

RECENT OCCURRENCE OF FOG OVER PAKISTAN (1997 to 2000)

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Abstract:

This study examines the data for normal period (1961-1990) over five month period (Nov-March), of the following years for the 56 stations of Pakistan.

1997-1998

1998-1999

1999-2000

However great concentration has been made on the 24 stations most of them are located in the Punjab, where the fog formation is very common especially in the recent years, The data of monthly number of fog days (Sky not seen) of the station for above period was initially examined to find out any significant change as compared to the normal frequency of fog days. Secondly various meteorological parameters were examined and following parameters were identified having significant role in the formation of fog.

Mean Monthly relative humidity in % at 0000 and 0300 U.T.C.

Mean Monthly dry bulb temperature in C° at 0000 and 0300 U.T.C.

Mean Monthly Wind speed in Knots at 0000 and 0300 U.T.C.

Lastly synoptic pattern associated with extensive fog phenomenon were analysed and studied on the synoptic charts prepared at Pakistan Meteorological Department forecasting office for the Month of November to March in the years 1997 to 2000.

Introduction:

Pakistan is an agricultural country. Its economy depends on the number of factors. One of the most important factors is weather. Fog as a weather phenomenon plays an important role in our economy. During last three years (1997-2000) fogs formed over the Punjab and adjoining areas of Pakistan and prevailed for a number of days in the months of November-March. A number of flights were cancelled and many road accidents occurred, as reported by the press.

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i. What is fog?

The meteorological definition of fog is a cloud (stratus) which has its cloud base on or close to ground, and reduces visibility to less than 1000 meters. Humidity at ground level can reach 100% in different way (Bruad, 1944). (They basically all look the same, though.)

ii. Forms of fogRadiation Fog:

‘Radiation fog’ is common in the mornings after heat has radiated in to the atmosphere during night. It normally dissipates after sunrise. Over land, fogs usually form just after sunset, though they may persist well into the next day. An evening fog begins when the sky is clear. As the sun goes down, the earth radiates heat into the clear sky and the air above the ground becomes cool. As the temperature drops, fog is formed. Because the Earth cools by radiating heat into space, these fogs are called radiation fogs.

Advection Fog:

‘Advection fog’ is formed by humid air moving horizontally, being cooled down from below.

Frontal Fog:

‘Frontal fog’ is formed between warm and cold air in a front.

Industrial Smog:

The mixture of smoke and fog over large cities is called smog. Fog over a city is usually more intense than over the surrounding countryside because the city discharges a greater amount of moisture into the atmosphere. This, combined with dust, heavy chimney smoke from factories, and auto exhaust fumes makes a thick vapor that does not disperse easily unless the wind is strong. There are also ‘sea fog’, ‘hill fog’, ‘steam fog’ and other forms of fog (www.comptons.com).

iii. Why Fog is environmentally Significant?

In polluted atmosphere, the water vapour may condense on aerosol particles. In polluted atmosphere, the aerosol particles will be composed of gases like Sulfur di oxide, Ammonia, Nitrogen Oxides Hydrogen Chloride etc. So, when the fog droplets form on these aerosols, water absorbs the gases. The water droplets are favourable site for oxidation of many reductants, above all, Sulfur di oxide to Sulfuric Acid. The liquid water content of typical fog is very small and so the concentration of ions are often 10 to 50 time larger than those of rain. So, in polluted atmosphere fog droplets are more polluted than raindrops. Clouds process substantial volumes of air and transfer gas and aerosols over

large distances. On the other hand, fog droplets are important collectors of local pollutants near the earth's surface (www.lehigh.edu).

These above factors were examined during the study period over Pakistan.

Data & Procedure:

This study examines the data for normal period (1961-90) over five-month period of the following years for the 56 stations of Pakistan:

- i. 1997-1998
- ii. 1998-1999
- iii. 1999-2000

However greater concentration has been made on the 24 stations; most of them are located in the Punjab, where the fog formation is very common especially in the recent years. The data of monthly number of fog days (sky not seen) of the station for the above period was initially examined to find out any significant changes as compared to the normal frequency of fog days. Secondary various meteorological parameters were examined and following parameters were identified having significant role in the formation of fog.

