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Research Article

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Air pollution level declines the bird species diversity in an urban area: a case study of Bilaspur, Chhattisgarh during the summer season

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ABSTRACT
With rapid growth and changes in daily life, air pollution is also increasing at a high rate. Air pollution threats are not only restricted to urban areas but harm rural areas also. Apart from being harmful to human beings; air pollution possesses a negative impact on bird species also. This study was carried out to find out the adverse impact of air pollution on the diversity of the avian community. The study was executed at five different locations in Bilaspur city during the summer season (2022). Vehicular emissions, burning of fossil fuels, constructions etc. are the major source of pollution in the city. The point count and checklist method was adopted for the observation of bird species. The air quality and pollution monitoring had been carried out through the 'Smiledrive Air Quality Monitor Pollution Meter' which detects the concentration and level of PM 2.5, PM 10, TVOC and HCHO in the air. The diversity of bird species was calculated through total species richness and the Shannon-Wiener diversity index. It was observed that the site having minimum pollution levels have a large bird population with maximum diversity and the sites having high pollution levels have the least diversity of birds. It is the reason that many bird species avoid areas with high pollution concentrations. The study also revealed the remarkably high population of birds of the 'Sturnidae' and 'Columbidae families in polluted sites which validates that the birds of these families have adapted themselves well in the sites with high pollution levels.
Keywords: Air pollution, birds, diversity, urban area.

INTRODUCTION

In today's era where the world is changing very fast, air pollution is emerging as a serious problem. This phenomenon is not only restricted to urban areas but also becoming common in rural areas. Atmospheric pollutants that arise from human activities exert a widespread effect on all living organisms. In this regard, human health has always been the primary concern of research (Gupta and Bakre *et al*., 2013). Various anthropogenic activities like vehicular emission, burning of fossil fuels, construction, industrialization, combustion etc. are the major source of pollution in the city. Yadav *et al*., (2012), explain that the air pollution problem is associated with vehicular emissions.

Air pollution is a major threat not only to human beings but to bird species also. Avian species are more likely to be susceptible to the high concentration of reactive gases and aerosols in the air than mammalian species, and so may serve as useful indicators of air quality (Brown *et al*., 1997). With rapid urbanization and industrialization, the green cover is declining at a very fast rate and the air quality of cities is getting worse day by day. Very few studies have been carried out to study the consequences of urbanization on birds (Sengupta *et al*., 2014). Birds in urban area have to face the challenges like availability of food materials, vegetation cover etc. Avian community is vulnerable to changes in the high concentration of pollutant matter in the air. Birds could also serve as sentinel species for air quality, as they are found globally, in both urban and rural areas, and make use of many different habitat types (Brown *et al*., 1997, Baesse *et al*., 2015).

This study was carried out to provide the response of the avian community towards air pollution and to find out the negative impact of air pollution on bird diversity.

MATERIALS AND METHODS

Study Site

This study was conducted in Bilaspur city which lies in the Chhattisgarh state of India. It is one of the major cities of the state. Bilaspur is divided by the winding Arpa River. The city is located at 22.0797^0 N Latitude 82.1409^0 E Longitude and the city is spread over an area of 205 km^2 with a mean sea level of 270 m. The summers are relatively hot and dry with maximum temperature reaching up to 49^0 C with average temperature being 33^0

C in summer and 15^0 C in winter. Bilaspur city has a sub-tropical, semi-arid and continental climate. The average rainfall varies between 580 mm to 680 mm.

The study was conducted in 5 different sites in Bilaspur city.

Site I [*Near Indira Setu Bridge*]: This area contains less vegetation cover and has heavy vehicular traffic throughout the day. (Fig.1)

Site II [*Nehru Chowk*]: This is the main square of the city and it is bustling here all day. This site contains adequate tree cover and vegetation. (Fig.2)

Site III [*Rajendra Nagar Chowk*]: This site contains a municipal park, open space and less traffic disturbance with a lot of greenery and tree cover. (Fig.3)

Site IV [*Collectorate Office*]: The area has local administrative offices with a lack of greenery and a high frequency of transportation and masses coming here. (Fig.4)

Site V [*Main Post Office*]: This area has moderate vehicular traffic along with sparce trees and vegetation. (Fig.5)

Fig.1: Location I: Near Indira Setu Bridge

Fig.2: Location II: Nehru Chowk

Fig.3: Location III: Rajendra Nagar Chowk

Fig.4: Location IV: Collectorate Office

Fig.5: Location V: Main Post Office

Bird Count

For the counting and sampling of birds, the point count method was applied (Bibby *et al*., 2000; Vielliard *et al*., 2010) in which fixed sampling points were established at a minimum distance of 200 m. apart, to minimize the chances of recording the same individuals at more than one point and also allowed the detection of species. Data were collected in the summer season from 5 different locations in Bilaspur city from April 2022 to June 2022. Birds have been recorded in two phases; the first phase is in the morning from 06:00 hrs to 09:00 hrs and the second phase is from 4:00 p.m. hrs to 18:00 hrs (Vishwakarma *et al*., 2021). The number of points varied to provide equal sampling coverage. In total 25 sampling points were used and each point was sampled for 15 minutes and the bird species seen or heard were recorded.

