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# Air Pollution Potential of Dhanbad Coalfield Area

**Pramod Kumar**

Email:nita_pramod@yahoo.com

Department of Chemistry, Sri Aurobindo College (University of Delhi), Malviya Nagar, New Delhi - 110017

## Abstract

The present work is to assess the air pollution potential of in around Dhanbad Coalfield Area. The percent Inversion, Mixing Height and Ventilation co-efficient of this location have been calculated diurnally and seasonally using the radiosonde data upto 700 milli bars (mb) collected forRanchi, the nearest available station. It has been found that ground based inversion was the minimum (5%) in monsoon and maximum (76%) in winter. In the upper air percent frequency of inversion was low in comparison to ground base.The mean minimum mixing height (161 m) was found to be the maximum in Post Monsoon whereas the mean maximum mixing height (1709 m) was observed maximum for summer.The value of ventilation coefficient was nearly the same for January, August and October.April had the highest minimum and maximum ventilation coefficient.Applying Gross's (1970) criteria of pollution potential in the present study, it was concluded that in all theseasons, pollution potential was higher except in April in afternoon. Since the value of afternoon ventilation coefficient was higher than the morning one in all the seasons,the potential may be predicted to decrease gradually with time by afternoon.

**Key words**: Pollution Potential, Inversion of temperature, Mixing Height and Ventilation Co-efficient.

## Introduction

Air pollution does have a substantial influence on social life and its various activities. Present day the status of air pollution is due to the poor understanding of the management and control of the interactions among science, technology and social demands. Therefore, it is necessary to study the capacity of the atmosphere of a particular place to dilute the pollutants released in it by diffusion and transport of the pollutants.Such a study needs considerable knowledge of air pollution climatology of a place. Air Pollution Climatology deals with aggregate of weather elements that influence the fate of airborne effluents. It provides a primary assessment of the variation in the dispersion ability of atmosphere both diurnally and seasonally of a particular location. It is helpful to the town planner for site selection of pollution sources and its operation,in order to minimise the effects of air pollution in relation to sensitive areas (people, animal and vegetation).

In the present study the Air Pollution Potential of Dhanbad (a mine rich area) has been studied. "Air pollution potential is the measure of the inability of the atmosphere to adequately dilute and disperse pollutants vertically and horizontally emitted intoit, based on the values of specific meteorological parameters of the macro scale features" [1]. Meteorological conditions, which are favorable for accumulation of pollutants, denote high pollution potentialwhereas, conditions in which dispersal of pollutants can occur effectively denote low pollution potential. So in order toadjudge the propriety of location of any new industry or anypollutants releasing source at any location, a detailed study of pollution potential of that location is necessary. The essential parameter to adjudge air pollution potential ofa place is its Ventilation Coefficient (V.C.), which is a product of the mixing height andthe transport wind through the mixed layer. Mixing height is the height (meters) upto which airpollutants are diffused by atmospheric turbulence. This height varies diurnally,from season to season, and is also depends on the topography of a particular place. Smaller theheight, adverse is the conditions for dispersionpollutants. High pollution potential results when themorning mixing height is < 500 meters and transport wind speed < 4 m/sand afternoon ventilation coefficient < 6000 $m^2/s$ and transportwind < 4 m/s [1].

**Materials and Methods**:

**Study Area:**

In the present study Air Pollution Potential in and around of Dhanbad (coal capital of India) has been described and discussed. This area has emerged into a potential industrial complex with intensive mining and associated industrial activities after independence. These industries play a significant role towards this visibly polluted complex due to release of particulate matter, sulfur dioxide, nitrogen oxide, carbon monoxides, hydrocarbons and toxic gases such as ammonia and cyanide in traces etc. into the atmosphere. Vehicles used in coal transportation and the domestic consumption of coal due to its easier availability, are another potential source of air pollution in this mining area. The mine fire which covers a large area (about 20 square kilometers in Jharia belt) emits a great deal of smokes and fumes into the atmosphere. The operation of internal combustion engines and blasting activities give rise to other pollutants mainly ammonia and aldehyde in small quantities. But the main cause of pollution in this mining area is due to suspended particulate matters (SPM). The SPM in the mining area is mineral and rock dust, fly ash, sand.

**Methodology:**

The present study aims to gain the understanding air pollution potential over the Dhanbad coalfield area. Since the upper air data was not available for Dhanbad, the radiosonde data (1983-87) upto 700 mill bar for Ranchi, the nearest available meteorological Station have been collected and analysed for Stable layers (% inversions), mixing height and Ventilation co-efficient (VC).