- a. Mean Monthly relative humidity in % at 0000 and 0300 UTC.
- b. Mean Monthly Dry bulb Temperature in C° at 0000 and 0300 UTC.
- c. Mean Monthly Wind Speed in Knots at 0000 and 0300 UTC.

Lastly synoptic pattern associated with the extensive fog phenomenon were analysed and studied on the synoptic charts prepared at Pakistan Meteorological Department (PMD) forecasting Offices for the month of November to March in the years 1997 to 2000.

Findings:

The following are the detailed description of the findings:

i. Frequency of Fog over Pakistan during 1997-2000

Fog persists over Pakistan during the month November to March. Figure-1 gives the comparison of 24 stations where the fog has been increased from normal significantly and is more dominant in the month of December & January (Figure-2). The normal fog frequency map, for the period of 1961-90, of Pakistan (Figure-3) shows that the fog is mainly formed over Punjab and adjoining areas with its center at the northern Punjab. During the 1997-98 (Nov-Mar) period the fog frequency is considerably increased and apart from the Punjab it has also formed over North Western Frontier Province (NWFP)

and Azad Jammu & Kashmir (AJK) areas (Figure-4). The main center of this fog in the eastern Punjab besides this its second center is over the northern Punjab. During the next season (1998-99) the fog was more intense over the Punjab and the same expanded to adjoining areas (Figure-5). The fog was dominant in the month of December & January especially in the eastern Punjab region, where fogs were recorded for 15-20 days in each of this two month. In the last season (1999-2000) fog continue to persist over the Punjab with its main center at Bahawalnagar (Figure-6)

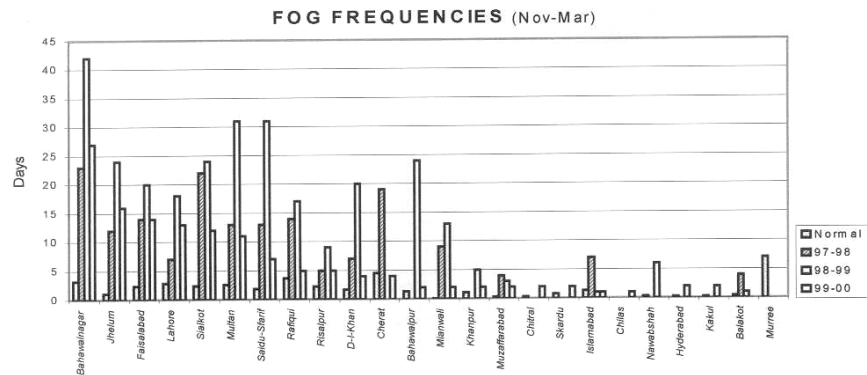


Figure-1

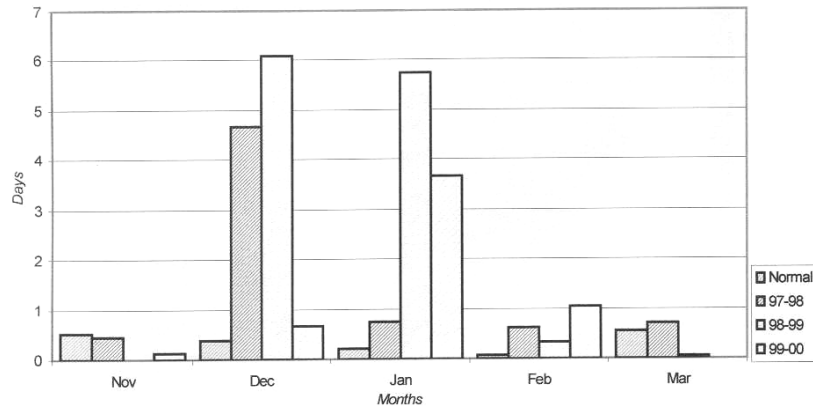
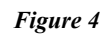
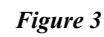
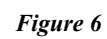
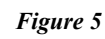


Figure-2





Following table shows the frequencies of fog during the month of November to March recorded at selected stations:

Station	Bahawal	Jhelum	F-abad	Lahore	Sialkot	Multan	S-Sharif	Rafiqui
Normal	3.2	1.1	2.4	2.8	2.4	2.6	1.8	3.7
97-98	2.3	12	14	7	22	13	13	14
98-99	42	24	20	18	24	31	31	17
99-00	27	16	14	13	12	11	7	5

