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Air Pollution Micrometeorology Study in the Neighbourhood Of Coastal Super Power Thermal Plant- A Case Study

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Abstract:- Air pollution Micrometrology in the Coastal site other than General Micrometrology will be essential now a days in association with Climate Change. Now a Chennai City had been faced recent trend in the Climate never faced in the last 100 years not yet be cleared. It will need further study which has to be needed in the future of the Chennai City. Chennaities and several researches both in water resources engineers and Environmentalist faced the last December Month.

Keywords:- Atmospheric stability, Climate Change, Micrometeorology, Mixing Height, Plume Reflection, Super thermal power plant, Wind Rose

I. INTRODUCTION

Air Pollution micrometeorology study in an industrial area is essential to determine the Ground Level Concentrations (GLC) emitted from industrial stacks in the downwind direction by the air quality modelers. Micrometeorology deals with atmospheric wind speed, direction, humidity, temperature, solar radiation, relative humidity and Radio Sonde (RS) measurements [1]. Micrometeorological observations related to the pollutant dispersion are being used in the popular Gaussian air quality [2] and [3] plume reflection models in the specified simulation domain for air quality management purposes and to preparation of Environmental Impact assessment.

Sulphur Dioxide (SO_2) is a dominant air pollutant has been emitted from coal burnt thermal power plant and resides in the lower atmosphere one to three days [4]. Acute to chronic exposure of SO_2 causes immediate bronchial constriction, increased pulmonary resistance and swelling of mucosal tissues [5]. Chemical transformation of primary SO_2 in to secondary SO_3 and to treasury sulfuric acid and sulphate particles impacts on vegetation and properties.

In this research paper air pollution micrometeorology is investigated in one of the air basin near the super thermal power plant at shoreline of east coast of India. It is aimed to explore the favorable and unfavorable atmospheric conditions in association with dispersion and dilution based on **[6]** stability classes. Mixing height derived from [7] methodology from RS data with which volume of atmospheric air available for pollutant dilution. Sum of physical stack height and plume rise estimation at various stability classes has worked out by using [8] methodology termed as effective height is used to find out the occurrence of plume reflection leads to building up of high GLC.

II. STUDY AREA AND PERIOD

IL&FS super thermal power plant is located in the Eastern coastal village of Karikuppam near Portonovo town of Cuddalore district, Tamilnadu state in the southern peninsular region of India. Power plant industrial infrastructure is geographically accommodated in between 11^0 51’to11^0 53’ N latitude and 79^0 74’to79^0 71’E longitude. The elevation of power plant site is about 1.5 m to 2.0 m above Mean Sea Level (MSL) and the stacks were erected nearly 2km from the shoreline.Fig.1 depicted the exact location of the study area. Period of the study is carried out in the octernal (Day) hours of spring season during December 2014, January and February 2015.

