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Principal Component Analysis for Relationship Between Air Quality and Bird Diversity During Pre- and Post-Monsoon Seasons of Asansol Area, West Bengal

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Abstract: ***The present study was to perform principal component analysis for air quality data and bird diversity during pre- and post-monsoon seasons of Asansol area, West Bengal. All the secondary data of ambient air pollutants such as $PM_{2.5}$, PM_{10}, SO_2 and NO_2 on Asansol area, West Bengal were procured from Air Quality Information System of West Bengal Pollution Control Board, Kolkata to know the present status of air quality during pre- and post-monsoon season (2021-2022). In the present study, multivariate analysis especially Principal Component Analysis (PCA) was performed using the PAST tool (version, 3.25). In this study, the PC-1 (66.74% of the original variation elucidated) observed relatively higher value of positive loading for bird diversity in A2 site while higher negative loading for PM_{10} followed by site A1, NO_2, SO_2 and $PM_{2.5}$ during pre-monsoon season. While the PC-1 (47.63% of the original variation elucidated) observed relatively higher value of positive loading for $PM_{2.5}$ followed by PM_{10}, SO_2, NO_2, and bird diversity in A2 site while higher negative loading for followed by bird diversity in A1 site during post-monsoon season. It is concluded that the alteration of air quality decreased the avifaunal diversity in the study area.***

Keywords: Air quality, Avifauna, Biodiversity, Correlation, Diversity, Principal Component Analysis

1. Introduction

It was reported that the declining trend of bird populations in the United States is primarily caused by air pollutants, particularly ozone, which are on the rise. [1] In addition to these factors, the decline in bird populations is caused by urbanization as well. [2, 3] Generally, poor air quality is caused by automobile and industrial emissions that contribute by air pollutants such as particulate matters, gaseous pollutants, aerosols, volatile organic compounds, etc. [4] However, current air pollution control is based on threats to human health, and no pollutant standards have been put forward for birds or other chordates.

Chowdhury et al. [2] conducted a study on avifaunal diversity related to traffic load near roadside parks, but this study did not perform air quality assessment. Some international studies have been reported that air pollution causes the decline of the bird diversity [5-7] and it was reported that there was a close relation between emissions due to vehicular movements and bird diversity in two parks located at Kolkata. [8]

Multivariate analysis, particularly principal component analysis (PCA), has been proposed many investigators in different research arena. [9-12] In earlier studies to analyse the data on air pollution related to source identification and characterization by many authors. [13-16] The covariance matrix, which maps multivariate data onto low-dimensional manifolds, forms the basis of the statistical methodology employed. By highlighting the structure of the dataset while preserving the contributions of variables to the variance of observation, this analysis is helpful. This method is employed in systems with many input variables to isolate the variables with the highest eigenvalues, which helps to further pinpoint the source of the issue. [16-18] On the other hand, some studies conducted on the PCA based study on avifauna diversity related to their habitat features. [19, 20] But the study is lacking on air quality and bird diversity relationship.

The objective of the study was to perform principal component analysis for air quality data and bird diversity during pre- and post-monsoon seasons of Asansol area, West Bengal.

2. Materials and Methods

An earlier study by Sengupta & Talapatra, the study sites were selected. [21] All the data on air pollutants such as $PM_{2.5}$, PM_{10}, SO_2 and NO_2 on Asansol area, West Bengal were procured from Air Quality Information System of West Bengal Pollution Control Board, Kolkata to know the present status of air quality during pre- and post-monsoon season (2021-2022). In the present study, multivariate analysis especially Principal Component Analysis (PCA) was performed using the PAST tool (version, 3.25) [22] to reduce the variables into fewer uncorrelated predictor variables. The individual participant principal component (PC) scores were obtained from the factor loadings of different parameters, and PCA was performed for each case, considering the six components. The results were expressed in scattered plots, loading plots and Scree plots for each season separately.

