The Elemental Composition of Atmospheric Particles and Dust Fall Rate in Erbil Governorate

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ABSTRACT

Sand and Dust Storms are usually developed in arid and semi-arid regions. Dust and sand storms are a persistent problem in Iraq and other areas in the Middle East. Dust fall is one of the important air pollutants in the ambient air of Erbil governorate. This study was aimed to investigate the falling dust rate and their chemical element composition by percentage (%) using (CIT-3000SMP X-ray Fluorescence) from January to December 2013. We compared the dust fall rate and elemental composition of atmospheric particles in three different areas within Erbil governorate. The dust fall rate and the chemical element composition of dust particles were determined at four sampling locations in Erbil governorate, which were included (Erbil, koya, Makhmur and Pirmam). Our results showed that the maximum dust fall rate was recorded in Erbil (97.6 gm/m².year), whereas minimum concentration was found in Koya (59.24 gm/m².year). The higher of mean percentage by weight of some elements such as (Fe, Sb, Se, Nb, Tc, Te, Ag, Ta, Mo, Po, In, Cd, V, At and Zr) were higher in Erbil city compared to other areas of study.

1. INTRODUCTION

Iraq is geographically situates in a position where dust and sand storm hits and last for days. According to Ministry of Environment in Iraq, 122 dust storms and 283 dusty days have been recorded, and sources have predicted that dusty days and dust storms could reach 300 times in the next decade (Kobler, 2013). Considerable amount of techniques and programs to mitigate and assess air pollution are regarded, there have been few studies on dust fall and their health and environmental consequences as Iraq have been facing a drought condition in the last decade. A study by (Aziz and Dabagh, 2012) in Erbil on evaluation of outdoor and indoor dust deposition found that decomposed dust were not more than limited values or levels of most of other countries. Natural and anthropogenic air pollutants can be transported in the atmosphere from original places for long distances (Varga et al., 2013). Particulate Matter (PM) can be found in two different
physical state which are solid and liquid that
suspected in the air. These forms may include
dust, pollen, soot, smoke and liquid droplets
(WHO, 2003). Dust particles have a profound
impact on the properties of the soil, the
emissions of metals and their compounds can
be occurred in the dry and wet deposition
(Kalembkiewicz et al., 2014). Coarse
Particulate matter with a size of greater than 10
μm is the main component of dust fall (Sami et al.,
2006). Dust storms have the main role in
falling dust through erosion and deposition
(Feng et al., 2008). Gaseous and particulate
pollutants have the main role of atmospheric
air pollution. The particulate and gaseous
pollutants emitted into the atmosphere quickly
and uncontrolled, also they have bad effects on
living organisms (Krolak, 2000). Naturally dust
fall could be generated from weathering of dry
soil (Smith and Lee, 2003). However, motor
vehicles, open burning, coal burning and
industrial emissions are the main sources of
anthropogenic activities in urban atmosphere,
which causes air pollution (Cao et al., 2011).
Dust borne heavy metals could be accumulated
in topsoil due to atmospheric deposition via
sedimentation, impaction and interception (Lu
et al., 2009). Soil dust could be contributed to
the concentration of heavy metals in the air
(Chen et al., 1997). Mineral dust can affected
the visibility distance and may contain
pathogenic micro-organisms which may lead to
spread some diseases (Ghosh et al., 2014). The
present study was aimed to investigate the
falling dust rate and the elemental composition
of atmospheric particles.

2. MATERIALS AND METHODS

2.1. Study Area

Dust sampling were taken at four sampling
sites, the first sampling site was located in the
Erbil city which is situated in South Kurdistan,
North of Federal Iraq. It is the capital of
Kurdistan Region; it is located at 44° 0’ 33.0 E
longitudes and 36° 11’ 28.0 N latitude. Second
site was in Koya districted, east of Erbil
province, it is located at 44°36’28.1 E
longitudes and 36°04’07.9 N latitude. Third site
was in Makhmoor districted which is located in
the South of Erbil province. It is located at
43°33’48.4 E longitudes and 35°46’34.9 N
latitude. Final and fourth site was in Pirmam
which is located in the North of Erbil province;
it is located at 44°11’21.4 E longitudes and
36°22’51.3 N latitude (Figure 1).