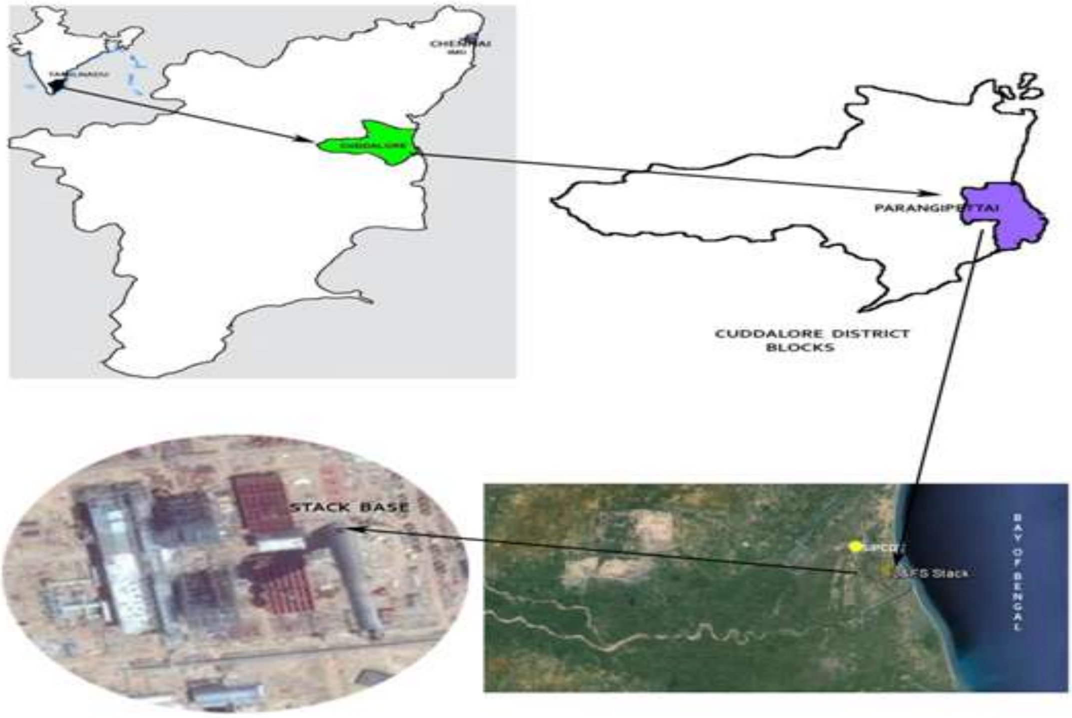

Fig. 1 Location of the Study area

III. DATA

Micro meteorological data was mainly depends upon the climatic conditions whereas an emission data based on the Sulphur content of the coal has to be burnt. Micrometeorological observations and daily upper air Radio Sonde (RS) data measurements should be site specific for effective air quality modeling study. Wind speed at stack height, and flue gas exist temperature are used to estimate the effective plume rise to reflect lower mixing height at atmosphere and lead to plume reflection [3**]**

IV. MICRO METEOROLOGICAL DATA

The routine site specific surface meteorological data wind speed, wind direction, temperature and humidity being measured with 5 minutes time resolution with an automated weather station by Tamilnadu Pollution Control Board (TNPCB) at State Industrial Promotion Corporation of Tamilnadu (SIPCOT) premises, Cuddalore is located 4 km in the direction of NNW and site specific to study area are acquired for the study period. Upper air RS data of Chennai Meenampakkam airport at 00 GMT have been observed by Indian Meteorological Department were used to determine the octernal hourly mixing height by **[7]** methodology. An essential parameter hourly solar radiation is estimated by using [9**]** method.

Mandatory input parameters in order to determine hourly effective height [**8]**, are stack height, flues gas exit velocity, temperature, diameter are furnished in Rapid Cumulative Environmental Impact Assessment Report [10] company were used in this research paper.

V. INVESTIGATION OF METEOROLOGICAL CONDITIONS

Prevailing meteorological conditions during the period of study in terms of hourly atmospheric stability, estimated wind speed at release height (u_{275}) by [11]'s extrapolation from reference observed u_{10} and associated effect of mixing (z_i) and effective height has been investigated. Based on this investigation favorable and worst meteorological conditions have to be analyzed for SO_2 dispersion pattern over the study region. Monthly hourly mean wind speed and direction are projected by means of constructing wind rose diagram for risk in the study area.

Atmospheric stability is one of the highly influencing parameter for pollutant transport, dispersion and dilution. Pasquill [6] categorized the stability classes alphabetically A (strongly unstable), B (moderately unstable, C (slightly unstable), D (neutral), E (slightly stable) and F (moderately stable). These stability classes were determined based on measured wind speed and estimated incoming solar radiation [9] specified by [12]. Stability A, B, C and D are more common in the octurnal hours and E&F are in the nocturnal hours.

Wind speed at release height referred as u_{275} at different stability class effect the plume rise and reflects in the effective height (H) magnitude. Mixing height (z_i) is another sensitive parameter to fix the available volume of air mass in the air basin to dilute the SO_2. Mixing height in association with effective height causes plume reflection and leads to high GLC in the downwind side. [13] experienced these phenomenon in his comprehensive research work near coal fired North Chennai coastal Thermal power plant (630MW).

Based on the above said parameters the hourly occurrence of worst meteorological conditions were identified [14] and the number of hourly occurrences subjected to frequency analysis.

