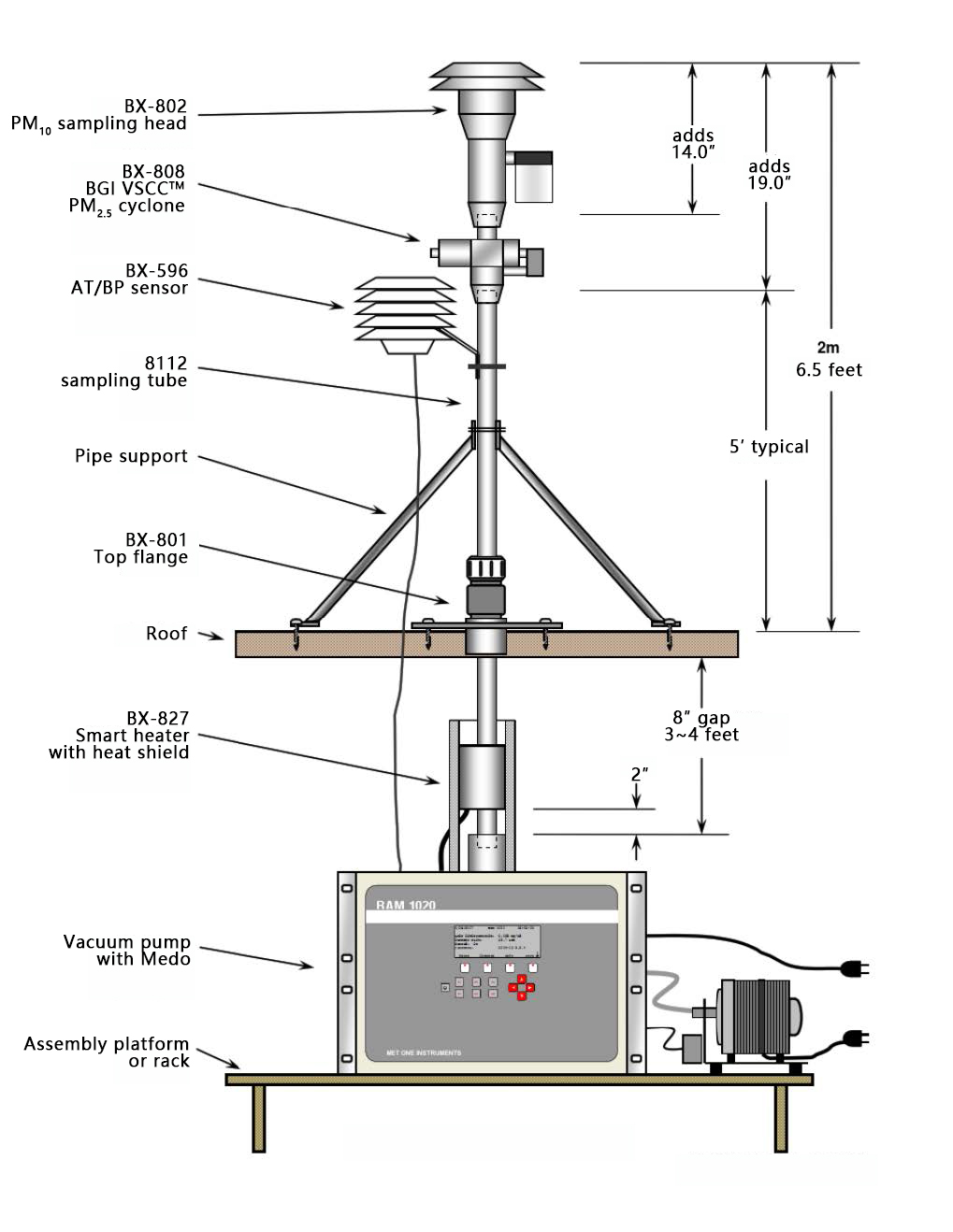
**Figure S1.** The instrument details and schematic diagram of PM2.5 sampler in this study, the particle was detected by β-ray attenuation principle. (Page 2)

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**Table S4.** The concentration of bound heavy metals in atmospheric PM2.5 in Lanzhou (μg·m-3). This is the original data of Figure 5 and Figure 6 in the manuscript. (Page 7)

**Figure S1.** The instrument details and schematic diagram of PM2.5 sampler in this study, the particle was detected by β-ray attenuation principle.