2.2. Sample Collection

Dust fall samples were collected monthly,
and weighed, then analyzed by CIT-
3000SMP X-ray Fluorescence at four sampling
sites to obtain the percentage of elemental
concentration, from January to December
2013, using dust collectors (dimensions 1m by
1m) as shown in Figure 2, which were put on
the roof of building at a height above 2 m to
prevent it from any interference from soil or
surface dust. Liquid samples especially from
winters, were evaporated and dried using oven
(T≤100°C) to obtain constant weight
(Kalembkiewicz et al., 2014).

Figure 2: Shows dust collector.
2.3. Statistical analysis

Statistical analysis was performed using a software program (SPSS version 21). All data were treated with Descriptive statistics for the percentage of elemental concentration and dust fall rate.

3. RESULTS

3.1. Dust fall rate

The maximum dust fall rate was recorded in Erbil (97.6 gm/m².year), followed by Makhmur (65.02 gm/m².year) and Pirmam (61.34 gm/m².year) respectively, whereas minimum concentration was found in Koya (59.24 gm/m².year). The results of dust fall rate at four sampling sites presented in Table (1).

3.2. Elemental composition analysis

Tables (2, 3, 4, 5) and figure (3) showed the percentages of each element concentration at the study areas, these results indicated that the percentage of elemental concentration of elements (Fe, Sb, Se, Nb, Tc, Te, Ag, Ta, Mo, Po, In, Cd, V, At and Zr) at Erbil city was relatively higher compared to the other sites, While the percentage of elemental concentration of other elements (Mn, Sn, As, Bi, W and Ni) were higher in Makhmur.

4. Discussion

Erbil city had the highest concentration of dust fall rate with (97.6 gm/m².year) as shown in table 1. The high concentration of dust fall rate at Erbil city, which might be due to deposited particulates are emitted from moving vehicles, vehicular fuel combustion and rapidly developing area with a high population within Erbil city. The urban area is consisting of varying concentrations of trace elements from anthropogenic and natural sources (Nwadiogbu et al., 2013). The deposited dust on roads don’t remain for long time, quickly and easily re-suspended back into the atmosphere, where they may contain an important amount of trace elements (Addo et al., 2012). Alahmr et al. (2012) reported that high automobile exhaust emissions in urban areas are the main source to generate particulate pollution and the result of road dust and emissions from moving vehicles. Kleeman and Cass (1998) argued that traffic is one of the important sources of atmospheric particulate pollution in urban areas. Moreover, Amato et al (2009) indicated that particulate matter of road dust on the pavement could be resuspended by traffic in urban area and become important sources of atmospheric particulate.

The higher deposition rates of each elements (Fe, Sb, Se, Nb, Tc, Te, Ag, Ta, Mo, Po, In, Cd, V, At and Zr) were obtained in Erbil city compared to other sites as shown in Tables (2, 3, 4, 5) and figure (3) which may be due to anthropogenic effects related to traffic sources and other activities. All of the motorway-related elements such as Cd, Cr, Cu, Fe, Mn, Mo, Ni, Pb, V, Zn, Al, Pt, Pd and Rh are dangerous in themselves, they are interact with other compounds and media in the environment that can lead to the most harmful consequences (Rayson, 1990). Elements including As, Sb, Cd, Cr, Hg, Pb and Be, have been identified as toxic air pollutants (Baird, 1995). Zhang, et al. (2010) found that most of mineral and pollutant element concentrations in particles were elevated in dusty days, about 2–4 times higher than the levels in non-dusty days. Each of Si, Ca, Fe and Al accounted for over 10% of the sums of total 20 elements in mass, for example, Si was in 44.3%, 38.7% for dusty and non-dusty cases, respectively.

