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FOG OVER BHUBANESWAR AIRPORT

1. Fog is defined as an obscurity in the surface layers of the atmosphere, which is caused by a suspension of water droplets, with or without smoke particles. It is defined by international agreement as being associated with visibility less than 1000 metres. If the visibility exceeds 1000 metres then the obscurity is known as mist. The visibility and low cloud base generally affect the handling of air traffic at the aerodromes. Fog and mist reduce the visibility at the airports to such an extent that the diversions are necessitated resulting in dislocation of air services and consequently increase in the cost of air operations.

Forecasting of fog formation and clearance is a classical problem. Various workers have undertaken the study of occurrence of fog at various airports (Basu, 1954; Basu, 1957; Natrajan & Banerji, 1959; Goldar & Banerjee, 1988) but till 90's no such attempt was made for Bhubaneswar airport. Climatological Table of Observatories (IMD 1999) gives the frequency of occurrence of fog at Bhubaneswar airport. Rao & Srinivasan (1969) have discussed the favourable synoptic features for the formation of fog over coastal Orissa. However, other features of fog such, as time of formation, dissipation and duration etc. was not studied. Therefore to provide a forecasting aid to fog prediction an attempt has been made to study the climatological features of occurrence of fog at Bhubaneswar airport. For this study 10 years data for the period 1980 to 1989 has been collected from the current weather register of Bhubaneswar airport. There were 118 occasions of fog during the period of study spread during the months from January to May and from October to December. No case of fog was observed during the southwest monsoon season. Recently Mishra and Mohapatra (2004) studied some climatological features of fog over Bhubaneswar airport using data for the period 1989 to 1998 and found the frequency of fog 13 per year, which indicates that frequency of fog has, not changes significantly.

2. *Result and discussions* - Fog season at Bhubaneswar occurs during the period from October to May. Bhubaneswar airport experiences fogs on an average of 12 days in a year. Table 1 gives the monthly percentage of fog for the period of study. Maximum number of fog days (36%) occurs during the month of January followed by February (26%) and March (15%). These three months account for 77% of fog days. During the period of study only one day of fog was observed during the month of May (1983). No case of fog was reported during the southwest monsoon season *i.e.*, during the months from June to September.

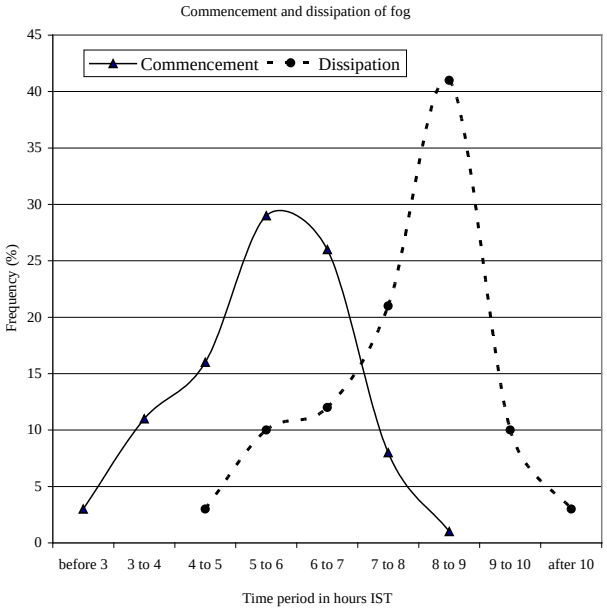

Fig. 1. Percentage frequency of time of commencement and dissipation (in hrs. IST) of fog at Bhubaneswar airport for the period 1980-89

2.1. *Time of commencement and dissipation of fog* - Brown and Roach (1976), Brown (1980), Roach *et al*. (1976), Findlater (1985), Wetzel (1996) have studied the physical processes responsible for radiative cooling and condensation of fog droplets. Radiation fogs mainly occur in moist air on cloudless nights within a high-pressure system, particularly after rainfall. The moist air closest to the colder surface will quickly cool to dew point with condensation occurring. As air is a poor conductor a light wind, 2 – 6 knots, will best facilitate the mixing of the cold air throughout the surface layer, creating the fog. The fog itself becomes the radiating surface in turn, encouraging further cooling and deepening of the fog. Advection fog may occur when warm, moist air is carried over a surface, which is cooler than the dew point of the air. Cooling and some turbulence in the lower layer drop the air temperature to dew point resulting in fog formation.