3. Results

The principal component analysis (PCA) was performed based on air quality parameters versus avifaunal diversity

during pre-monsoon season in site A1 and A2 and the summary results is tabulated (Table 1). In this study, the PC-1 (66.74% of the original variation elucidated) observed relatively higher value of positive loading for bird diversity in A2 site while higher negative loading for PM_{10} followed by site A1, NO_2, SO_2 and $PM_{2.5}$ during pre-monsoon season (Fig 1 and Fig 2). Moreover, the PC-2 (19.70% of the original variation elucidated) observed relatively higher value of positive loading for PM_{10} followed by $PM_{2.5}$, NO_2, SO_2 and bird diversity in A2 site during pre-monsoon season while higher negative loading for A3 site (Fig 1 and Fig 3). Fig 4 exhibits the Scree plot for per-monsoon season.

Table 1: PCA on air quality parameters versus avifaunal diversity during pre-monsoon season in site A1 and A2

PC	Eigenvalue	% variance
1	111.65	66.738
2	32.9533	19.698
3	17.5082	10.465
4	3.71097	2.2182
5	1.3809	0.82542
6	0.09277	0.055452

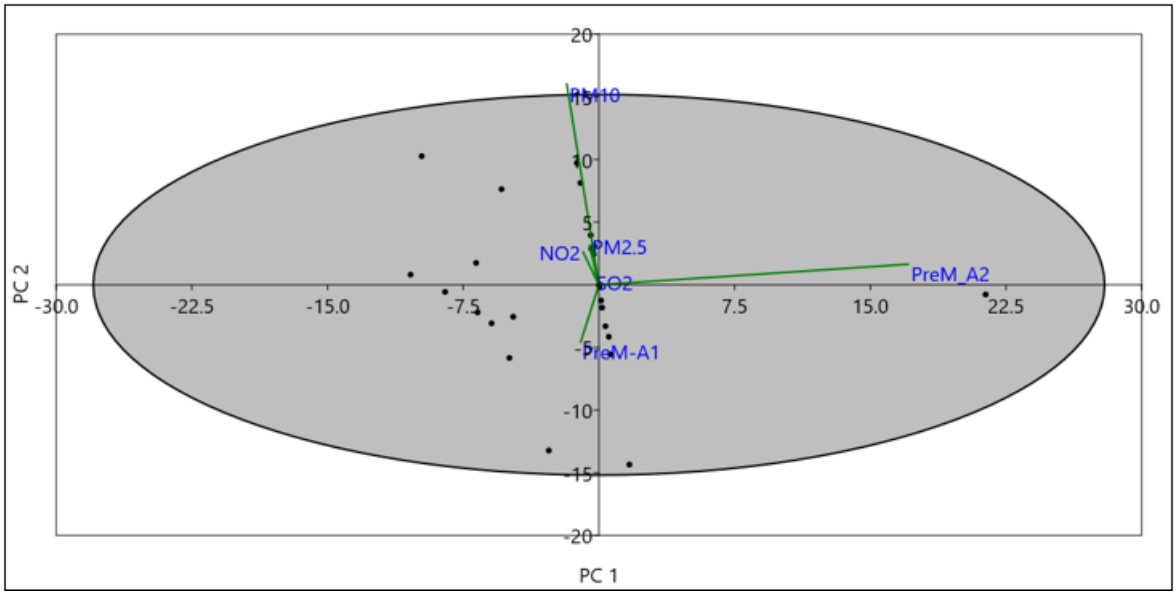

Figure 1: Scattered plot on air quality parameters versus avifaunal diversity during pre-monsoon season in site A1 and A2