The amount of dry deposition which occurred in the process of transportation and dust and sand storm and the distribution of elemental dust were not very different with previously collected data in Kurdistan Region.
(Aziz and Dabagh, 2012). Lai et al. (2007) showed that the abundance of Pb, Cd and Fe in the atmosphere might occur as the result of vehicle exhaust emissions, industrial discharge, oil lubricants, and automobile parts along with the corrosion of building materials. Oyeleke et al. (2016) stated that combustion source such as vehicle emission and non-combustion source such as industrial discharges can cause increasing heavy metals in urbanized areas. Dey et al. (2004) studied that mineral dust and sand could be bowed by dust storms and carries a cloud of minute particulates. Therefore, it transferred into the atmosphere and interacts with urban air pollution. Patel et al. (2001) reported that high concentration of heavy metals could be transferred from the atmosphere to the urban area and deposit through precipitation.

The main cause for developing a dust storm is years of inappropriate farming practice, mismanagement of water resources and climate change continue to contribute to reduced vegetation coverage, desertification and droughts, which directly contribute to the growing regional dust storm problem. Droughts and arid conditions favor the dissolution of soil particles, and wind contributes to the emergence of dust storm (Varoujan et al., 2013). To solve this issue serious measure are to taken by Kurdistan Region Government. One of these measures are designing green belt around cities and restoring agricultural lands.

5. CONCLUSIONS

We conclude that the traffic emissions and increasing the population density as anthropogenic sources, in addition to natural dust particles from dust fall and dust storm in Erbil governorate have been the main role for increasing dust fall rate and dust elements.

Figure 1: (A) Shows the Kurdistan Region of Iraq; (B) Shows the Erbil governorate with sampling sites.
Figure 3: The percentages of each element mean concentration at the study areas.
Table 1: Descriptive statistics for falling dust rate (gm/m².year) in the study area.

| Locations | Minimum | Maximum | Sum  | Mean  | Std. Deviation |
|-----------|---------|---------|------|-------|----------------|
| Makhmur   | 1.56    | 12.70   | 65.02| 5.4183| 3.68858        |
| Koya      | 1.52    | 8.80    | 59.24| 4.9367| 2.67172        |
| Pirmam    | 2.64    | 10.30   | 61.34| 5.1117| 2.17338        |
| Erbil     | 2.23    | 23.23   | 97.60| 8.1333| 5.96046        |

Table 2: Descriptive statistics for the percentage value for each element concentration in Erbil.

| Elements        | Mean    | Std. deviation | Interquartile Range 25 | Interquartile Range 75 |
|-----------------|---------|----------------|------------------------|------------------------|
| Phosphorus (P)  | 0.00189 | 0.00019        | 0.00187                | 0.00202                |
| Calcium (Ca)    | 11.49409| 1.48169        | 10.67649               | 12.71987               |
| Manganese (Mn)  | 0.17502 | 0.12591        | 0.04849                | 0.25297                |
| Vanadium (V)    | 0.00408 | 0.00961        | 0                      | 0.00420                |
| Sulfur (S)      | 2.23365 | 1.20465        | 1.56806                | 3.24411                |
| Potassium (K)   | 2.86979 | 0.38525        | 2.60921                | 3.12835                |
| Iron (Fe)       | 3.42150 | 0.70294        | 2.83044                | 4.06591                |
| Molybdenum (Mo)| 0.16053 | 0.02774        | 0.14394                | 0.19136                |
| Nickel (Ni)     | 0.01338 | 0.00093        | 0.01260                | 0.01407                |
| Arsenic (As)    | 0       | 0.005221       | 0.03217                | 0.04027                |
| Zirconium (Zr)  | 0.00432 | 0.00048        | 0.00401                | 0.00450                |
| Selenium (Se)   | 0.00349 | 0.00091        | 0.00298                | 0.00366                |
| Niobium (Nb)    | 0.00478 | 0.00021        | 0.00459                | 0.00499                |
| Strontium (Sr)  | 0.00156 | 0.00018        | 0.00140                | 0.0017                 |
| Cadmium (Cd)    | 0.02282 | 0.00191        | 0.02162                | 0.02343                |
| Cerium (Ce)     | 0.00055 | 0.00003        | 0.00051                | 0.00058                |
| Technetium (Tc) | 0.00232 | 0.00031        | 0.00217                | 0.00242                |
| Ruthenium (Ru)  | 0.00681 | 0.00019        | 0.00668                | 0.00698                |
| Rhodium (Rh)    | 0.00650 | 0.00021        | 0.00634                | 0.00657                |
| Palladium (Pd)  | 0.00465 | 0.00019        | 0.00455                | 0.00471                |
| Indium (In)     | 0.00064 | 0.00002        | 0.00062                | 0.00065                |
| Antimony (Sb)   | 1.86731 | 0.09601        | 1.79055                | 1.95018                |
| Tellurium (Te)  | 0.00129 | 0.00015        | 0.00113                | 0.00144                |
| Tungsten (W)    | 0.01378 | 0.00111        | 0.01294                | 0.01471                |
| Tantalum (Ta)   | 0.00065 | 0.00006        | 0.0006                 | 0.00071                |
| Silver (Ag)     | 0.00148 | 0.00005        | 0.00143                | 0.00151                |
| Tin (Sn)        | 0.12005 | 0.00826        | 0.11491                | 0.12568                |
| Bismuth (Bi)    | 0.04982 | 0.00945        | 0.04257                | 0.05549                |
| Thallium (Tl)   | 0.00048 | 0.00002        | 0.00046                | 0.00049                |
| Polonium (Po)   | 0.01959 | 0.00205        | 0.01856                | 0.02069                |
| Astatine (At)   | 0.00021 | 0.00005        | 0.00016                | 0.00024                |
Table 3: Descriptive statistics for the percentage value for each element concentration in Koya.