To determine the mixing height, Holzworth's[2]method has been followed. It is determined with the morningtemperatures profile data from radiosonde observations andsurface temperature data. The point at which the dry adiabatethrough the surface temperature intersects the morning temperature profile, decides the mixing height. Maximum mixingheights for afternoon periods were estimated by extending a dryadiabate from the daily maximum surface temperature to itsintersection with the early morning temperature profiles. Forminimum mixing height, minimum temperature data complied withincremental temperature due to urban and industrial effects was used and same process was followed for calculating the maximummixing height also.

To account for the urban heat island intensity whichvaries from place to place depending upon the city size,topography, state of the ground, wind speed etc. +3°C has beenadded to early morning minimum temperature and +1°C to thedaily maximum surface temperature except for monsoon seasonwhen a value of +2°C has been assumed, because of persistent overcast conditions which considerably reduce the daytimetemperature while increasing night time value [3]. Above assumed value for heat island intensity for Ranchisupposed to be justified with respect to Delhi (heat islandintensity value given in Table 1) due to its particulartopographic setup, better vegetation and lower population. Mixing height is calculated for every day of each season forfive years and the averages of maximum and minimum height havealso been calculated.

Table1

Mean heat island intensity (°C) at maximum and minimum epoch at Delhi [4,5]

| Month | Heat Island Intensity (°C) | | Month | Heat Island Intensity (°C) | |
|---|---|---|---|---|---|
| | Max | Min | | Max | Min |
| Jan | 4 | 6 | Aug | 2 | 4 |
| Apr | 3 | 6 | Oct | 4 | 6 |

Through the mixed layer, mean speed from 00 GMTradiosonde observation has been calculated and multiplied bythe corresponding mixing height (obtained from maximum andminimum temperature) to get value of maximum and minimumventilation coefficients.

## RESULTS AND DISCUSSION

## STABLE LAYERS OVER RANCHI

Percentage frequency of occurrence of inversions forRanchi for 00 GMT (Z) and 12 GMT for five years (1983 - 87) upto 600 mbfor four months representing four different seasons viz. Winter (January), Pre-monsoon (April), Monsoon (August) and Post-monsoon (October) have been summarized below in Table 2.

Table 2

**Percentage frequency of inversion at 00 GMT, Ranchi (1983-87)**

| Layer | Month | | | |
|---|---|---|---|---|
| | January | April | August | October |
| Surface to 900 mb | 76 | 36 | 5 | 30 |
| 900 to 850 mb | 13 | 3 | 0 | 3 |
| 850 to 800 mb | 13 | 5 | 2 | 14 |
| 800 to 750 mb | 9 | 2 | 2 | 8 |
| 750 to 700 mb | 8 | 0 | 4 | 12 |
| 700 to 650 mb | 7 | 4 | 1 | 4 |

The following broad conclusions have been drawn:

1. Total numbers of inversions at 12 Z were 19 percent in comparison to that of 00 Z.
2. 75 percent of ground-based inversions were observedin five-year data for January and out of which total inversions(ground based and elevated inversions) were 60 per cent. Theseradiation inversions are formed due to nocturnal cooling during clear nights and very low winds prevailing at this place.
3. In April, again ground based inversions were nearly 40 per cent whereas in August it was observed to be minimum (5 per cent). Such minimum frequency in this month is supposed tobe due to cloudy weather.
4. In October, it has increased again.

Frequencies of occurrence of elevated inversions are again more in January followed by October. The frequency of elevatedinversion layers at 12 Z is observed to be lower at all thelevels in comparison to 00 Z.

Occurrence of isothermal layers has also been computed, and was found to be in very low percentage. Maximum (10 percent) have been observed in October out of that 5percent was ground based. In January and August it was lessthan 2 percent.

Ground based inversions limit the dispersion of pollutants vertically. The top of inversion acts effectively asa lid and traps any pollutants released below it. Thus it mayconcluded on the basis of the present study, with foregoingprinciple, of all the months, January may be worst for mixingof pollutants whereas, August is better in the studied area.

**MIXING HEIGHT**:

In the present study mean minimum and maximum mixing heights have been calculated for five years period (1983-87) for all four typical months of the seasons and shown in Table 4 below.

Table 4.

**Mean mixing height (1983-87) in meters**

| Month/Season | Minimum | Maximum |
|---|---|---|
| January/Winter | 132 | 1122 |
| April/Summer | 159 | 1709 |
| August/Monsoon | 136 | 779 |
| October/Post Monsoon | 161 | 1137 |

The study shows that in January, the minimum mixing height has varied between 0 to 624 meters with a mean value of132 meters, but the maximum height reached upto 1900 meters in 1986. Mean maximum mixing height was found to be 1122 meters.

In April also minimum mixing height was found to be zero, but hardly for three or four times in five years period.The average minimum mixing height was 159 meters whereas,maximum mixing height was 1709 meters. The maximum mixingheight has also been observed upto 4300 meters.