Station	Risalpur	DI.Khan	Cherat	B.Pur	Mainwali	Khanpur	M.Abad	Chitral
Normal	2.2	1.7	4.5	1.3	0.1	1.1	0.3	0.3
97-98	5	7	19	0	9	0	4	0
98-99	5	20	0	24	13	5	3	0
99-00	5	4	4	2	2	2	2	2

Station	Skardu	Islam	Chilas	Nawab	Hyder	Kakul	Balakot	Murree
Normal	0.8	1.3	0.0	0.3	0.2	0.2	0.4	7.0
97-98	0	7	0	0	0	0	4	0
98-99	0	1	0	6	2	2	1	0
99-00	2	1	1	0	0	0	0	0

ii. Relative Humidity

It has been observed that the normal relative humidity at 0000 UTC and 0300 UTC over the fog-affected areas ranges between 75-85%. The mean relative humidity at 0000 UTC and 0300 UTC was significantly higher during last three seasons than the normal values (Figure-7, Figer-8). During this period the mean monthly relative humidity recorded in various stations in the north-east of Pakistan was more than 90% especially in the months of December and January (Figure-9, Figure-10)

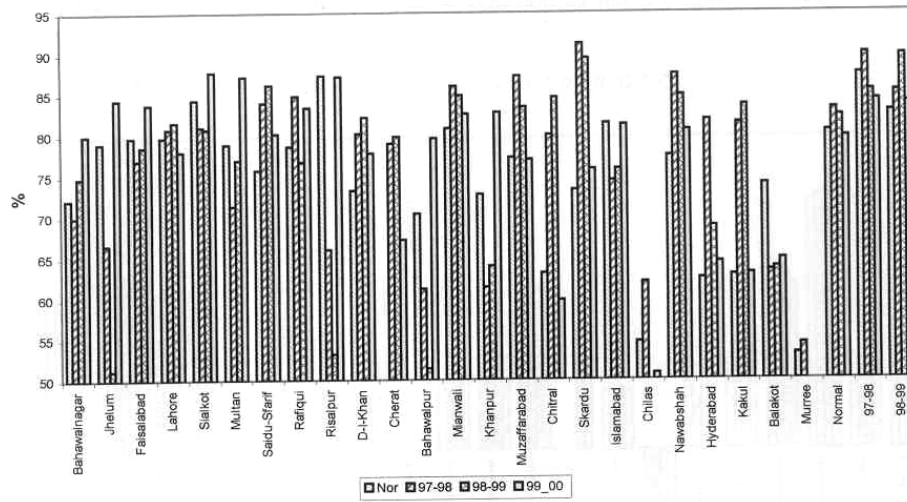
RELATIVE HUMIDITY (0300 UTC)