It has been observed that only radiation type of fog forms at Bhubaneswar airport. Percentage frequency of time of commencement and dissipation of fog has been shown in Fig. 1. It was found that on 73% of fog day's fog commenced during the period 0400 hrs (IST) to 0700 hrs (IST). On about 56% of fog days the fog commenced during the period 0500 hrs (IST) to 0700 hrs (IST). Only on 9% of fog - days fog commenced after 0700 hrs (IST) whereas only on 8% of fog days it commenced before 0300 hrs (IST). The earliest fog started at 0115 hrs (IST)

TABLE 1

Monthly frequency of fog at Bhubaneswar airport for the period 1980-89

	Months								Total
	Jan	Feb	Mar	Apr	May	Oct	Nov	Dec	
Number of days	42	31	18	3	1	5	7	11	118
Frequency	4.2	3.1	1.8	0.3	0.1	0.5	0.7	1.1	11.8
% Frequency	36%	26%	15%	3%	1%	4%	6%	9%	100%

TABLE 2

Duration of fog (in hours) at Bhubaneswar airport for the period 1980-89

Months	Number of days with fog for duration in hours						Total
	< 1	1 to 2	2 to 3	3 to 4	4 to 5	> 5	
Jan	8	10	6	5	6	7	42
Feb	7	8	8	3	3	2	31
Mar	5	5	3	2	3	0	18
Apr	1	2	0	0	0	0	3
May	1	0	0	0	0	0	1
Oct	0	1	1	1	1	1	5
Nov	1	1	2	0	3	0	7
Dec	2	2	4	1	2	0	11
Total	25	29	24	12	18	10	118

TABLE 3

Frequency of different categories of fog at Bhubaneswar airport for the period 1980-89

Categories of fog	Number of days with fog in the month								Total
	Jan	Feb	Mar	Apr	May	Oct	Nov	Dec	
Light fog	14	13	3	1	1	1	5	4	42
Moderate fog	2	5	5	2	-	2	-	1	17
Thick fog	11	10	6	-	-	2	-	5	34
Very thick fog	15	3	4	-	-	-	2	1	25
Total	42	31	18	3	1	5	7	11	118

on 15 November 1987 and dissipated at 0615 hrs (IST). Throughout the fog period the sky was not visible, wind was easterly 05 to 08 knots, the dry bulb temperature was between 23.6° C to 23.8° C, and humidity was 100%. The sunrise time at Bhubaneswar is between 0530 to 0625 hrs (IST) from October to February. A comparison of time of onset of fog with sunrise time indicates that in the majority of the cases fog set in either before sunrise of within half an hour after sunrise.

It was observed that on about 87% of fog days, fog dissipated before 0900 hrs (IST) whereas on 62% of fog

days, fog dissipated between 0700 hrs (IST) and 0900 hrs (IST). Only on 3% of fog day's fog dissipated after 1000 hrs (IST). The process of dissipation of fog after sunrise is attributed to the evaporation of fog droplets (Atkins, 1965; Wetzel *et al*., 1996) due to direct absorption of sunlight.

After sunrise, the solar heating of the ground results in heating the air molecules in contact with the ground. These heated air molecules, move up and transfer heat energy by conduction. This process continues for about 2 to 6 hours, in which, the vertically moving molecules erode the whole inversion and air parcels in the form of convection. At the same time, convection also results in increasing the surface winds, thereby, further resulting in the reduction of fog on the ground. Moreover, the absorbed solar radiation by the fog droplets can also contribute in decreasing the intensity of fog.