**Table S1.** The setting parameters of instrument.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ICP-MS | Atomized gas | Cooling  gas | Auxiliary  gas | Extraction voltage | RF power | Sampling depth |
|  | 0.86L/min | 13.0L/min | 0.80L/min | -134.0 V | 1216 W | 150 steps |
| AFS | Carrier gas | Shielding  gas | Negative high voltage | Current-carrying | Lamp current (As) | Lamp current (Hg) |
|  | 400ml/min | 800ml/min | 270 | 5% HCl | 60mA | 30mA |

**Table S2.** Quality control in metal determination process.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Heavy metal | Regression  equation | R | Detection limit (μg/L) | Measurement value | | |
| Blank  (μg/L) | Sample  (μg/L) | Recovery rate（%） |
| V | y=15592x+7843 | 0.9999 | 0.0002 | 32.05±2.20 | 43.30±2.71 | 123.0±1.41 |
| Mn | y=29106x+10316 | 0.9999 | 0.0001 | 42.80±3.25 | 66.20±5.71 | 92.10±4.67 |
| Co | y=21445x+534 | 0.9999 | 0.0002 | 1.980±0.24 | 3.000±0.01 | 100.5±0.71 |
| Sb | y=11504x+256 | 0.9999 | 0.0004 | 3.005±0.01 | 3.810±0.13 | 97.50±3.53 |
| Fe | y=14811x+1104735 | 0.9994 | 0.0580 | 2561±45.25 | 2495±275.8 | 99.45±1.20 |
| Cu | y=5377x+3674 | 0.9999 | 0.0005 | 42.60±5.23 | 47.55±2.05 | 95.20±2.26 |
| Cd | y=5026x+201 | 0.9994 | 0.0005 | 1.170±0.01 | 3.750±0.07 | 101.5±0.71 |
| Pb | y=72353x+34120 | 0.9991 | 0.0008 | 11.95±0.21 | 49.75±0.21 | 114.5±2.12 |
| Hg | y=568.013x-6.0304 | 0.9998 | 0.0007 | 0.210±0.01 | 0.440±0.04 | 86.40±2.55 |
| As | y=246.817x+67.383 | 0.9998 | 0.0067 | 0.570±0.04 | 3.000±0.48 | 86.10±0.99 |

**Table S3.** The concentration of atmospheric PM2.5 in Lanzhou (mg·m-3). This is the original data of Figure 2 in the manuscript. (LZU, Lanzhou University; BPI, Biological Products Institute; RDI, Railway Design Institute; SWH, Staff and Works Hospital; LYH, Lanyuan Hotel)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | BPI | | | | RDI | | | | SWH | | | |
|  | Spring | Summer | Autumn | Winter | Spring | Summer | Autumn | Winter | Spring | Summer | Autumn | Winter |
| 1 | 0.028 | 0.065 | 0.051 | 0.017 | 0.019 | 0.063 | 0.039 | 0.028 | 0.041 | 0.064 | 0.064 | 0.033 |
| 2 | 0.046 | 0.057 | 0.050 | 0.017 | 0.033 | 0.055 | 0.039 | 0.026 | 0.031 | 0.073 | 0.073 | 0.040 |
| 3 | 0.048 | 0.055 | 0.046 | 0.030 | 0.044 | 0.049 | 0.040 | 0.036 | 0.041 | 0.098 | 0.098 | 0.038 |
| 4 | 0.054 | 0.060 | 0.062 | 0.048 | 0.047 | 0.067 | 0.051 | 0.057 | 0.068 | 0.085 | 0.085 | 0.098 |
| 5 | 0.021 | 0.053 | 0.094 | 0.053 | 0.022 | 0.058 | 0.055 | 0.091 | 0.057 | 0.085 | 0.085 | 0.088 |
| 6 | 0.019 | 0.042 | 0.052 | 0.060 | 0.017 | 0.048 | 0.035 | 0.113 | 0.027 | 0.067 | 0.067 | 0.091 |
