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Influence of meteorological parameters on gamma radionuclides and major-ions of bulk deposition in Málaga (South of Spain)

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INTRODUCTION. Gamma radionuclides and major-ion concentrations in bulk deposition samples were monthly measured in bulk deposition over a seven year period (January 2005- December 2013). Bulk deposition was dominated by Ca^{2+},Cl^-, SO_4^{2-} and Na^+ and the average pH was 6.4. Cl^- and SO_4^{2-} were the main anions while Ca^{2+} and Na^+ were the main cations. The radiotracers present in all samples were ^{7}Be, ^{210}Pb and ^{40}K appeared in 50% of the samples. The temporal variations of major-ions and radionuclides exhibit similar seasonal behaviour with low values in winter-autumn months and maximum values in spring-summer months. Furthermore, correlation analysis and principal component analysis method were also performed on individual bulk deposition to identify possible common sources of the major-ions and gamma radionuclides. The meteorological parameters that best correlated with gamma radionuclides and major ions in bulk deposition were number of intrusions and the amount of precipitation.

MATERIAL AND METHODS. Samples were routinely collected on a monthly basis using a steel tray $1m^2$ in area as a collecting system and polyethylene vessels of 25L capacity for rainwater samples reservoirs. Measurements by gamma spectrometry were performed to determine the ^{7}Be , ^{210}Pb and ^{40}K activities of the samples using an intrinsic REGe detector. The samples were divided in two parts: (i) 50 mL were acidified with 0.3% HNO_3 and stored at 4ºC for further Ca^{2+} Na^+, Mg^{2+} and K^+ analyses, which were carried out with ICP-OES (Optima, 7300-DV) (ii) 10 mL were stored at 4ºC and anions NO_3^-, SO_4^- and Cl^- were done in accordance with Dionex ICS-90 ion chromatography System .

RESULTS AND DISCUSSION

The results from specific activities (in Bq/L) of ^{7}Be , ^{210}Pb and ^{40}K and major-ions in (µeq /L) were analyzed to derive the statistical estimates characterizing the distributions. ***Table 1*** and **2** provide: Number of cases (N), arithmetic mean (AM), geometric mean (GM), standard deviation (SD),standard error, maximum and minimum values, the coefficient of variation (CV) and Skewness(GI).

	7 (Bq L	210 (Bq L	7	40 (Bq L
N of cases	107	107	107	47
Arit. Mean	2.6	0.41	7.3	0.23
Geo. Mean	2.2	0.36	6.0	0.18
Maximum	8.3	1.32	35.95	0.84
Minimum	0.6	0.05	1.3	0.02
Std. deviation	1.7	0.23	5.3	0.16
Std. error	0.17	0.02	0.5	0.023
Variation coeff.	64%	55%	72.4	69%
Skewness(GI)	4.9	5.8	11,4	4,8

TABLE 1 Due to value of skewness (GI), the specific activities of ^{7}Be, ^{210}Pb, ^{40}K and ratio $^{7}Be/^{210}Pb$ in bulk deposition should fit approximately to log-normal distribution. Then, the geometric mean was used as the main characterization factor of the specific activities of ^{7}Be, ^{210}Pb, ^{40}K and $^{7}Be/^{210}Pb$.

	Ca	Na	Mg	K	SO	NO	Cl	pH
Mean	4.47E+02	2.10E+02	1.09E+02	2.91E+01	2.32E+02	1.40E+02	3.40E+03	6.4
Std error of mean	4.20E+01	1.75E+01	1.17E+01	4.67E+00	3.90E+01	4.27E+01	5.20E+01	0.2
Geo. mean	3.16E+02	1.54E+02	78.8E+01	1.46E+01	1.33E+02	8.40E+01	2.03E+02	6.3
Maximum	1.8E+03	7.01E+02	5.21E+02	1.68E+01	1.85E+03	5.50E+03	2.60E+03	8.7
Minimum	5.30E+01	2.70E+01	4.23E+01	1.28E+00	1.60E+01	2.20E+00	1.03E+01	4.5
Std deviation	3.70E+02	1.54E+02	8.97E+01	3.60E+01	2.99E+02	1.27E+02	3.93E+02	1.3
Variation C.	83.0%	75.0%	82.5%	123.0%	129.0%	92.0%	114.8%	18%
Skewness(GI)	4.96	4.74	6.57	6.30	10.4	4.10	9.5	0.23
Kurtosis	3.3	2.90	10.5	6.60	23.3	1.64	28.5	1.24

TABLE 2. The ion concentrations show higher dispersions around their mean values according to the standard deviations. Skewness calculations give positive values that indicate an asymmetric shape of the data distribution. The kurtosis values range from 0.63 to 13.64 indicate significant departures from normality.