For observations, Binocular- Nikon Aculon 10 x 50 and Camera- Canon 700D with 100-400 Tamron Lens and Nikon P_{900} 83x zoom lens were used; and for bird identification Grimmett *et al*., 2013 was referred.

Air Pollutants

The monitoring of air quality and pollution had been done through 'Smiledrive Air Quality Monitor Pollution Meter". The instrument detects the concentration and levels of PM 2.5, PM 10, TVOC and HCHO in the air.

This monitoring device is placed at the selected 5 locations in the city. The device is first calibrated and then kept stationary for 20 minutes for recording the observations. The same course of action is performed at each selected site to record the concentration of pollutants. A total of 25 readings were taken and these observations were taken on the same day when the bird census was being done.

Data Analysis

Out of the 25 total observations recorded at the 5 selected sites (5 observations at each site); the recorded and the collected data is then analysed for the outcome.

The species richness was computed and species evenness and Shannon-Wiener diversity index were calculated using the total number of contacts of an individual species in each point count (Krebs 1998). The recorded air pollutant data was evaluated and the mean of each pollutant parameter (viz. TVOC, HCHO, PM 2.5 and PM 10) was calculated through total observed reading for each selected site. (Table 1).

Table 1. Mean of recorded air pollutants at each site

Site	Pollutants			
	TVOC (mg/m^3)	HCHO (mg/m^3)	PM 2.5 ($\mu g/m^3$)	PM 10 ($\mu g/m^3$)
I	0.528	0.064	66	79
II	0.182	0.028	36	40
III	0.111	0.025	32	36
IV	1.243	0.074	88	101
V	0.338	0.058	63	66

After the computation of pollutant data, species richness and Shannon-Wiener diversity index, the correlation coefficient was calculated to assess the relationship between the pollutant (viz. HCHO and PM 2.5) and the diversity of birds. The relation between two factors or entities can be established by correlation coefficient and thus, air pollution and biodiversity are interdependent (Tanveer A *et. al*., 2002).

RESULTS AND DISCUSSION

Air Pollutants

Through the statistical, tabular and graphical analysis of the recorded pollutant data, the following interpretation can be made:

The mean TVOC value (in mg/m^3) ranges from 0.111 to 1.243 (Fig.6) and the mean HCHO value (in mg/m^3) ranges from 0.025 to 0.074 (Fig.7) among all the 5 selected sites.

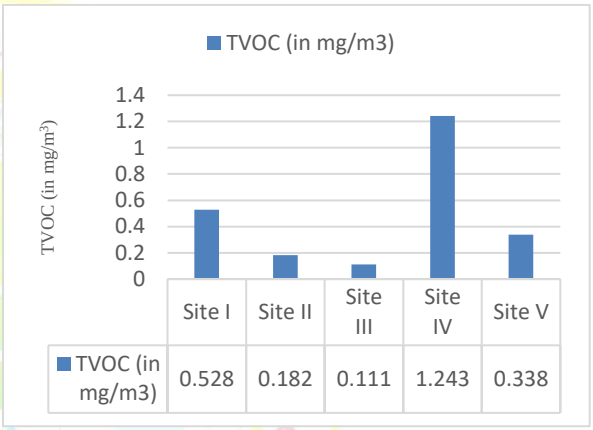

Fig.6: Mean TVOC (in mg/m3) of each site

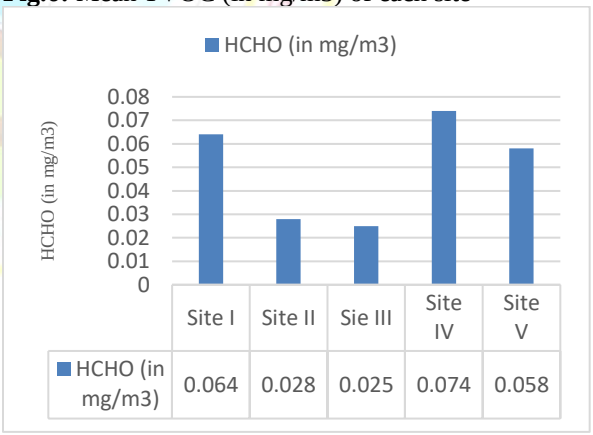

Fig.7: Mean HCHO (in mg/m3) of each site.