| 7 | 0.018 | 0.016 | 0.042 | 0.084 | 0.018 | 0.023 | 0.039 | 0.104 | 0.023 | 0.030 | 0.030 | 0.104 |
| 8 | 0.039 | 0.023 | 0.051 | 0.084 | 0.027 | 0.016 | 0.051 | 0.079 | 0.328 | 0.033 | 0.033 | 0.113 |
| 9 | 0.044 | 0.026 | 0.048 | 0.071 | 0.039 | 0.020 | 0.056 | 0.098 | 0.050 | 0.036 | 0.036 | 0.089 |
| 10 | 0.046 | 0.029 | 0.052 | 0.059 | 0.043 | 0.021 | 0.051 | 0.081 | 0.227 | 0.047 | 0.047 | 0.093 |
| 11 | 0.048 | 0.035 | 0.050 | 0.066 | 0.045 | 0.023 | 0.049 | 0.089 | 0.060 | 0.042 | 0.042 | 0.098 |
| 12 | 0.059 | 0.031 | 0.081 | 0.098 | 0.054 | 0.025 | 0.069 | 0.108 | 0.088 | 0.063 | 0.063 | 0.181 |
| 13 | 0.022 | 0.042 | 0.078 | 0.104 | 0.020 | 0.050 | 0.088 | 0.141 | 0.072 | 0.075 | 0.075 | 0.150 |
| 14 | 0.020 | 0.033 | 0.043 | 0.069 | 0.015 | 0.045 | 0.046 | 0.081 | 0.028 | 0.059 | 0.059 | 0.119 |
| 15 | 0.021 | 0.048 | 0.058 | 0.056 | 0.018 | 0.026 | 0.064 | 0.087 | 0.024 | 0.063 | 0.063 | 0.091 |
| 16 | 0.027 | 0.033 | 0.073 | 0.062 | 0.024 | 0.029 | 0.080 | 0.063 | 0.028 | 0.040 | 0.040 | 0.086 |
| 17 | 0.046 | 0.033 | 0.046 | 0.054 | 0.037 | 0.021 | 0.059 | 0.056 | 0.044 | 0.035 | 0.035 | 0.062 |
| 18 | 0.074 | 0.035 | 0.042 | 0.052 | 0.039 | 0.024 | 0.035 | 0.056 | 0.211 | 0.046 | 0.046 | 0.058 |
| 19 | 0.059 | 0.052 | 0.045 | 0.063 | 0.044 | 0.056 | 0.037 | 0.065 | 0.062 | 0.056 | 0.056 | 0.067 |
| 20 | 0.072 | 0.062 | 0.043 | 0.084 | 0.061 | 0.086 | 0.033 | 0.080 | 0.091 | 0.084 | 0.084 | 0.095 |
| 21 | 0.044 | 0.060 | 0.056 | 0.064 | 0.046 | 0.026 | 0.048 | 0.092 | 0.082 | 0.074 | 0.074 | 0.092 |
| 22 | 0.021 | 0.028 | 0.046 | 0.063 | 0.016 | 0.034 | 0.040 | 0.074 | 0.023 | 0.058 | 0.058 | 0.090 |
| 23 | 0.024 | 0.042 | 0.040 | 0.069 | 0.016 | 0.038 | 0.033 | 0.093 | 0.028 | 0.046 | 0.046 | 0.102 |
| 24 | 0.092 | 0.061 | 0.033 | 0.077 | 0.029 | 0.044 | 0.028 | 0.068 | 0.073 | 0.048 | 0.048 | 0.085 |
| 25 | 0.167 | 0.054 | 0.015 | 0.096 | 0.030 | 0.045 | 0.013 | 0.064 | 0.056 | 0.045 | 0.045 | 0.068 |
| 26 | 0.080 | 0.055 | 0.016 | 0.065 | 0.031 | 0.060 | 0.013 | 0.082 | 0.070 | 0.058 | 0.058 | 0.069 |
| 27 | 0.056 | 0.071 | 0.014 | 0.067 | 0.034 | 0.098 | 0.013 | 0.089 | 0.071 | 0.070 | 0.070 | 0.080 |
| 28 | 0.356 | 0.104 | 0.015 | 0.090 | 0.061 | 0.081 | 0.015 | 0.116 | 0.099 | 0.127 | 0.127 | 0.072 |
| 29 | 0.057 | 0.075 | 0.030 | 0.121 | 0.027 | 0.037 | 0.029 | 0.150 | 0.082 | 0.117 | 0.117 | 0.078 |
| 30 | 0.226 | 0.037 | 0.028 | 0.151 | 0.020 | 0.020 | 0.025 | 0.140 | 0.028 | 0.072 | 0.072 | 0.102 |
| 31 | 0.267 | 0.027 | 0.023 | 0.151 | 0.018 | 0.027 | 0.019 | 0.147 | 0.025 | 0.055 | 0.055 | 0.162 |