| Elements       | Mean  | Std. deviation | Interquartile Range 25 | Interquartile Range 75 |
|----------------|-------|----------------|------------------------|------------------------|
| Phosphorus (P) | 0.00183 | 0.00030       | 0.00173                | 0.00202                |
| Calcium (Ca)   | 10.93161 | 2.30803       | 10.55751               | 12.24374               |
| Manganese (Mn)| 0.17436 | 0.09810       | 0.08011                | 0.24875                |
| Vanadium (V)   | 0.00312 | 0.00749       | 0.00176                |                        |
| Sulfur (S)     | 2.23158 | 1.16145       | 1.82259                | 2.62270                |
| Potassium (K)  | 2.83693 | 0.33400       | 2.73598                | 3.03324                |
| Iron (Fe)      | 3.17342 | 0.90113       | 2.55182                | 3.76370                |
| Molybdenum (Mo)| 0.11814 | 0.06750       | 0.06125                | 0.16595                |
| Nickel (Ni)    | 0.01318 | 0.00125       | 0.01225                | 0.01363                |
| Arsenic (As)   | 0.03549 | 0.00335       | 0.03234                | 0.03815                |
| Zirconium (Zr) | 0.00398 | 0.00044       | 0.00369                | 0.00429                |
| Selenium (Se)  | 0.00310 | 0.00050       | 0.00269                | 0.00361                |
| Niobium (Nb)   | 0.00435 | 0.00063       | 0.004211               | 0.00466                |
| Strontium (Sr) | 0.00148 | 0.00023       | 0.00126                | 0.00166                |
| Cadmium (Cd)   | 0.02099 | 0.00371       | 0.01931                | 0.02306                |
| Cerium (Ce)    | 0.00057 | 0.00004       | 0.00055                | 0.00060                |
| Technetium (Tc)| 0.00192 | 0.00050       | 0.00155                | 0.00231                |
| Ruthenium (Ru) | 0.00674 | 0.00047       | 0.00645                | 0.00697                |
| Rhodium (Rh)   | 0.00620 | 0.00063       | 0.00602                | 0.00656                |
| Palladium (Pd) | 0.00447 | 0.00050       | 0.00421                | 0.00477                |
| Indium (In)    | 0.00058 | 0.00009       | 0.00058                | 0.00063                |
| Antimony (Sb)  | 1.35383 | 0.58048       | 1.36677                | 1.73913                |
| Tellurium (Te) | 0.00078 | 0.00043       | 0.00065                | 0.00113                |
| Tungsten (W)   | 0.01375 | 0.00140       | 0.01274                | 0.01411                |
| Tantalum (Ta)  | 0.00063 | 0.00007       | 0.00058                | 0.00067                |
| Silver (Ag)    | 0.00131 | 0.00021       | 0.00136                | 0.00150                |
| Tin (Sn)       | 0.08840 | 0.02984       | 0.07746                | 0.10903                |
| Bismuth (Bi)   | 0.05065 | 0.00656       | 0.04404                | 0.05556                |
| Thallium (Tl)  | 0.00048 | 0.00002       | 0.00046                | 0.0005                 |
| Polonium (Po)  | 0.01930 | 0.00237       | 0.01796                | 0.01996                |
| Astatine (At)  | 0.00019 | 0.00005       | 0.00014                | 0.00023                |
Table 4: Descriptive statistics for the percentage value for each element concentration in Makhmur.