The mean PM 2.5 and PM 10 values (in $\mu g/m^3$) range from 32 to 88 (Fig.8) and 36 to 101 (Fig.9) respectively in the selected 5 sites.

Site IV is the most polluted site followed by the site I and site V.

Site III is the least polluted site followed by site II.

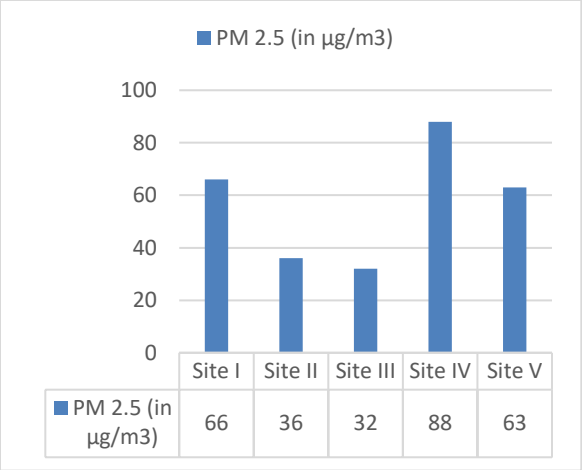

Fig.8: Mean PM 2.5 (in µg/m3) of each site.

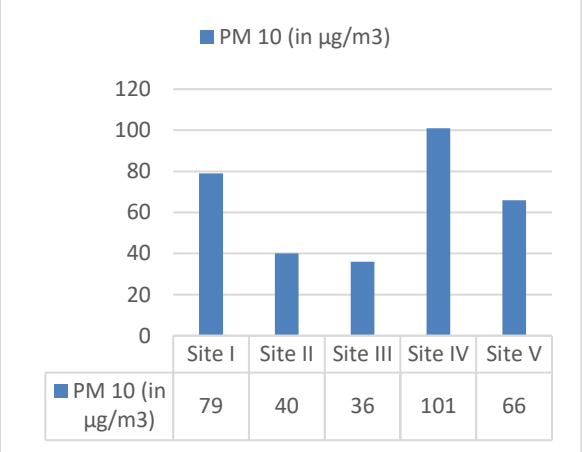

Fig.9: Mean PM 10 (in µg/m3) of each site.

Bird Diversity and Richness

A total of 230 individuals belonging to 10 different families were recorded. The highest number of individuals (i.e., 61) were recorded in site III (least polluted site) followed by site V (i.e., 52 individuals). The least number of individuals was recorded in site II (Table 2). Out of the total birds recorded, birds belonging to 06 different families were common in all 5 sites.

Table 2. A total number of birds of the different families at each site.

Family	Sites					
	I	II	III	IV	V	Total
Sturnidae	17	10	08	12	14	61
Dicruridae	02	03	05	02	03	15
Accipitriformes	06	02	03	06	01	18
Coraciidae	01	03	05	03	04	16
Psittaculidae	00	04	06	04	08	22
Columbidae	05	10	16	12	08	51
Cuculidae	02	01	04	01	03	11
Muscicapidae	03	00	03	02	04	12
Ardeidae	02	00	04	02	02	10
Pycnonotidae	00	00	07	02	05	14
Total	38	33	61	46	52	230

The species richness index ranged between 1.716 (site II) to 2.350 (site IV). For diversity, Shannon-Wiener index values range from 1.68 to 2.16 while the species evenness lies between 0.81 to 0.94. (Table 3).

Table 3: Species richness, Shannon-Wiener index and Species Evenness of each site.

Site	Parameters		
	Species Richness	Shannon-Wiener Index	Species Evenness
I	1.924	1.68	0.81
II	1.716	1.69	0.87
III	2.189	2.16	0.94
IV	2.350	1.99	0.86
V	2.27	2.08	0.90

The study found a moderate negative correlation between the air pollutants (viz., HCHO and PM 2.5) and bird species diversity (Shannon-Wiener diversity index). The negative value of the correlation coefficient marks the inverse relationship between the two variables i.e., with an increase in the value of one variable, the value of the other variable decreases consequently. The degree of relation is featured in Table 4 and Table 5.

Table 4: Correlation coefficient of HCHO with Richness index and Shannon-Wiener Diversity index.

Air Pollutant (HCHO)	Correlation With
Richness Index	r = 0.4784
Shannon-Wiener Diversity Index	r = - 0.0682

Table 5: Correlation coefficient of PM 2.5 with Richness index and Shannon-Wiener Diversity index.

Air Pollutant (PM 2.5)	Correlation With
Richness Index	r = 0.5342
Shannon-Wiener Diversity Index	r = - 0.0976

The study documented the 230 bird individuals of 10 different families across the 5 selected sites of Bilaspur city (Fig.10). The sites with no or less vegetation along with high vehicular traffic have more deteriorated air quality as compared to the sites with moderate to good vegetation cover and less vehicular traffic.