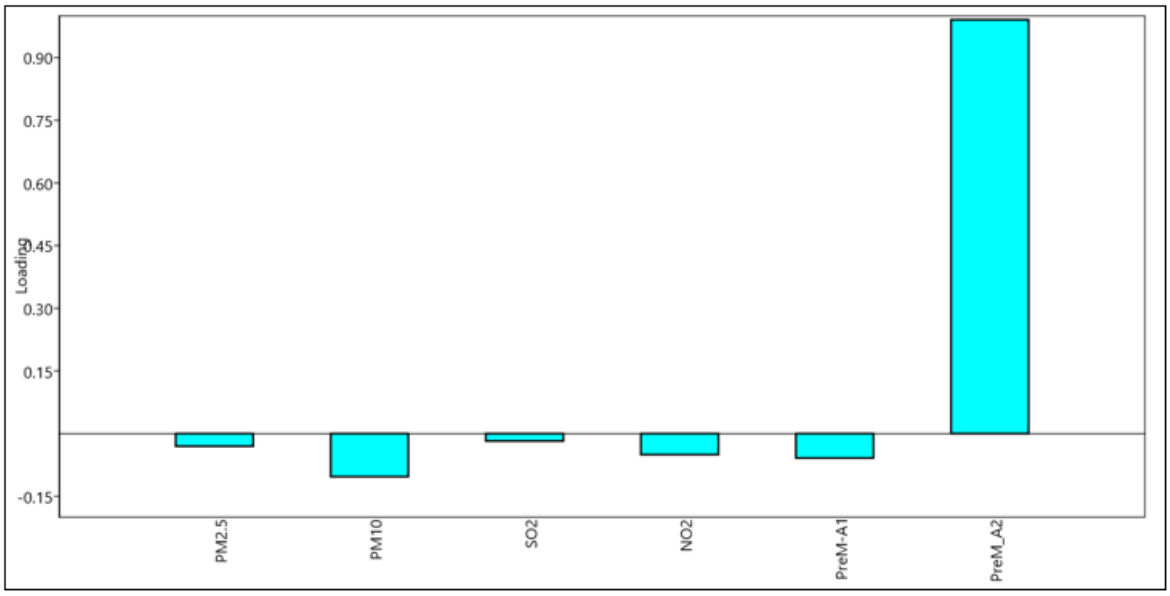

Figure 2: Loading plot for PC1 during pre-monsoon

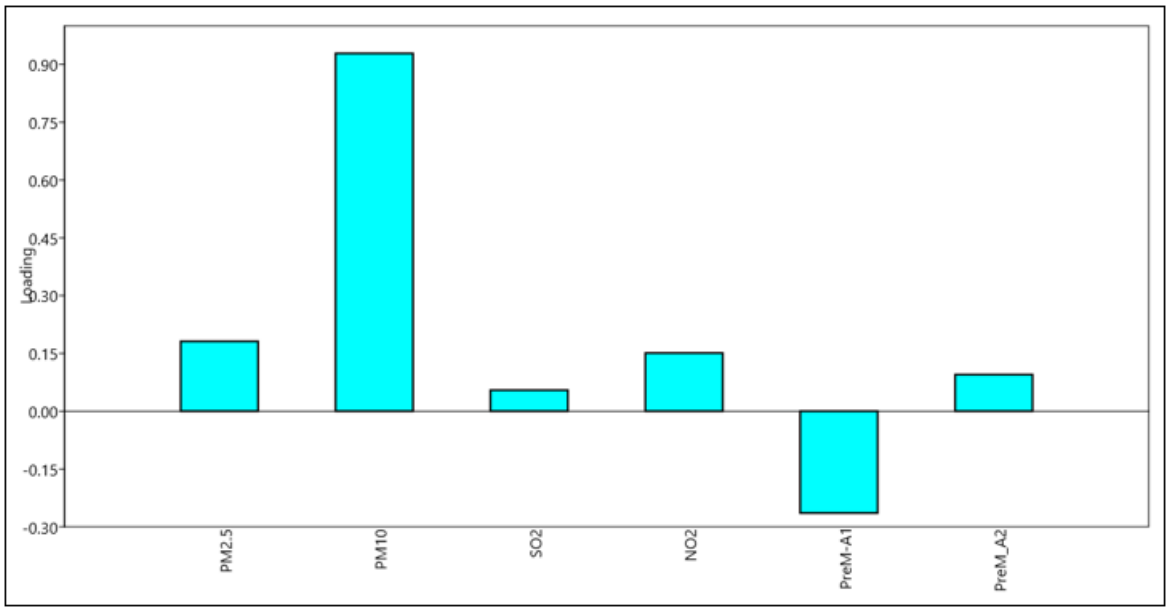

Figure 3: Loading plot for PC2 during pre-monsoon

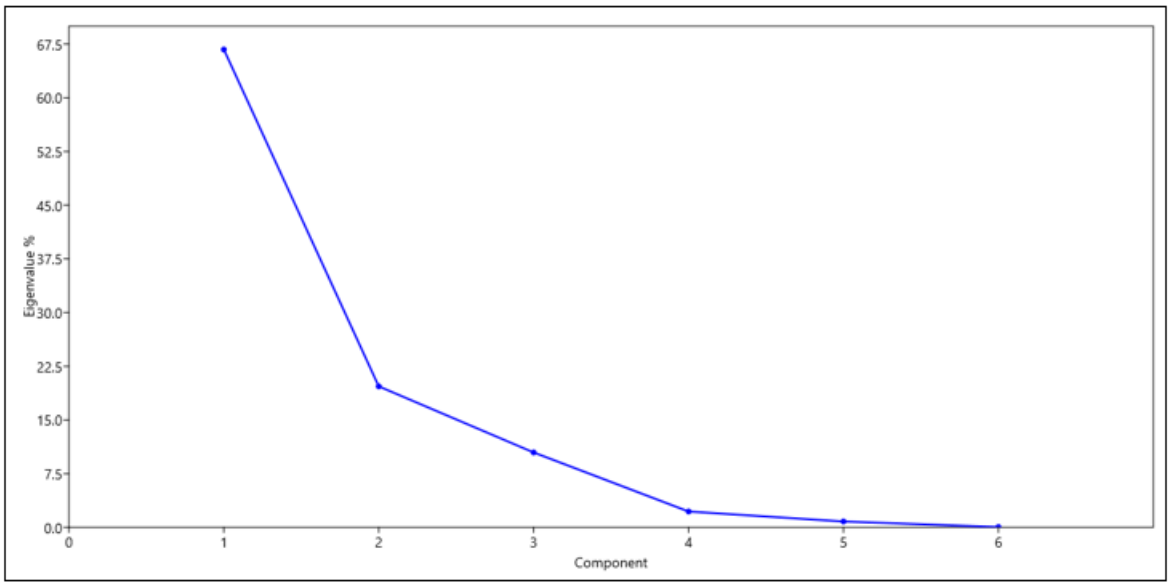

Figure 4: Scree plot representation for pre-monsoon

The principal component analysis (PCA) was performed based on air quality parameters versus avifaunal diversity during post-monsoon season in site A1 and A3 and the summary results is tabulated (Table 2). In this study, the PC-1 (47.63% of the original variation elucidated) observed relatively higher value of positive loading for $PM_{2.5}$ followed by PM_{10}, SO_2, NO_2, and bird diversity in A2 site while higher negative loading for followed by bird diversity in A1 site during post-monsoon season (Fig 5 and Fig 6). Moreover, the PC-2 (37.44% of the original variation elucidated) observed relatively higher value of positive loading bird diversity in A3 site followed by A1 site and $PM_{2.5}$ while negative loading for PM_{10} followed by NO_2, SO_2 (Fig 5 and Fig 7). Fig 8 exhibits the Scree plot for per-monsoon season.