| Elements        | Mean    | Std. deviation | Interquartile | Mean     | Std. deviation | Interquartile |
|-----------------|---------|----------------|--------------|----------|----------------|--------------|
|                 |         |                | Range 25     | Range 75 | Range 25     | Range 75     |
| Phosphorus (P)  | 0.00187 | 0.00015        | 0.00174      | 0.00202  |                |              |
| Calcium (Ca)    | 10.95817| 0.90135        | 10.45097     | 11.81887 |                |              |
| Manganese (Mn)  | 0.18735 | 0.11539        | 0.09350      | 0.26776  |                |              |
| Vanadium (V)    | 0.00136 | 0.00402        | 0             | 0        | 0.00046        |              |
| Sulfur (S)      | 2.89524 | 1.57334        | 1.60315      | 4.63130  |                |              |
| Potassium (K)   | 2.88123 | 0.17770        | 2.74745      | 3.04197  |                |              |
| Iron (Fe)       | 3.08803 | 0.56810        | 2.60148      | 3.64724  |                |              |
| Molybdenum (Mo) | 0.15627 | 0.05744        | 0.11704      | 0.20023  |                |              |
| Nickel (Ni)     | 0.01359 | 0.00086        | 0.01311      | 0.01430  |                |              |
| Arsenic (As)    | 0.03616 | 0.00481        | 0.03359      | 0.03963  |                |              |
| Zirconium (Zr)  | 0.00416 | 0.00030        | 0.00398      | 0.00419  |                |              |
| Selenium (Se)   | 0.00322 | 0.00041        | 0.0029       | 0.00356  |                |              |
| Niobium (Nb)    | 0.00466 | 0.00035        | 0.00442      | 0.00496  |                |              |
| Strontium (Sr)  | 0.00168 | 0.00022        | 0.00149      | 0.00184  |                |              |
| Cadmium (Cd)    | 0.02173 | 0.00175        | 0.02009      | 0.02325  |                |              |
| Cerium (Ce)     | 0.00057 | 0.00003        | 0.00055      | 0.00060  |                |              |
| Technetium (Tc) | 0.00220 | 0.00013        | 0.00214      | 0.00228  |                |              |
| Ruthenium (Ru)  | 0.00700 | 0.00018        | 0.00684      | 0.00712  |                |              |
| Rhodium (Rh)    | 0.00648 | 0.00020        | 0.00642      | 0.00656  |                |              |
| Palladium (Pd)  | 0.00463 | 0.00018        | 0.00447      | 0.00478  |                |              |
| Indium (In)     | 0.00060 | 0.00004        | 0.00056      | 0.00064  |                |              |
| Antimony (Sb)   | 1.644389| 0.38162        | 1.32701      | 2.00454  |                |              |
| Tellurium (Te)  | 0.00096 | 0.00055        | 0.00057      | 0.00146  |                |              |
| Tungsten (W)    | 0.01419 | 0.00110        | 0.01394      | 0.01465  |                |              |
| Tantalum (Ta)   | 0.00065 | 0.00004        | 0.00061      | 0.00069  |                |              |
| Silver (Ag)     | 0.00144 | 0.00010        | 0.00137      | 0.00153  |                |              |
| Tin (Sn)        | 0.12455 | 0.02912        | 0.10815      | 0.14665  |                |              |
| Bismuth (Bi)    | 0.05137 | 0.00916        | 0.04550      | 0.05626  |                |              |
| Thallium (Tl)   | 0.00044 | 0.00002        | 0.00041      | 0.00046  |                |              |
| Polonium (Po)   | 0.01927 | 0.00166        | 0.01812      | 0.02074  |                |              |
| Astatine (At)   | 0.00019 | 0.00004        | 0.00015      | 0.00023  |                |              |
Table 5: Descriptive statistics for the percentage value for each element concentration in Pirmam.