| 32 | 0.745 | 0.035 | 0.026 | 0.161 | 0.027 | 0.037 | 0.022 | 0.171 | 0.056 | 0.073 | 0.073 | 0.169 |
| 33 | 0.068 | 0.047 | 0.023 | 0.143 | 0.043 | 0.046 | 0.022 | 0.161 | 0.065 | 0.067 | 0.067 | 0.148 |
| 34 | 0.058 | 0.052 | 0.025 | 0.136 | 0.050 | 0.042 | 0.020 | 0.155 | 0.064 | 0.062 | 0.062 | 0.144 |
| 35 | 0.064 | 0.065 | 0.036 | 0.149 | 0.049 | 0.059 | 0.035 | 0.161 | 0.080 | 0.063 | 0.063 | 0.148 |
| 36 | 0.109 | 0.074 | 0.027 | 0.198 | 0.087 | 0.058 | 0.031 | 0.170 | 0.137 | 0.985 | 0.129 | 0.207 |
| 37 | 0.103 | 0.048 | 0.032 | 0.200 | 0.072 | 0.026 | 0.028 | 0.138 | 0.120 | 0.037 | 0.985 | 0.259 |
| 38 | 0.038 | 0.035 | 0.023 | 0.169 | 0.024 | 0.017 | 0.017 | 0.214 | 0.060 | 0.038 | 0.037 | 0.215 |
| 39 | 0.030 | 0.026 | 0.026 | 0.152 | 0.023 | 0.013 | 0.028 | 0.155 | 0.027 | 0.033 | 0.038 | 0.194 |
| 40 | 0.055 | 0.025 | 0.029 | 0.163 | 0.036 | 0.019 | 0.021 | 0.132 | 0.057 | 0.058 | 0.033 | 0.142 |
| 41 | 0.091 | 0.039 | 0.034 | 0.093 | 0.043 | 0.038 | 0.026 | 0.145 | 0.086 | 0.062 | 0.058 | 0.117 |
| 42 | 0.084 | 0.058 | 0.026 | 0.053 | 0.055 | 0.040 | 0.022 | 0.136 | 0.107 | 0.097 | 0.062 | 0.079 |
| 43 | 0.077 | 0.072 | 0.032 | 0.052 | 0.057 | 0.049 | 0.026 | 0.109 | 0.090 | 0.092 | 0.097 | 0.059 |
| 44 | 0.113 | 0.086 | 0.032 | 0.084 | 0.085 | 0.066 | 0.034 | 0.083 | 0.149 | 0.097 | 0.092 | 0.095 |
| 45 | 0.069 | 0.073 | 0.035 | 0.094 | 0.052 | 0.063 | 0.034 | 0.115 | 0.143 | 0.041 | 0.097 | 0.129 |
| 46 | 0.047 | 0.050 | 0.018 | 0.075 | 0.031 | 0.043 | 0.018 | 0.109 | 0.054 | 0.035 | 0.041 | 0.085 |
| 47 | 0.038 | 0.039 | 0.022 | 0.081 | 0.032 | 0.030 | 0.017 | 0.101 | 0.040 | 0.036 | 0.035 | 0.098 |
| 48 | 0.059 | 0.030 | 0.023 | 0.099 | 0.043 | 0.021 | 0.019 | 0.114 | 0.045 | 0.036 | 0.036 | 0.136 |
| 49 | 0.072 | 0.033 | 0.028 | 0.080 | 0.050 | 0.029 | 0.020 | 0.111 | 0.065 | 0.039 | 0.036 | 0.123 |
| 50 | 0.062 | 0.032 | 0.042 | 0.055 | 0.055 | 0.037 | 0.036 | 0.102 | 0.062 | 0.065 | 0.039 | 0.108 |
| 51 | 0.074 | 0.038 | 0.051 | 0.084 | 0.178 | 0.030 | 0.046 | 0.100 | 0.077 | 0.038 | 0.065 | 0.112 |
| 52 | 0.105 | 0.031 | 0.059 | 0.132 | 0.080 | 0.025 | 0.053 | 0.118 | 0.138 | 0.038 | 0.038 | 0.169 |
| 53 | 0.088 | 0.042 | 0.055 | 0.153 | 0.066 | 0.027 | 0.044 | 0.175 | 0.114 | 0.037 | 0.038 | 0.199 |
| 54 | 0.039 | 0.035 | 0.032 | 0.128 | 0.035 | 0.028 | 0.025 | 0.173 | 0.053 | 0.032 | 0.037 | 0.140 |
| 55 | 0.036 | 0.026 | 0.038 | 0.171 | 0.033 | 0.021 | 0.026 | 0.151 | 0.039 | 0.023 | 0.032 | 0.159 |
| 56 | 0.093 | 0.025 | 0.051 | 0.152 | 0.051 | 0.016 | 0.039 | 0.161 | 0.108 | 0.021 | 0.023 | 0.151 |
