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MULTIVARIATE STATISTICAL ANALYSIS OF AIR QUALITY MONITORING DATA IN ROMANIA (2011–2021)

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Introduction

Air quality monitoring is essential for assessing the degree of atmospheric contamination, identifying potential sources of contamination, adopting appropriate air remediation strategies, and developing effective environmental policies to ensure the protection of public health and the conservation of natural resources.

Materials and methods

Annual amounts of several contaminants (NO_2, non-metallic VOC, SO_2, NH_3, CO, $PM_{2.5}$, PM_{10}, Pb, Cd, and Hg) in the air in Romania during 2011–2021 [1], which are specified in Table 1, were processed using Principal Component Analysis (PCA), with XLSTAT Version 2019.1.

Results and conclusions

The data summarized in Table 1 highlight that, in general, the lowest amounts of contaminants were recorded in 2000, during the COVID-19 pandemic, and the highest amounts in 2011–2012. Also, the values of SO_2 and Hg masses (*SO_2* and *Hg*) had a higher variability (*CV* = 54.32% and *CV* = 17.80%) than the values of the other contaminant amounts (*CV* = 2.615-7.292%). The data summarized in Table 1 were processed using PCA, and 3 principal components (PC1, PC2, and PC3), which explained 94.9% (67.8% + 15.7% + 11.4%) of the total variance, were used in the multivariate analysis. The results presented in Figure 1 indicate the following: (i) *NO_2*, *VOC*, *SO_2*, *CO*, *$PM_{2.5}$*, *PM_{10}*, *Cd*, *Hg*, and *Pb* were higher in the period 2011–2012 compared to 2013–2021 (discrimination on the PC1 axis between the years framed by blue ellipses); (ii) *NH_3* was higher and *PM_{10}* was lower in 2015 and 2017 compared to 2021 (discrimination on the PC2 axis between the years highlighted in green); (iii) *Pb* was higher and *SO_2* was lower in 2019 compared to 2013 and 2014 (discrimination on the PC3 axis between the years highlighted in blue). The aspects presented suggest potential sources of contaminants, *i.e.*: (i) public electricity/heat production and combustion processes in industry for NO_2, VOC, CO, $PM_{2.5}$, Cd, Hg, and part of Pb, PM_{10}, and SO_2; (ii) manure management and application of nitrogen-based fertilizers for NH_3, and cement/lime production, construction/demolition, quarrying/mining, asphalting, and tire/brake wear for PM_{10};

(iii) iron/steel production and tire/brake wear for Pb, and petroleum refining for SO_2. Based on these findings, effective air remediation strategies could be adopted.

Table 1. Annual amounts of contaminants in the air in Romania during 2011–2021

Year	*NO_2* (kt)	*VOC* (kt)	*SO_2* (kt)	*NH_3* (kt)	*CO* (kt)	*$PM_{2.5}$* (kt)	*PM_{10}* (kt)	*Pb* (t)	*Cd* (t)	*Hg* (t)
2011	259.0	257.2	237.3	168.3	1009	118.8	156.6	49.29	3.540	2.860
2012	251.4	255.6	257.4	163.1	977.8	120.8	160.4	45.34	3.480	2.190
2013	229.9	244.4	207.9	164.6	954.7	113.4	150.4	42.28	3.180	1.800
2014	221.8	241.9	181.1	165.5	959.0	113.6	150.7	43.14	3.180	1.830
2015	220.7	239.2	148.9	169.5	913.6	108.6	145.0	45.65	3.120	1.870
2016	211.2	231.9	98.08	165.8	935.2	108.8	143.0	45.07	3.170	1.800
2017	220.0	235.3	78.39	166.8	942.2	110.1	143.0	45.49	3.220	1.830
2018	222.5	231.4	70.97	161.7	943.5	109.4	145.7	46.76	3.220	1.840
2019	218.3	232.8	85.90	158.9	949.5	110.5	151.0	47.07	3.160	1.830
2020	205.0	231.6	60.89	156.2	910.2	109.6	149.1	41.58	2.900	1.590
2021	214.2	234.2	66.28	158.6	964.3	116.1	157.2	46.41	3.140	1.710
MIN	**205.0**	**231.4**	**60.89**	**156.2**	**910.2**	**108.6**	**143.0**	**41.58**	**2.900**	**1.590**
MAX	**259.0**	**257.2**	**257.4**	**169.5**	**1009**	**120.8**	**160.4**	**49.29**	**3.540**	**2.860**
MN	**224.9**	**239.6**	**135.7**	**163.5**	**950.8**	**112.7**	**150.2**	**45.28**	**3.210**	**1.923**
SD	**16.40**	**9.375**	**73.74**	**4.276**	**27.96**	**4.246**	**5.882**	**2.242**	**0.172**	**0.342**
***CV* (%)**	**7.292**	**3.913**	**54.32**	**2.615**	**2.941**	**3.768**	**3.916**	**4.951**	**5.369**	**17.80**

NO_2, *VOC*, *SO_2*, *NH_3*, *CO*, *$PM_{2.5}$*, *PM_{10}*, *Pb*, *Cd*, and *Hg* – masses of NO_2, non-metallic VOC, SO_2, NH_3, CO, $PM_{2.5}$, PM_{10}, Pb, Cd, and Hg;
MIN, *MAX*, and *MN* – minimum, maximum, and mean values;
SD – standard deviation; *CV* – coefficient of variation; *t* – tons; *kt* – kiloton.

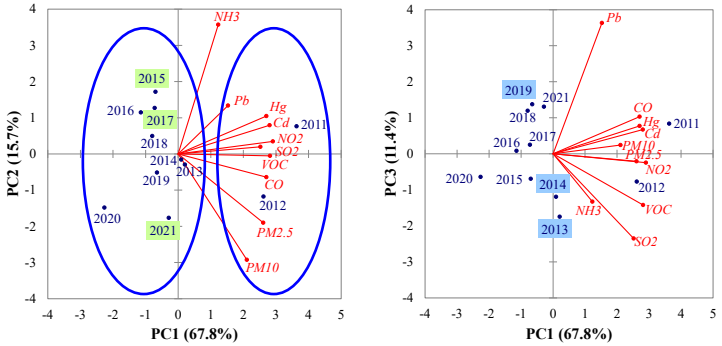

Figure 1. PCA bi-plot.

References

[1] https://cdr.eionet.europa.eu/ro/eu/nec_revised/inventories/envzbhiiq/Annex_I_RO_1990-2021_resubmission.xlsx/manage_document