| Elements          | Mean      | Std. deviation | Interquartile |
|-------------------|-----------|----------------|---------------|
|                   |           |                | Range 25      | Range 75      |
| Phosphorus (P)    | 0.00196   | 0.00019        | 0.00181       | 0.00205       |
| Calcium (Ca)      | 11.85008  | 1.32782        | 10.63674      | 13.02502      |
| Manganese (Mn)    | 0.15098   | 0.12054        | 0.04451       | 0.26161       |
| Vanadium (V)      | 0.00138   | 0.00441        | 0            | 0             |
| Sulfur (S)        | 2.52013   | 1.21184        | 1.42348       | 3.35988       |
| Potassium (K)     | 2.78299   | 0.44601        | 2.38628       | 3.10647       |
| Iron (Fe)         | 3.00396   | 0.69191        | 2.40350       | 3.62680       |
| Molybdenum (Mo)   | 0.12724   | 0.06993        | 0.08070       | 0.18043       |
| Nickel (Ni)       | 0.01310   | 0.00077        | 0.01237       | 0.01385       |
| Arsenic (As)      | 0.03369   | 0.00549        | 0.03159       | 0.03718       |
| Zirconium (Zr)    | 0.00427   | 0.00034        | 0.00397       | 0.00462       |
| Selenium (Se)     | 0.00329   | 0.00043        | 0.00294       | 0.00369       |
| Niobium (Nb)      | 0.00456   | 0.00039        | 0.00413       | 0.00483       |
| Strontium (Sr)    | 0.00148   | 0.00024        | 0.00145       | 0.00165       |
| Cadmium (Cd)      | 0.02132   | 0.00193        | 0.01989       | 0.02270       |
| Cerium (Ce)       | 0.00058   | 0.00002        | 0.00055       | 0.00061       |
| Technetium (Tc)   | 0.00220   | 0.00033        | 0.00202       | 0.00237       |
| Ruthenium (Ru)    | 0.00685   | 0.00036        | 0.00675       | 0.00702       |
| Rhodium (Rh)      | 0.00635   | 0.00028        | 0.00616       | 0.00650       |
| Palladium (Pd)    | 0.00454   | 0.00023        | 0.00438       | 0.00474       |
| Indium (In)       | 0.00060   | 0.00004        | 0.00057       | 0.00062       |
| Antimony (Sb)     | 1.59008   | 0.30344        | 1.26857       | 1.85978       |
| Tellurium (Te)    | 0.00095   | 0.00033        | 0.00070       | 0.00118       |
| Tungsten (W)      | 0.01367   | 0.00089        | 0.01295       | 0.01440       |
| Tantalum (Ta)     | 0.00065   | 0.00004        | 0.00061       | 0.00068       |
| Silver (Ag)       | 0.00141   | 0.00010        | 0.00129       | 0.00149       |
| Tin (Sn)          | 0.10119   | 0.01795        | 0.09085       | 0.11722       |
| Bismuth (Bi)      | 0.04689   | 0.01018        | 0.04237       | 0.05064       |
| Thallium (Tl)     | 0.00045   | 0.00003        | 0.00043       | 0.00047       |
| Polonium (Po)     | 0.01849   | 0.00207        | 0.01714       | 0.02035       |
| Astatine (At)     | 0.00020   | 0.00003        | 0.00017       | 0.00024       |
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