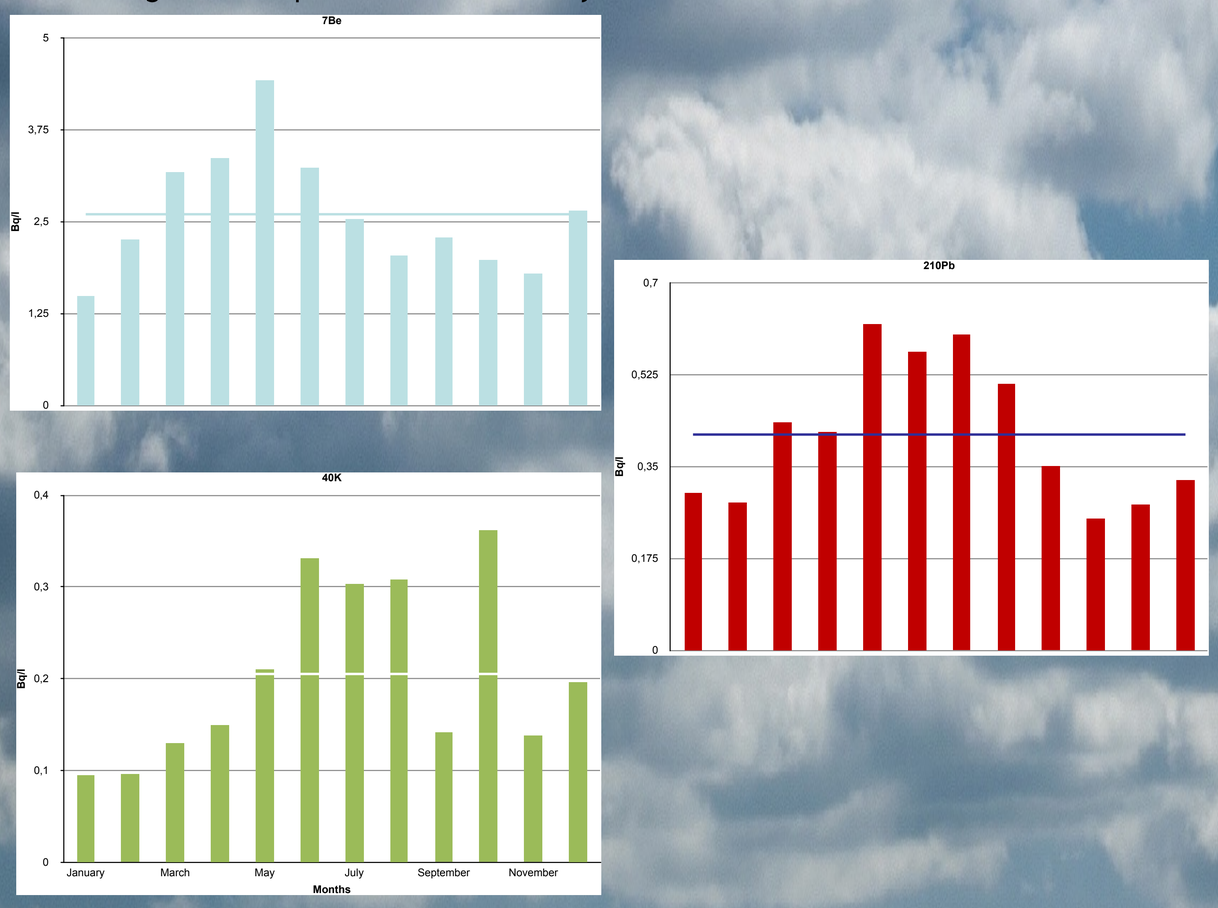

Figure 1.- Monthly variations of gamma radionuclides (^{7}Be, ^{210}Pb and ^{40}K) concentrations in bulk deposition (Bq/^{L}) from January 2005 to December 2013. The lowest values were observed in autumn and winter and the highest values in spring and summer .