Figure-9

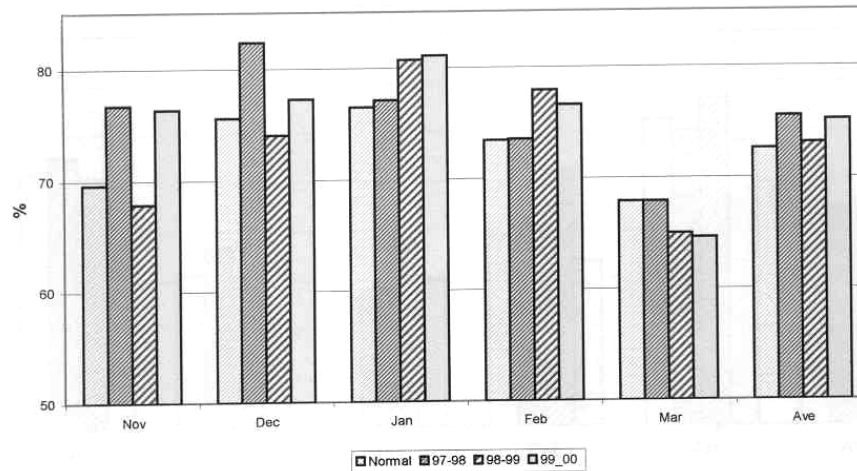
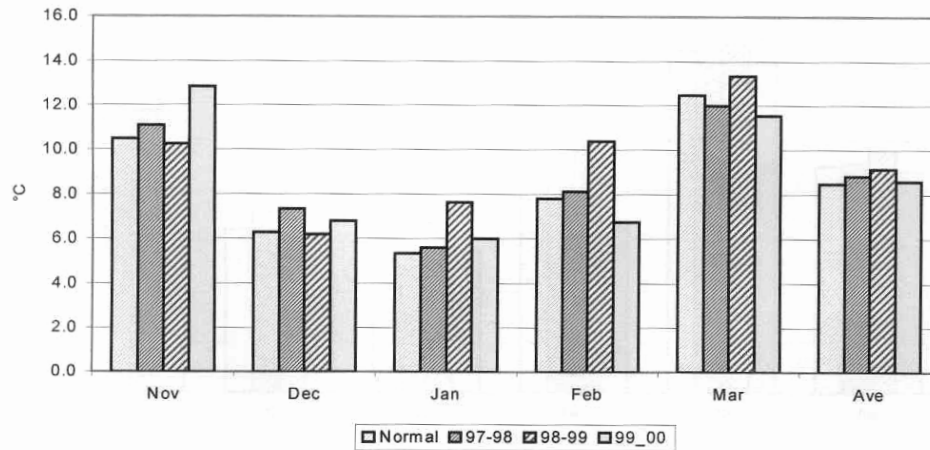
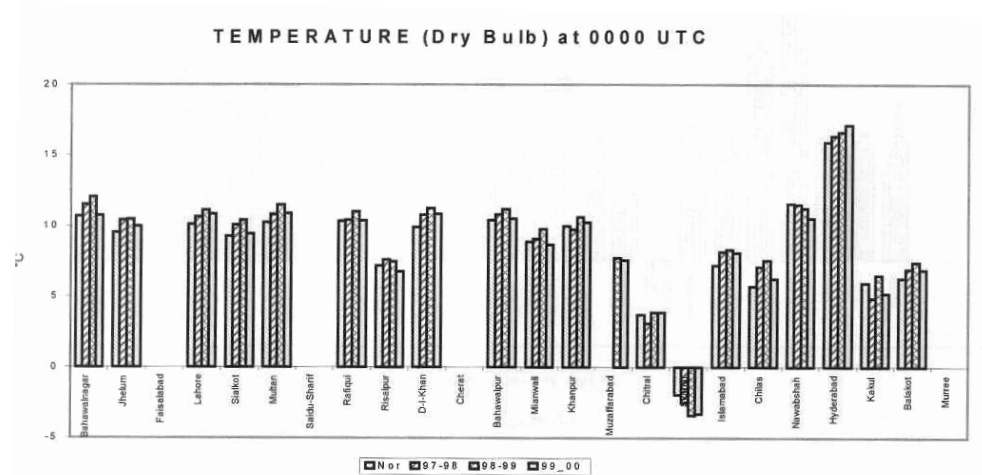


Figure-10

iii. Temperature

The mean monthly dry bulb temperature at 0000UTC and 0300UTC, were on higher Side during the years 1997-99, when compared with its normal values (Figure-11 to Figure 14).