| 57 | 0.080 | 0.021 | 0.053 | 0.119 | 0.056 | 0.015 | 0.042 | 0.156 | 0.113 | 0.038 | 0.021 | 0.127 |
| 58 | 0.066 | 0.035 | 0.054 | 0.117 | 0.057 | 0.019 | 0.045 | 0.145 | 0.103 | 0.044 | 0.038 | 0.127 |
| 59 | 0.066 | 0.025 | 0.052 | 0.128 | 0.067 | 0.024 | 0.042 | 0.131 | 0.122 | 0.034 | 0.044 | 0.133 |
| 60 | 0.108 | 0.052 | 0.075 | 0.165 | 0.089 | 0.033 | 0.051 | 0.156 | 0.144 | 0.040 | 0.034 | 0.211 |
| 61 | 0.080 | 0.050 | 0.046 | 0.190 | 0.065 | 0.025 | 0.053 | 0.197 | 0.141 | 0.043 | 0.040 | 0.232 |
| 62 | 0.041 | 0.032 | 0.026 | 0.164 | 0.116 | 0.023 | 0.022 | 0.193 | 0.059 | 0.032 | 0.043 | 0.164 |
| 63 | 0.048 | 0.028 | 0.047 | 0.121 | 0.223 | 0.019 | 0.039 | 0.157 | 0.028 | 0.024 | 0.032 | 0.173 |
| 64 | 0.118 | 0.030 | 0.077 | 0.179 | 0.088 | 0.027 | 0.059 | 0.179 | 0.048 | 0.024 | 0.024 | 0.147 |
| 65 | 0.361 | 0.041 | 0.059 | 0.096 | 0.314 | 0.032 | 0.070 | 0.135 | 0.468 | 0.035 | 0.024 | 0.093 |
| 66 | 0.209 | 0.043 | 0.056 | 0.068 | 0.219 | 0.057 | 0.069 | 0.122 | 0.237 | 0.074 | 0.035 | 0.078 |
| 67 | 0.406 | 0.035 | 0.063 | 0.068 | 0.094 | 0.046 | 0.068 | 0.105 | 0.119 | 0.077 | 0.074 | 0.075 |
| 68 | 0.710 | 0.039 | 0.092 | 0.118 | 0.088 | 0.030 | 0.080 | 0.138 | 0.111 | 0.050 | 0.077 | 0.116 |
| 69 | 0.600 | 0.051 | 0.092 | 0.181 | 0.103 | 0.035 | 0.096 | 0.185 | 0.131 | 0.045 | 0.050 | 0.119 |
| 70 | 0.181 | 0.044 | 0.063 | 0.120 | 0.092 | 0.043 | 0.061 | 0.147 | 0.415 | 0.059 | 0.045 | 0.140 |
| 71 | 0.151 | 0.049 | 0.058 | 0.118 | 0.066 | 0.033 | 0.048 | 0.133 | 0.107 | 0.061 | 0.059 | 0.160 |
| 72 | 0.189 | 0.045 | 0.071 | 0.125 | 0.166 | 0.042 | 0.073 | 0.151 | 0.078 | 0.049 | 0.061 | 0.134 |
| 73 | 0.182 | 0.034 | 0.053 | 0.106 | 0.347 | 0.034 | 0.067 | 0.012 | 0.065 | 0.047 | 0.049 | 0.127 |
| 74 | 0.144 | 0.043 | 0.052 | 0.098 | 0.252 | 0.029 | 0.068 | 0.125 | 0.123 | 0.049 | 0.047 | 0.125 |
| 75 | 0.167 | 0.031 | 0.058 | 0.112 | 0.143 | 0.036 | 0.068 | 0.138 | 0.117 | 0.056 | 0.049 | 0.131 |
| 76 | 0.113 | 0.030 | 0.092 | 0.172 | 0.191 | 0.029 | 0.085 | 1.783 | 0.137 | 0.051 | 0.056 | 0.193 |
| 77 | 0.118 | 0.035 | 0.080 | 0.198 | 0.085 | 0.031 | 0.083 | 0.217 | 0.136 | 0.055 | 0.051 | 0.206 |
| 78 | 0.136 | 0.037 | 0.062 | 0.163 | 0.086 | 0.047 | 0.055 | 0.176 | 0.097 | 0.054 | 0.055 | 0.167 |
| 79 | 0.139 | 0.035 | 0.063 | 0.135 | 0.112 | 0.034 | 0.057 | 0.126 | 0.117 | 0.052 | 0.054 | 0.106 |
| 80 | 0.126 | 0.032 | 0.023 | 0.098 | 0.115 | 0.026 | 0.015 | 0.128 | 0.151 | 0.055 | 0.059 | 0.091 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | LYH | | | | LZU | | | |
| Spring | Summer | Autumn | Winter | Spring | Summer | Autumn | Winter |