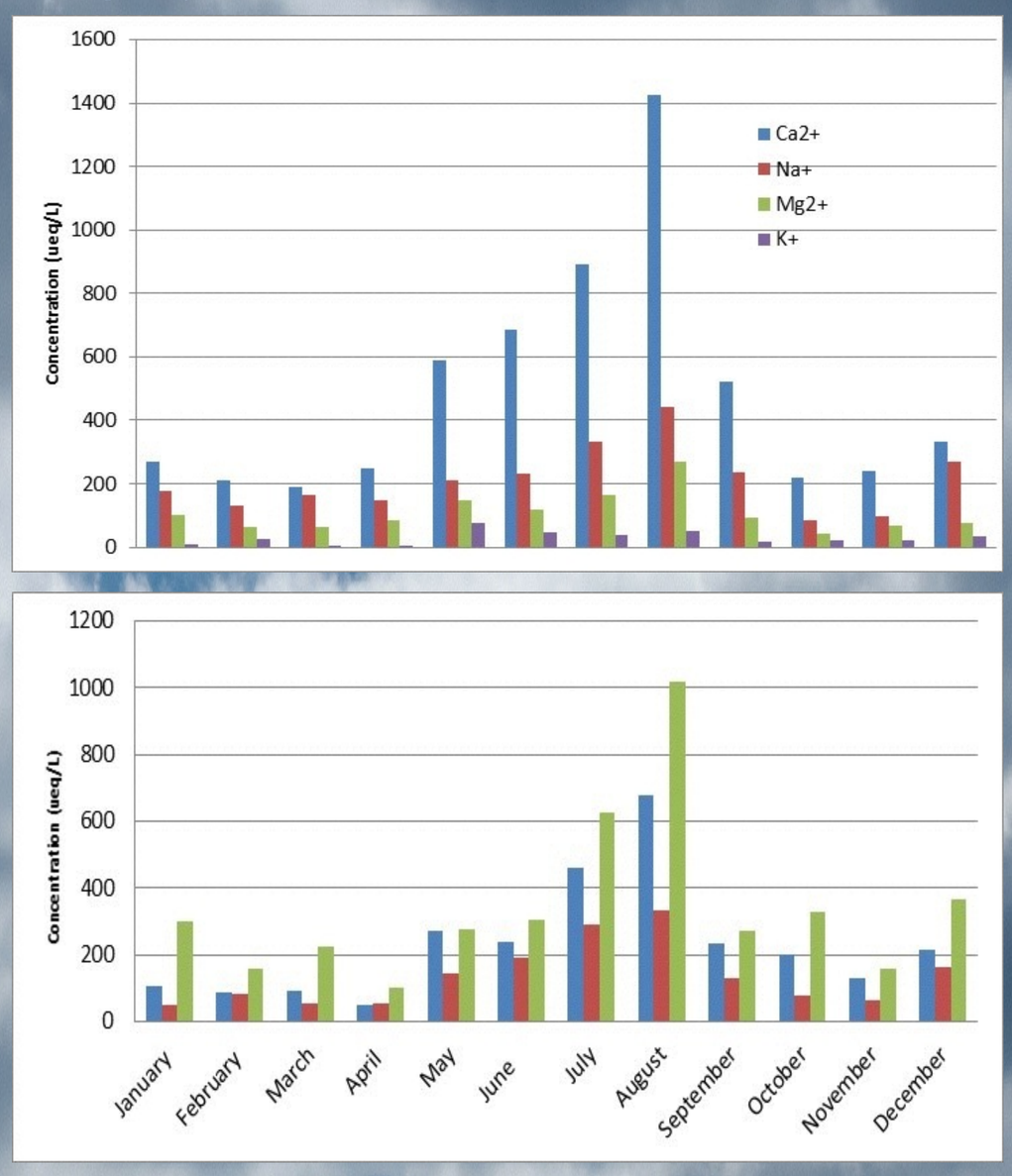

Fig.2. Monthly variations of major-ions during the nine years period .

	1	2	3	4
Ca	0.622	0.576	0.357	-0.141
Na	**0.827**	0.112	0.304	0.160
Mg	**0.551**	0.422	0.479	-0.004
K	0.092	0.089	-0.042	**0.854**
SO	**0.881**	0.100	0.085	-0.065
NO	**0.773**	0.436	0.155	0.038
Cl	**0.903**	0.111	-0.037	-0.024
Rainfall	-0.324	**-0.696**	0.158	0.063
Intrusions	0.420	**0.516**	0.398	-0.351
Humidity	-0.158	**-0.840**	0.031	-0.146
Temperature	0.397	**0.660**	0.097	-0.415
Wind	-0.069	**0.609**	0.165	0.346
7	0.028	-0.324	**0.845**	-0.070
210	0.263	0.329	**0.713**	0.029%
% Variance	44.870	12.491	9.149	8.382
% Cumulative	44.870	57.362	66.511	74.893

Table 3. Factor loadings matrix obtained from bulk deposition samples at our coastal site.

Conclusions. Principal component analysis was also performed to find possible sources of the major ions and gamma radionuclides. Four components that account 75% of the total variance were extracted. The first one represented acid and alkaline pollutants in bulk deposition. The second one may be linked to ion Ca^{2+} and meteorological parameters. The third one suggested the correlation between the gamma radionuclides in bulk deposition. The fourth one included potassium ion (K^+), air temperature, intrusions and wind.

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