Table 1: PCA on air quality parameters versus avifaunal diversity during post monsoon season in site A1 and A3

PC	Eigenvalue	% variance
1	169.692	47.632
2	133.381	37.44
3	41.0778	11.53
4	11.1367	3.126
5	0.742985	0.20855
6	0.224282	0.062955

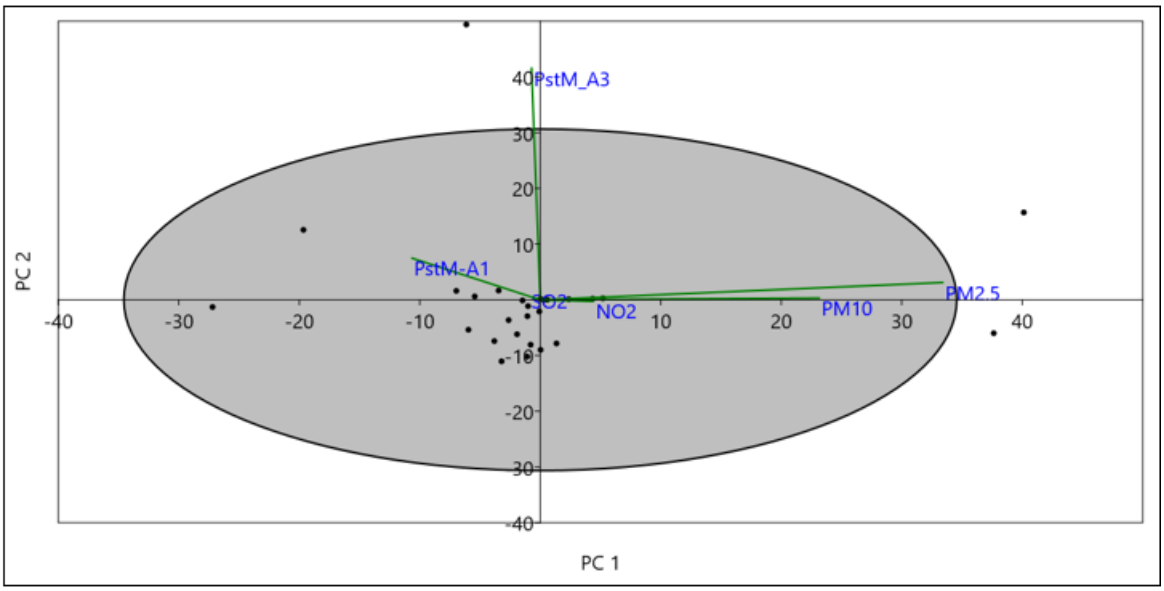

Figure 5: Scattered plot during post-monsoon season

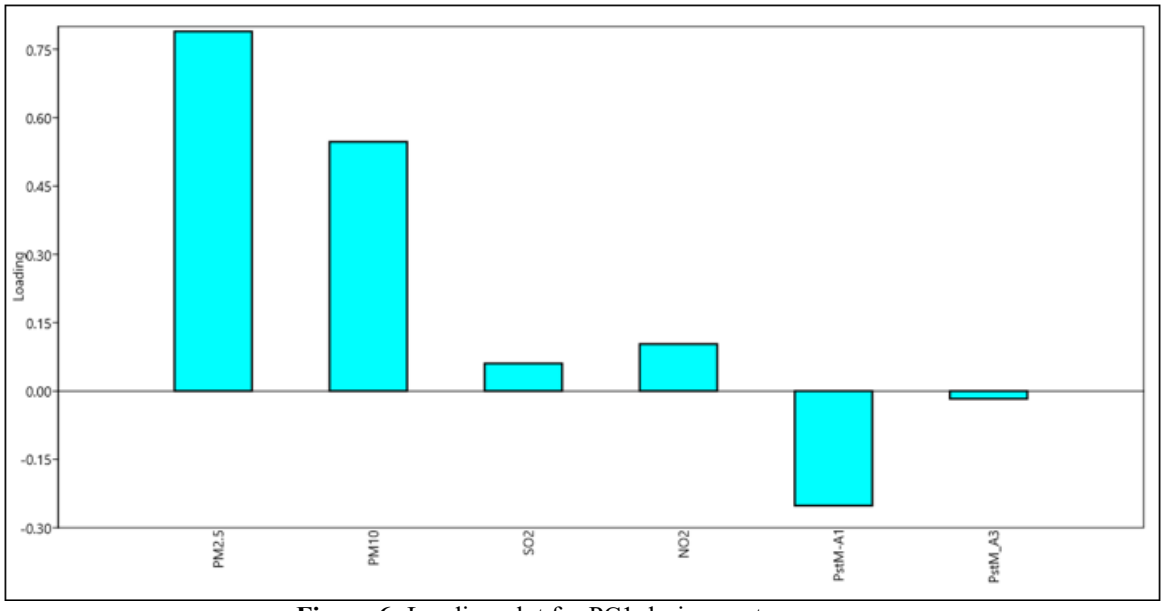

Figure 6: Loading plot for PC1 during post-monsoon

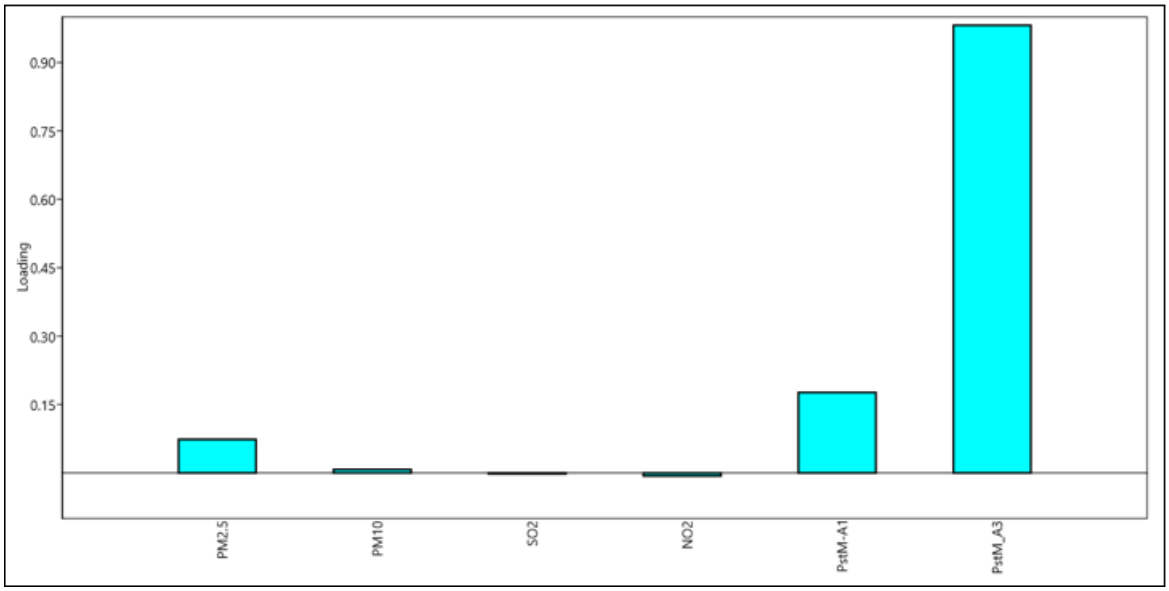

Figure 7: Loading plot for PC2 during post-monsoon

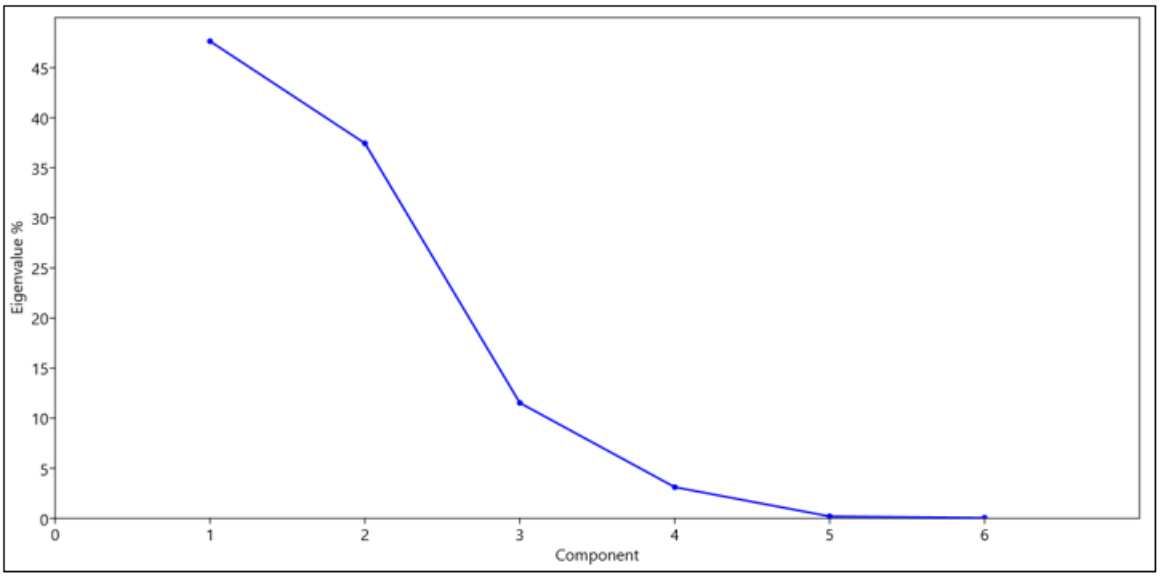

Figure 8: Scree plot representation for post-monsoon

4. Discussion

According to Jolliffe & Cadima, PCA is a method for lowering the dimensionality of initial datasets, which improves interpretability but reducing information loss. [22] In the present study, the negative correlation of air quality parameters and the bird diversity in A1 site during pre-monsoon revealed that air pollutants are responsible for lower bird diversity in the study area while positive correlation on air quality parameters but negative correlation for A1 and A3 sites, which means specific indicator species available comparatively more in the study sites. As per Stanisz, PCA is suitable method to determine air pollution load. [23] In a study by Kumar et al., Canonical Correspondence Analysis (CCA) methods revealed a decreasing trend in bird species abundance with an increasing in concentration of PM_{10}. [24] A recent study Lin & Liang reported that poor environmental quality is responsible for lower bird diversity. [25]

5. Conclusion

The present study indicated that the alteration of air quality decreased the avifaunal diversity in the study area. The data of air pollutants viz. $PM_{2.5}$, PM_{10}, SO_2 and NO_2 are within the prescribed limits as per National Ambient Air Quality standards but these concentrations may be harmful for avifaunal species.

Acknowledgement
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Conflict of interest
None declared.