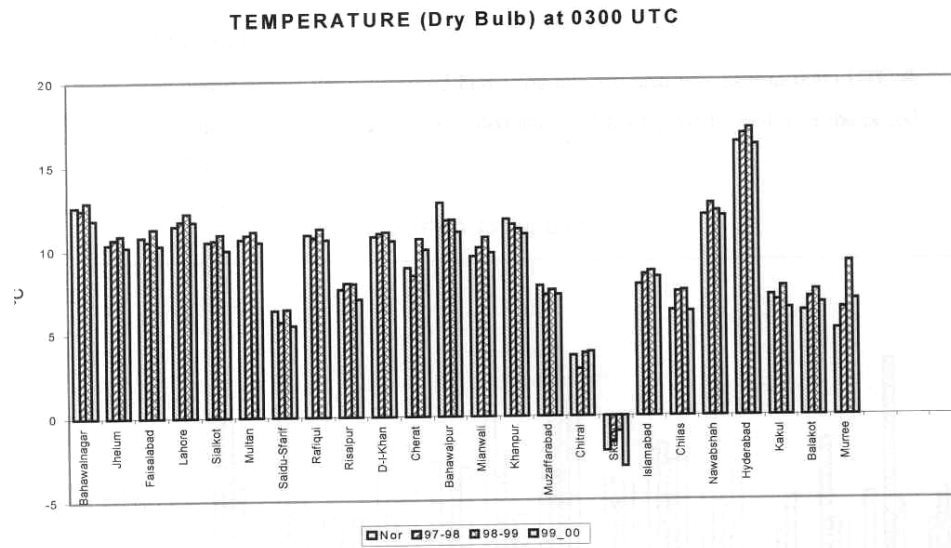


Figure-13

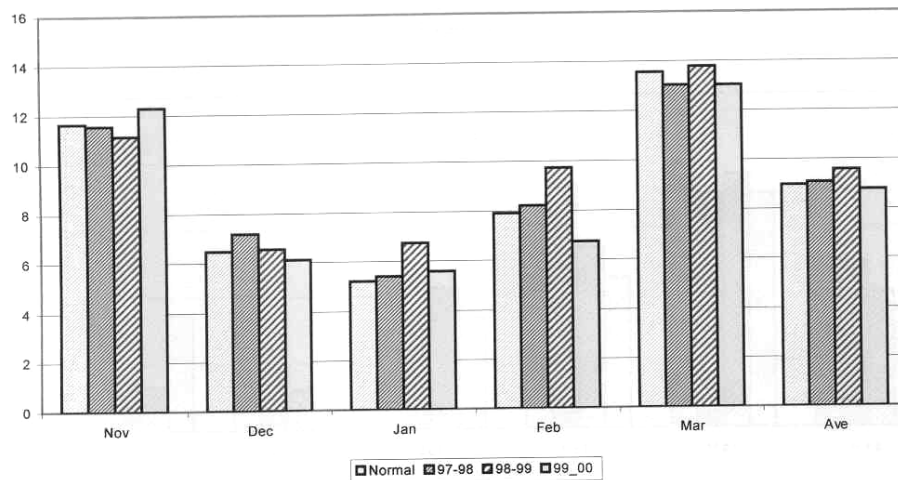


Figure-14

iv. Wind Speed

It has been observed that the wind speed in the fog affected area was light at 0000UTC & 0300UTC. Many of these places have recorded light (1-3 Knots) wind speed over the period under study (Figure-15 to Figure-18)