| 1 | 0.028 | 0.012 | 0.045 | 0.025 | 0.034 | 0.039 | 0.026 | 0.030 |
| 2 | 0.019 | 0.027 | 0.037 | 0.027 | 0.046 | 0.063 | 0.027 | 0.042 |
| 3 | 0.036 | 0.029 | 0.046 | 0.037 | 0.050 | 0.052 | 0.031 | 0.027 |
| 4 | 0.111 | 0.035 | 0.057 | 0.050 | 0.041 | 0.023 | 0.039 | 0.047 |
| 5 | 0.106 | 0.041 | 0.060 | 0.103 | 0.015 | 0.020 | 0.058 | 0.035 |
| 6 | 0.025 | 0.038 | 0.042 | 0.141 | 0.017 | 0.012 | 0.041 | 0.040 |
| 7 | 0.024 | 0.012 | 0.039 | 0.100 | 0.020 | 0.009 | 0.033 | 0.045 |
| 8 | 0.025 | 0.014 | 0.041 | 0.097 | 0.017 | 0.016 | 0.043 | 0.046 |
| 9 | 0.042 | 0.012 | 0.050 | 0.098 | 0.041 | 0.012 | 0.021 | 0.046 |
| 10 | 0.039 | 0.023 | 0.056 | 0.097 | 0.042 | 0.005 | 0.018 | 0.047 |
| 11 | 0.067 | 0.021 | 0.064 | 0.085 | 0.041 | 0.003 | 0.030 | 0.058 |
| 12 | 0.088 | 0.024 | 0.088 | 0.111 | 0.037 | 0.006 | 0.042 | 0.052 |
| 13 | 0.094 | 0.032 | 0.134 | 0.237 | 0.010 | 0.020 | 0.032 | 0.056 |
| 14 | 0.031 | 0.024 | 0.070 | 0.111 | 0.014 | 0.014 | 0.020 | 0.073 |
| 15 | 0.023 | 0.041 | 0.068 | 0.098 | 0.013 | 0.046 | 0.025 | 0.078 |
| 16 | 0.022 | 0.027 | 0.106 | 0.077 | 0.019 | 0.024 | 0.028 | 0.104 |
| 17 | 0.034 | 0.022 | 0.090 | 0.059 | 0.040 | 0.026 | 0.026 | 0.092 |
| 18 | 0.040 | 0.035 | 0.061 | 0.059 | 0.036 | 0.029 | 0.024 | 0.100 |
| 19 | 0.068 | 0.028 | 0.056 | 0.057 | 0.050 | 0.040 | 0.022 | 0.101 |
| 20 | 0.091 | 0.026 | 0.053 | 0.084 | 0.064 | 0.033 | 0.020 | 0.106 |
| 21 | 0.128 | 0.038 | 0.041 | 0.163 | 0.024 | 0.053 | 0.033 | 0.115 |
| 22 | 0.018 | 0.019 | 0.040 | 0.136 | 0.024 | 0.037 | 0.068 | 0.086 |
| 23 | 0.033 | 0.021 | 0.034 | 0.098 | 0.023 | 0.025 | 0.040 | 0.094 |
| 24 | 0.038 | 0.025 | 0.033 | 0.085 | 0.026 | 0.032 | 0.048 | 0.109 |
| 25 | 0.046 | 0.023 | 0.019 | 0.079 | 0.046 | 0.021 | 0.031 | 0.117 |
| 26 | 0.036 | 0.041 | 0.014 | 0.078 | 0.049 | 0.022 | 0.023 | 0.082 |
| 27 | 0.044 | 0.050 | 0.015 | 0.083 | 0.046 | 0.030 | 0.026 | 0.091 |
| 28 | 0.103 | 0.066 | 0.028 | 0.102 | 0.081 | 0.037 | 0.032 | 0.098 |
| 29 | 0.044 | 0.063 | 0.031 | 0.232 | 0.043 | 0.025 | 0.023 | 0.100 |
| 30 | 0.027 | 0.032 | 0.033 | 0.246 | 0.031 | 0.016 | 0.014 | 0.110 |
| 31 | 0.027 | 0.033 | 0.021 | 0.182 | 0.026 | 0.012 | 0.020 | 0.116 |
| 32 | 0.044 | 0.054 | 0.030 | 0.245 | 0.020 | 0.021 | 0.023 | 0.134 |
| 33 | 0.059 | 0.059 | 0.026 | 0.195 | 0.045 | 0.020 | 0.027 | 0.137 |
| 34 | 0.113 | 0.101 | 0.020 | 0.154 | 0.048 | 0.020 | 0.022 | 0.117 |
| 35 | 0.074 | 0.133 | 0.032 | 0.147 | 0.050 | 0.021 | 0.032 | 0.109 |
| 36 | 0.129 | 0.078 | 0.038 | 0.183 | 0.059 | 0.029 | 0.032 | 0.103 |
| 37 | 0.129 | 0.049 | 0.043 | 0.292 | 0.047 | 0.029 | 0.022 | 0.140 |