References

[1] Liang Y, Rudika I, Zou EY, Johnston A, Amanda D. Rodewald AD, et al. Conservation cobenefits from air pollution regulation: Evidence from birds. Proceedings of the National Academy of Sciences USA.2020; 117 (49): 30900-6.
[2] Chowdhury R., Sarkar S, Nandy A, Talapatra SN. Assessment of bird diversity as bioindicators in two parks, Kolkata, India. International Letters of Natural Sciences.2014; 16: 131-9.
[3] Gatesire T, Nsabimana D, Nyiramana A, Seburanga JL, Mirville MO. Bird diversity and distribution in relation to urban landscape types in Northern Rwanda. New Scientific World Journal.2014; 2014: 157824.
[4] Nakhjiri A, Kakroodi AA. Air pollution in industrial clusters: A comprehensive analysis and prediction using multi-source data. Ecological Informatics.2024; 80: 102504.
[5] Brown RE, Brain JD, Wang N. The avian respiratory system: a unique model for studies of respiratory toxicosis and for monitoring air quality. Environ Health Perspect.1997; 105: 188-200.
[6] Sanderfoot OV, Holloway T. Air pollution impacts on avian species via inhalation exposure and associated outcomes. Environ Res Lett.2017; 12: 083002.
[7] Li Z, Courchamp F, Blumstein DT. Pigeons home faster through polluted air. Sci Rep.2016; 6: 1-6.
[8] Roy Bhowmick S. Biodiversity assessment of bird species as bioindicators and the impact of air pollution on the ecological community. International Journal of Pure and Applied Zoology.2021; 9 (2): 18-25.
[9] Ma S, Dai Y. Principal component analysis based methods in bioinformatics studies. Brief Bioinform.2011; 12 (6): 714-22.
[10] Jolliffe IT, Cadima J. Principal component analysis: a review and recent developments. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences.2016; 374 (2065): 20150202.
[11] Rahman Q, Nadeem M, Altaf M, Khan S, Saeed A, Naseer J, et al. Assessment of anthropogenic-causing-agents act on waterbirds-diversity in the vicinity of Tarbela Dam, Indus River, Pakistan. Brazilian Journal of Biology.2021; 84: e251197.
[12] Dasgupta S, Ray S. A study examining the level of awareness regarding lifestyle risks and management practices among diabetes patients in Eastern India.

MGM Journal of Medical Sciences.2023; 10 (3): 469-77.
[13] Yongming H, Peixuan D, Junji C, Posmentier ES. Multivariate analysis of heavy metal contamination in urban dusts of Xi'an, Central China. Sci Total Environ.2006 Feb 15; 355 (1-3): 176-86.
[14] Tokalioglu S, Kartal S. Multivariate analysis of the data and speciation of heavy metals in street dust samples from the organized industrial district in Kayseri (Turkey). Atmos Environ.2006; 40: 2797-2805.
[15] Liu CC, Chen WH, Yuan CS, Lin C. Multivariate analysis of effects of diurnal temperature and seasonal humidity variations by tropical savanna climate on the emissions of anthropogenic volatile organic compounds. Sci Total Environ.2014; 470-471: 311-23.
[16] Chen GF, Lai CH, Chen WH. Principal component analysis and mapping to characterize the emission of volatile organic compounds in a typical petrochemical industrial park. Aerosol Air Qual Res.2020; 20: 465-76.
[17] Wold S, Esbensen K, Geladi P. Principal component analysis. Chemom Intell Lab Syst.1987; 2: 37-52.
[18] Edwards RD, Jurvelin J, Koistinen K, Saarela K, Jantunen M. VOC source identification from personal and residential indoor, outdoor and workplace microenvironment samples in EXPOLIS-Helsinki, Finland. Atmos Environ.2001; 35: 4829-41.
[19] Kheraa N, Mehtaa V, Sabatab BC. Interrelationship of birds and habitat features in urban greenspaces in Delhi, India. Urban Forestry & Urban Greening.2009; 8: 187-19.
[20] Morelli F, Reif J, Díaz M, Tryjanowski P, Ibáñez-Álamo JD, Suhonen J, et al. Top ten birds indicators of high environmental quality in European cities. Ecological Indicators.2021; 133: 108397.
[21] Sengupta D, Talapatra SN. Study of bird diversity during monsoon season related to air quality at Asansol, West Bengal. International Journal of Science and Research.2023; 12 (10): 1887-90.
[22] Jolliffe IT, Cadima J. Principal component analysis: A review and recent developments. Phil Trans R Soc.2016; 374: 20150202.
[23] Stanisz A. Accessible Statistics Course using STATISTICA PL on Examples from Medicine. StatSoft: Kraków, Poland, Volume 1, 2006.
[24] Kumar V, Jolli V, Babu CR. Landuse patterns, air quality and bird diversity in urban landscapes of Delhi. Zoodiversity.2022; 56 (1): 39-50.
[25] Lin S, Liang W. Assessing urban environmental quality and citizen science data quality: Identifying indicator bird species in cities of China. Global Ecology and Conservation.2025; 29: e03575.