2.2. *Duration of fog* - Table 2 gives the frequency of fog lasting for different durations during each month. It is seen from Table 2 that on about 67% of fog days, fog lasted for less than three hours whereas on about 46% of fog days fog lasted for 1 to 3 hours. Fog of duration more than 5 hours occurred mostly during the month January (7 days). February recorded 2 fog days and October only 1 fog day of duration more than 5 hours for the period of study. Highest duration of fog of 7 hours 05 minute was recorded on 24 January 1988 during the period of study. The fog started at 0215 hrs (IST) and dissipated at 0920 hrs (IST).

2.3. *Intensity of fog* - Fog is generally classified into four categories according to surface visibility conditions.

1. Light fog — Visibility less than 1000 m but more than 500 m
2. Moderate fog — Visibility less than 500 m but more than 200 m
3. Thick fog — Visibility less than 200 m but more than 50 m
4. Very thick fog — Visibility less than 50 m

Table 3 gives the frequencies of fog of different categories' for each month for the period of study. From the Table 3 it is observed that frequency of very thick fog is maximum during January. Thick fog and very thick fog occurs on 50% of fog days followed by light fog on 35% of fog days. During November and May only light fog occurred, whereas light to moderate fog occurred during the month of April. On 39% of fog days, visibility was less than 100 m whereas on 28% of fog days sky was not visible during fog.

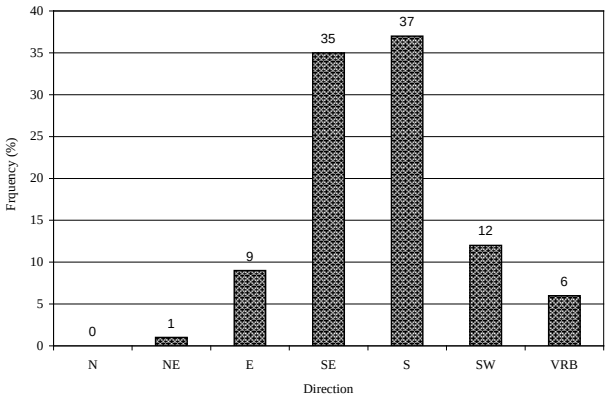

Fig. 2. Percentage frequency of average surface wind on the previous night of fog at Bhubaneswar airport for the period 1980-89

2.4. *Surface winds on previous nights of fog days* - For the formation of fog nocturnal cooling and sufficient moisture are essential ingredients. Surface wind plays an important role in moisture supply and turbulent mixing of air in lower layers near the ground. Therefore, to study the effect of surface wind on the occurrence of fog, the average surface wind in the preceding night of fog day was calculated by taking average of hourly wind data between 1200 UTC and 2400 UTC. Fig. 2 gives the frequency of average surface wind on the previous night of the fog days for the period of study.

Bhubaneswar airport is about 60 to 80 km from the coast and is bounded by the coastline from southwest to easterly direction. From Fig. 2 it is observed that on about 72% of fog days the average wind direction, in the preceding night was found to be from southerly to southeasterly direction with average wind speed of 03 to 05 knots. On 12% and 9% of fog days the wind was from Southwesterly and easterly direction respectively. Due to topography of the place these winds supply additional moisture and salt nuclei, which help the formation of fog.

3. On an average, there are 12 days of fog every year at the Bhubaneswar airport. January and February account for 62% of fog days with January registering the maximum number of fog days. January and February have recorded longest duration of fog of more than 6 hours duration. Fog may commence at any time between 0200 hrs (IST) to 0800 hrs (IST) but the duration from 0500 hrs (IST) to 0700 hrs (IST) is the most favourable period for commencement of fog. On majority of fog days fog lasts for less than 3 hours but on a few days during the months of January and February it may 1ast for more than 5 hours. Most favourable time of dissipation of fog at Bhubaneswar airport is between 0700 hrs (IST) to 0900

hrs (IST). Thick and very thick fog mostly occurs during the months of January and February. On most of occasions average surface wind direction during the preceding night of the fog day was found to be mainly south to southeasterly with southerly winds having the maximum frequency.

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