In August, the difference between mean maximum (779 m) and mean minimum mixing height (136 m) was found to beminimum in comparison to other months. In this month minimum mixing height varied from 0 to 500 meters. The maximum upto1716 meters in 1985 has been observed. In October, minimum mixing height variedfrom 0 to 777 meters and maximum from 465 to 2700 meters with an average mean of 161 meters for minimum and 1137 meters formaximum mixing height.Sometimes minimum mixing height is Zero due to diurnal variation of surface temperature and the existence ofmorning inversion conditions.

Results in the present study are more or less similar to seasonal variation of Delhi [6]. The low value of mixing height in thispresent study for Ranchi is much lower than that of Delhi. This may be due to lower correction of heat island intensity for Ranchi, which is lower when compared to Delhi.

Of the four months, mixing heights are highest in April followed by October and minimum in the month of August.The range of mixing heights has similar pattern as that ofsurface temperature difference. In April, mixing heights canbe explained due to maximum surface heat input in this month.

The permanent low-pressure features and the existence of thermal highs are responsible to a greater extent for thehigher values of mixing height in summers[7-8].

Thefrequencies of occurrence of low mixing height arethe maximum in winter, which could be attributed toexistence of surface based inversion.

As mixing height is highest in April among all the seasons, good vertical mixing of contaminants can be expected in this month. However, in August mixing height is low. But due to rain, pollutants will be removed through wet deposition.Therefore, concentration of air pollutants will be lower.However this month should be viewed with caution due to acid rain, water and soil pollution as its side effects. Januaryand October may be deemed as the worst months for dilution ofpollutants.

**Ventilation Coefficients (V.C.)**

Mean ventilation coefficients have been calculated forall the seasons and the values obtained are tabulated in Table5. Winds used in these computations are the averages over the entire mixing layers.

Table 5

**Mean Ventilation Coefficient**

| Month/Season | Ventilation Co-efficient ($m^2S^{-1}$) | |
|---|---|---|
| | Morning | Afternoon |
| January/Winter | 330 | 4490 |
| April/Pre-monsoon | 440 | 9714 |
| August/Monsoon | 434 | 4460 |
| October/Post Monsoon | 402 | 4560 |

In January, the V.C. varied from 0 to 2250 $m^2S^{-1}$ in the morning (minimum),and in the afternoon (maximum) it varied 900 $m^2S^{-1}$(1987) to 9400 $m^2S^{-1}$ (1986). The range between the mean minimum and maximum ventilation coefficients is from 300 to 4490 $m^2S^{-1}$.

In April, the mean V.C. ranged from 440 to 9414 $m^2S^{-1}$. The highest afternoon ventilation coefficient was 39,000 $m^2s^{-1}$ in 1984 and its lowest value observed was 1500 $m^2$ $s^{-1}$ in1987. The highest value for morning ventilation coefficient in this month was 3, 600 $m^2$ $s^{-1}$ in 1985.

In August, the mean ranged between 434 to 4, 660 $m^2s^{-1}$. The highest maximum value was 22500 $m^2s^{-1}$ in 1984 andlowest maximum ventilation coefficient was 1500 $m^2$ $s^{-1}$ in1986.

Similarly in October, the mean values ranged from 400 to 4558 $m^2s^{-1}$. The highest value for maximum ventilationcoefficient was observed to be 18,400 $m^2s^{-1}$in 1984 and lowest800 $m^2s^{-1}$in 1986. The highest value of morning mixing heightwas found to be 7,070 $m^2s^{-1}$in 1984.

Thus it is observed that the value of ventilationcoefficient is nearly same for January, August and October.April has the highest minimum and maximum ventilationcoefficient.

Applying Gross'scriteria (1) of pollution potential in the present study, it may concluded that in all theseasons, pollution potential will be higher except in April inafternoon. Since the value of afternoon ventilationcoefficient is higher than the morning one in all the seasons,the potential will decrease gradually with time by afternoon.

The reason for obtaining the lower values for ventilation coefficient may also be due to small correction forheat island intensity for Ranchi compared to Delhi(4).

## CONCLUSION

The mixing heights and ventilation coefficients at Ranchi, considering it to be a representative station of thearea, indicate high pollution potential of most part of theyear except in the pre-monsoon season. It is therefore advisable to make impact assessment of this region before permitting any major industry, to comeup. Any disregard to this suggestion is likely to leadepisodal condition in this region.

The present study points out the seasonal anddiurnal pollution potential in the region of the vastindustries oriented mining areas around Dhanbad. This studywill enable the planners and administrators to take necessarysteps to abate pollution by way of emission scheduling andlocating new industries in such a way that pollutants may notreach in the sensitive areas of the region discussed above.

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