| 38 | 0.084 | 0.034 | 0.027 | 0.241 | 0.025 | 0.008 | 0.021 | 0.105 |
| 39 | 0.020 | 0.028 | 0.026 | 0.194 | 0.020 | 0.014 | 0.025 | 0.099 |
| 40 | 0.038 | 0.036 | 0.028 | 0.097 | 0.025 | 0.019 | 0.028 | 0.131 |
| 41 | 0.038 | 0.059 | 0.031 | 0.091 | 0.052 | 0.020 | 0.031 | 0.148 |
| 42 | 0.051 | 0.081 | 0.038 | 0.058 | 0.053 | 0.020 | 0.026 | 0.133 |
| 43 | 0.090 | 0.070 | 0.062 | 0.047 | 0.046 | 0.025 | 0.032 | 0.098 |
| 44 | 0.102 | 0.089 | 0.056 | 0.068 | 0.057 | 0.022 | 0.030 | 0.080 |
| 45 | 0.081 | 0.069 | 0.048 | 0.107 | 0.077 | 0.034 | 0.033 | 0.099 |
| 46 | 0.057 | 0.039 | 0.030 | 0.120 | 0.052 | 0.081 | 0.020 | 0.065 |
| 47 | 0.039 | 0.044 | 0.023 | 0.094 | 0.038 | 0.045 | 0.018 | 0.067 |
| 48 | 0.052 | 0.057 | 0.026 | 0.112 | 0.036 | 0.031 | 0.019 | 0.139 |
| 49 | 0.051 | 0.042 | 0.027 | 0.104 | 0.039 | 0.024 | 0.030 | 0.114 |
| 50 | 0.108 | 0.056 | 0.038 | 0.090 | 0.038 | 0.027 | 0.035 | 0.082 |
| 51 | 0.103 | 0.057 | 0.059 | 0.087 | 0.050 | 0.030 | 0.029 | 0.069 |
| 52 | 0.144 | 0.052 | 0.078 | 0.135 | 0.056 | 0.022 | 0.037 | 0.082 |
| 53 | 0.164 | 0.034 | 0.057 | 0.223 | 0.048 | 0.014 | 0.032 | 0.085 |
| 54 | 0.075 | 0.028 | 0.039 | 0.188 | 0.037 | 0.021 | 0.022 | 0.079 |
| 55 | 0.029 | 0.036 | 0.030 | 0.148 | 0.032 | 0.022 | 0.020 | 0.088 |
| 56 | 0.045 | 0.035 | 0.035 | 0.179 | 0.038 | 0.022 | 0.034 | 0.121 |
| 57 | 0.042 | 0.031 | 0.038 | 0.157 | 0.044 | 0.014 | 0.043 | 0.088 |
| 58 | 0.096 | 0.023 | 0.057 | 0.145 | 0.036 | 0.008 | 0.049 | 0.072 |
| 59 | 0.105 | 0.027 | 0.064 | 0.137 | 0.032 | 0.013 | 0.050 | 0.072 |
| 60 | 0.146 | 0.056 | 0.066 | 0.150 | 0.035 | 0.017 | 0.033 | 0.092 |
| 61 | 0.144 | 0.030 | 0.047 | 0.285 | 0.032 | 0.013 | 0.047 | 0.106 |
| 62 | 0.064 | 0.033 | 0.020 | 0.169 | 0.026 | 0.017 | 0.032 | 0.076 |
| 63 | 0.023 | 0.048 | 0.033 | 0.160 | 0.023 | 0.017 | 0.032 | 0.091 |
| 64 | 0.044 | 0.052 | 0.057 | 0.171 | 0.025 | 0.023 | 0.047 | 0.132 |
| 65 | 0.439 | 0.089 | 0.079 | 0.126 | 0.108 | 0.026 | 0.047 | 0.136 |
| 66 | 0.239 | 0.076 | 0.075 | 0.132 | 0.153 | 0.030 | 0.059 | 0.088 |
| 67 | 0.191 | 0.052 | 0.087 | 0.070 | 0.116 | 0.029 | 0.050 | 0.070 |
| 68 | 0.123 | 0.039 | 0.101 | 0.087 | 0.127 | 0.036 | 0.055 | 0.072 |
| 69 | 0.140 | 0.046 | 0.097 | 0.119 | 0.120 | 0.031 | 0.055 | 0.080 |
| 70 | 0.144 | 0.064 | 0.069 | 0.148 | 0.093 | 0.020 | 0.036 | 0.048 |
| 71 | 0.102 | 0.055 | 0.055 | 0.143 | 0.078 | 0.024 | 0.020 | 0.042 |
| 72 | 0.081 | 0.051 | 0.083 | 0.213 | 0.049 | 0.027 | 0.048 | 0.070 |
| 73 | 0.066 | 0.048 | 0.076 | 0.182 | 0.066 | 0.025 | 0.043 | 0.059 |
| 74 | 0.125 | 0.057 | 0.100 | 0.120 | 0.114 | 0.019 | 0.052 | 0.067 |