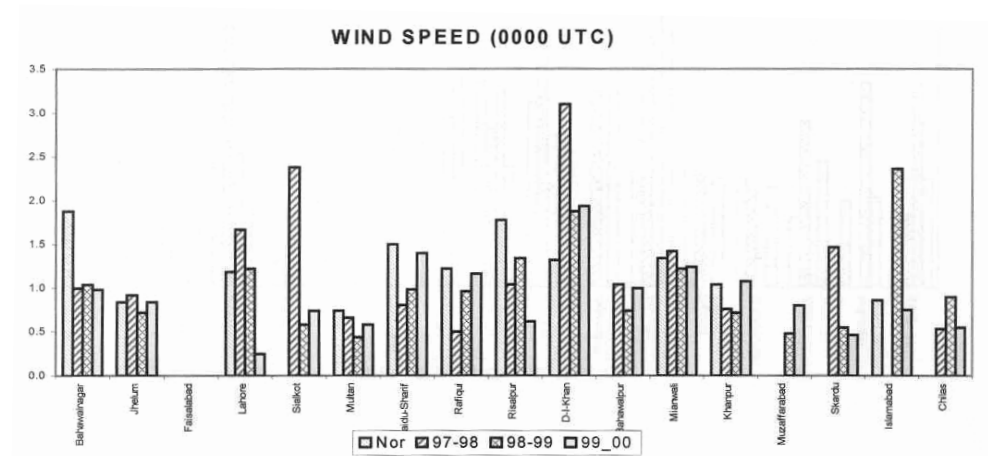


Figure-15

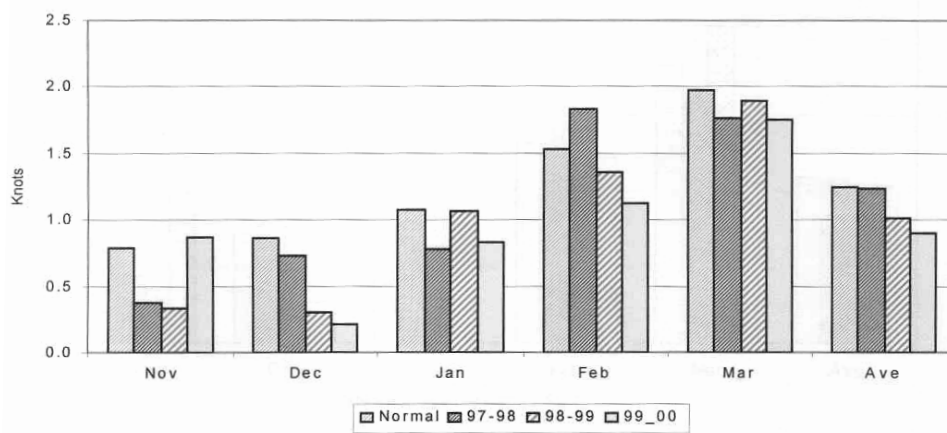


Figure-16

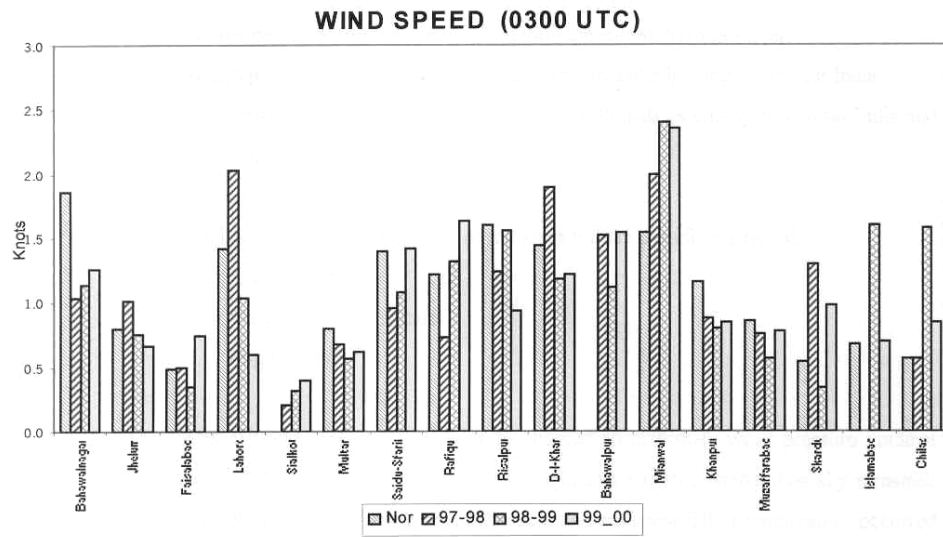


Figure-17

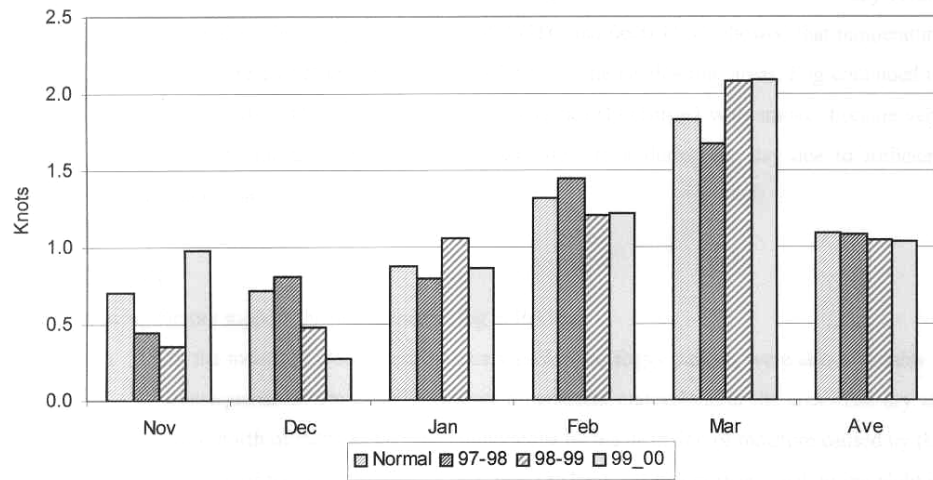


Figure-18

v. Mean Synoptic Situation (November-March 1997-2000)

During the above period of fog the synoptic situation are summarised as under.