The Shannon-Wiener diversity index shows the high value of bird diversity in a less polluted area and comparatively less diversity of birds in a highly polluted area which shows that the avian community avoids areas with high air pollution and poor air quality. But the evenness of the bird community was not highly affected by the air pollution. The distribution of abundance across the species in a community was nearly the same in all the selected sites. The correlation between the air pollutant (viz., HCHO and PM 2.5) and species richness shows a moderate positive relation which exhibits that change in

air pollutant concentration does not highly affect the richness of the avian community.

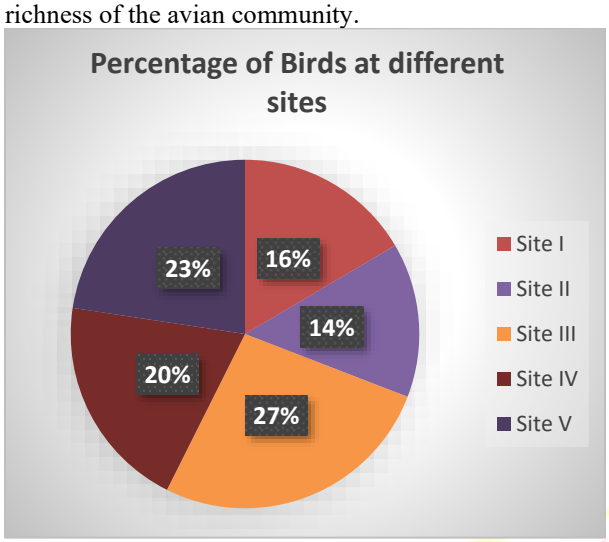

Fig.10. Pie Chart showing percentage composition of birds of different families recorded at each site.

But the major finding of the study shows the negative correlation between the air pollutant (viz., HCHO and PM 2.5) and the bird diversity (Shannon-Wiener diversity index) (Table 4 and Table 5), which indicates that an increase in the concentration of air pollutant of a particular habitat, the diversity of bird species of that habitat decreases and vice versa. A negative correlation denotes the inverse relationship between the two variables, so with the increase in the merit of one variable the merit of the other variable decreases.

Out of the recorded bird species, the birds of 'Ardeidae' family viz., Cattle Egret *(Bubulcus ibis)* and Intermediate Egret *(Ardea intermedia)* were recorded least in the city site followed by the birds of 'Cuculidae' family viz., Asian Koel *(Eudynamys scolopaceus)* and Greater Coucal *(Centropus sinensis)*.

The study also affirms the remarkably high population of birds belonging to 'Sturnidae' family viz. Asian Pied Starling *(Gracupica contra)* and Common Myna *(Acridotheres tristis)* and birds of 'Columbidae' family viz. Rock Pigeon *(Columba livia)*, Laughing Dove *(Spilopelia senegalensis)* and Spotted Dove (*Spilopelia chinensis*) in highly polluted sites. It validates that these bird species have adapted themselves to survive in areas with high air pollution and minimal vegetation. These birds use buildings for roosting, foraging and nesting and are mostly unaffected by noise and human presence, such species can be termed 'Urban Exploiters' (Mohring *et al*., 2021). Avian species which were closely linked to humans like House Sparrow *(Passer domesticus)* and House Crow *(Corvus splendens)* were not recorded in the urban area which could be due to the reason like replacement of natural biotic cover with an artificial substrate like concrete, lawns and asphalt (Turrini *et al*., 2015). The other bird species like Black Kite *(Milvus migrans)*, Indian Roller *(Coracias benghalensis)*, Rose Ring Parakeet *(Psittacula krameri)* and Black Drongo *(Dicrurus macrocercus)* were recorded in adequate numbers throughout the city.

Bilaspur city lacks much green cover and vegetation (Fig.11) due to which less diversity of bird species is observed. With rapid urbanization and industrialization, the air quality of the city is getting worse day by day which is the major reason for the loss of avian diversity in the city (Tiwari *et al*., 2022).

Fig. 11. Map showing the densely populated area of Bilaspur city with a lack of vegetation and greenery.

CONCLUSION

This study was carried out to find out the adverse impacts of air pollution on the diversity of the avian community and also to understand the avian responses towards air pollution by integrating a large number of data sets. Air pollution has a hazardous effect not only on human health but also on the avian community. This study showed the inverse relationship between air pollution and the diversity of birds. The high concentration of pollutants in the air declines the bird diversity of that area. Thus, air pollution must be checked and controlled strongly and positive efforts must be made to enhance the greenery, vegetation cover and biodiversity of the urban area.

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