| 75 | 0.145 | 0.055 | 0.067 | 0.122 | 0.169 | 0.020 | 0.052 | 0.069 |
| 76 | 0.147 | 0.060 | 0.097 | 0.153 | 0.192 | 0.020 | 0.054 | 0.083 |
| 77 | 0.075 | 0.055 | 0.113 | 0.344 | 0.157 | 0.009 | 0.021 | 0.107 |
| 78 | 0.110 | 0.053 | 0.082 | 0.162 | 0.105 | 0.012 | 0.019 | 0.068 |
| 79 | 0.130 | 0.056 | 0.051 | 0.102 | 0.127 | 0.014 | 0.021 | 0.069 |
| 80 | 0.161 | 0.055 | 0.026 | 0.124 | 0.085 | 0.031 | 0.018 | 0.107 |

**Table S4**. The concentration of bound heavy metals in atmospheric PM2.5 in Lanzhou (μg·m-3). This is the original data of Figure 5 and Figure 6 in the manuscript.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sites | Season | V | Mn | Fe | Co | Pb | Cu | Cd | Sb | As | Hg |
| LZU | Winter | 0.039 | 0.013 | 0.061 | 0.0009 | 0.142 | - | 0.0037 | - | 0.07 | 0.001 |
| Spring | 0.033 | 0.018 | 0.103 | 0.0011 | 0.131 | 0.003 | 0.0006 | - | 0.07 | 0.001 |
| Summer | 0.028 | 0.01 | 0.081 | 0.0007 | 0.114 | - | 0.0005 | - | 0.07 | 0.0005 |
| Autumn | 0.028 | 0.008 | 0.095 | 0.0007 | 0.091 | - | 0.0006 | - | 0.07 | 0.0006 |
| BPI | Winter | 0.159 | 0.015 | 0.123 | 0.0013 | 0.407 | 0.029 | 0.001 | 0.0008 | 0.003 | 0.002 |
| Spring | 0.136 | 0.013 | 0.123 | 0.0013 | 0.355 | 0.022 | 0.0016 | 0.0006 | 0.003 | 0.002 |
| Summer | 0.152 | 0.015 | 0.102 | 0.001 | 0.315 | 0.013 | 0.0008 | 0.0006 | 0.01 | 0.002 |
| Autumn | 0.119 | 0.013 | 0.109 | 0.0013 | 0.304 | 0.007 | 0.0005 | 0.0035 | 0.002 | 0.002 |
| RDI | Winter | 0.155 | 0.015 | 0.121 | 0.0013 | 0.404 | 0.031 | 0.001 | 0.0008 | 0.007 | 0.0006 |
| Spring | 0.092 | 0.014 | 0.112 | 0.0013 | 0.464 | 0.011 | 0.001 | 0.0005 | 0.007 | 0.0006 |
| Summer | 0.076 | 0.011 | 0.09 | 0.001 | 0.378 | 0.008 | 0.0009 | 0.0005 | 0.007 | 0.0006 |
| Autumn | 0.064 | 0.01 | 0.073 | 0.0008 | 0.311 | 0.003 | 0.0008 | 0.0005 | 0.007 | 0.0003 |
| SWH | Winter | 0.151 | 0.015 | 0.12 | 0.0013 | 0.405 | 0.014 | 0.001 | 0.0035 | 0.05 | 0.002 |
| Spring | 0.114 | 0.013 | 0.099 | 0.0011 | 0.404 | 0.015 | 0.001 | 0.0006 | 0.05 | 0.002 |
| Summer | 0.062 | 0.009 | 0.073 | 0.0008 | 0.273 | 0.003 | 0.001 | 0.0005 | 0.05 | 0.002 |
| Autumn | 0.078 | 0.011 | 0.071 | 0.001 | 0.323 | 0.003 | 0.001 | 0.0006 | 0.04 | 0.002 |
| LYH | Winter | 0.087 | 0.016 | 0.118 | 0.0012 | 0.271 | 0.032 | 0.001 | 0.0009 | 0.05 | 0.0005 |
| Spring | 0.102 | 0.016 | 0.127 | 0.0012 | 0.29 | 0.022 | 0.0009 | 0.0008 | 0.05 | 0.0006 |
| Summer | 0.081 | 0.012 | 0.086 | 0.001 | 0.151 | 0.014 | 0.0008 | 0.0008 | 0.06 | 0.0006 |
| Autumn | 0.074 | 0.009 | 0.099 | 0.0009 | 0.159 | 0.012 | 0.0005 | 0.0006 | 0.05 | 0.0004 |