- A trough persisted over northern parts of Pakistan and adjoining northwest India.
- A high-pressure area also persisted over central Punjab extending to central India and Arabian Sea.

The three conditions for the development of radiation fog are therefore satisfied.

- 1) Light winds
- 2) Clear sky or little cloud
- 3) High humidity.

Surface charts of 0000 UTC for these months showed an extremely weak pressure gradient over northeast of Pakistan with correspondingly light and variable winds. The sky remained clear to almost clear over northern parts of Pakistan and sufficient fall of temperature occurred to cool the air down to its dew point. Temperature dropped some 10-15°C during the night time. In the early hours of the day before the fog formation, the synoptic charts of 0300 UTC and 0600 UTC, showed that temperature over northern areas of Pakistan had fallen 6-7°C than the neighboring areas. Fog continued to develop during the following days and, becoming heavily charged with smoke, became very thick. The sun's radiation was unable to penetrate into it during the day due to sufficient moisture in the air.

Discussion:

The following factors support the persistence of fog in Pakistan.

- a. In the month of December & January prolonged foggy periods were also invariably a consequence of the establishment of a persistent anticyclone in the area. The dry air from north of Pakistan became humid/moist by the incursion of moisture caused by the passage of western disturbance and since the land was colder than usual during night in December and January fog formed at a number of places.
- b. The northern parts of Pakistan are surrounded by hills on three sides, so that the moisture becomes stagnant for a longer time. When the Siberian cold air comes from the high elevation into the low elevation (eastern Himalayas or Tibet) it meets the warm and moist air from the south and southwest due to western disturbances approaching Pakistan and neighboring India. This situation together with the anticyclonic circulation already existing there helped the formation and persistence of fog in the

area. The fog dissipated as a result of the shifting of the anticyclone over Pakistan towards the east due to the movement of the western disturbance.

- c. In case when the western disturbance is strong, more air from the south and southwest will be sucked into this newly formed low at the place of the anticyclone and sometimes the air from the south goes beyond central India and meets the cold air in the Punjab, some parts of it, however, turns eastward and joins the anticyclonic circulation. The northwest branch of the flow results in heavy fog in the north of Pakistan.
- d. River Indus also plays an important role for the supply of moisture. If the cold air mass stagnates in the areas where the moisture is stored, the moisture quickly condenses to fog. The result is a fog of several days' duration which ends with the breaking down of the high-pressure areas over the Indian region.
- e. According to the synoptic situation during the study period, it was observed that approximately all those days when fog occurred over northeast of Pakistan an anticyclonic circulation continuously persisted over India. This permanent anticyclonic feature (Sutcliffe, 1948) does not undergo any apparition in position, moving north and south with sun, and extend over the land area in winter season, being partly intensified by some degree of surface cooling. These anticyclonic areas are the main source regions of maritime tropical air masses, which give much low cloud, fog, and drizzle on drifting to higher latitudes, but in the subsiding region the atmosphere is clear.

Conclusion:

To conclude this study the following factors have been identified to have contributed in recent accession of fog over Pakistan.

- i. Rise in the Relative Humidity.
- ii. Prevalence of little or almost calm air over the fog effected areas.
- iii. The industrial development is also one of central cause for the increase in pollutants in the atmosphere over the last three decade. The majority of this pollution was created from the burning of coal for energy generation, space heating, cooking, and transportations. It has been observed in industrialized urban areas of Pakistani & Indian Punjab and Indian state of UP that large quantities of coal are burned without adequate pollution control causing formation of fog.

Recommendations:

It is recommended that the occurrence of fog peak during (1961-2000) may be compared in more detail with weather elements like: rain, humidity, wind and stability of the atmosphere in future. Establishment of fog monitoring station in the fog-affected areas is also recommended.

Acknowledgment:

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(<http://www.lehigh.edu/~pamd/fog.htm>)