VI. RESULTS AND DISCUSSION

This study consist of actually 1080 hourly day time meteorological conditions by means of wind speed and direction, stability, release height wind speed (u_{275}), mixing height (z_i) and effective height (H) occurred in the research area during the study period and few hourly data were missing. Frequency analysis of theses parameters were made to project the favorable and worst meteorological conditions in the view of pollutant dispersion. Around 25 km from the emission release point, prevalence of homogeneous meteorological condition is assumed in this terrain.

VII. WIND ROSE

Wind rose is a pictorial definition of spatial and temporal distribution of wind with scalar and vector quantity which means speed and direction at 10m level (u_{10}) respectively. In this research paper wind rose were drawn with 16 direction sectors at each direction sector of 22.5^0 beginning from 0^0, 90^0,180^0and270^0 are referred to North, East, South and West dominantly. All other sub sectors incremented from 0^0 plus 22.5^0 and related meteorological wind directions are NNE,NE,ENE,ESE,SE,SSE,SSW,SW,WSW,WNW,NW and NNW. Calm wind speed of less than 1m/sec [15] and percentage of occurrence indicated at the centre of wind rose diagram. Three hour wind roses of each month are depicted in Figs. 2 to 4. The behavior of wind speed and direction are well described in these figures.

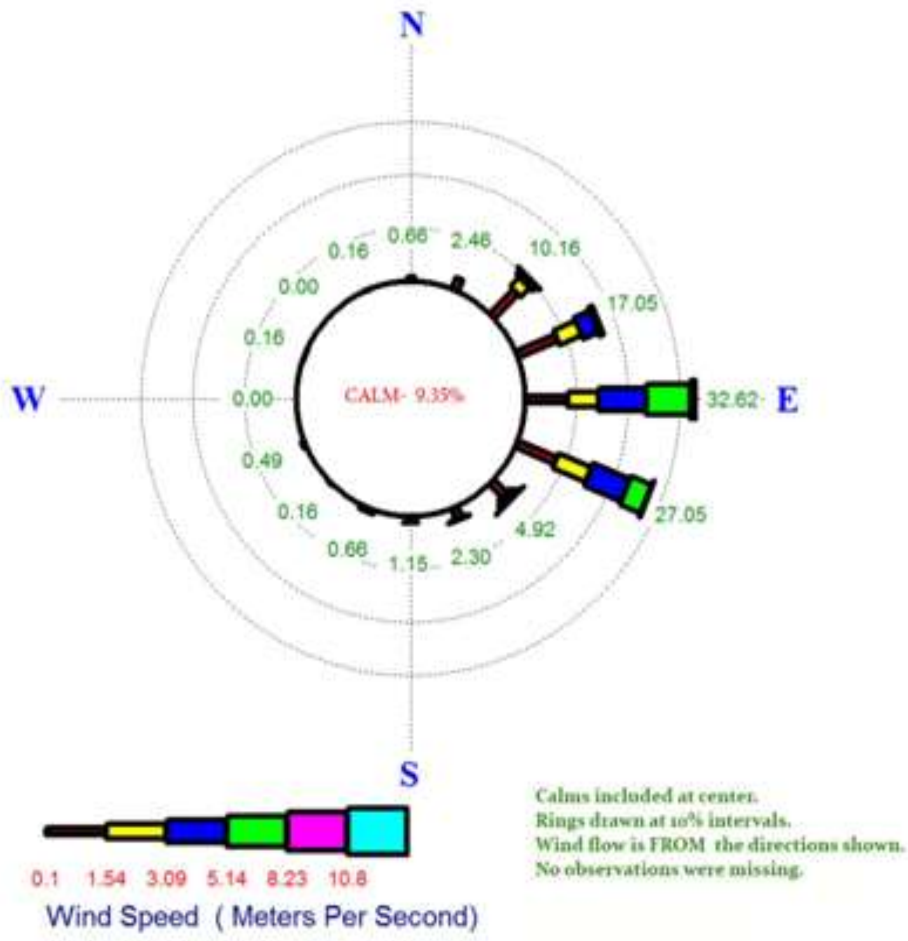

Fig 2 Wind rose- December 2014

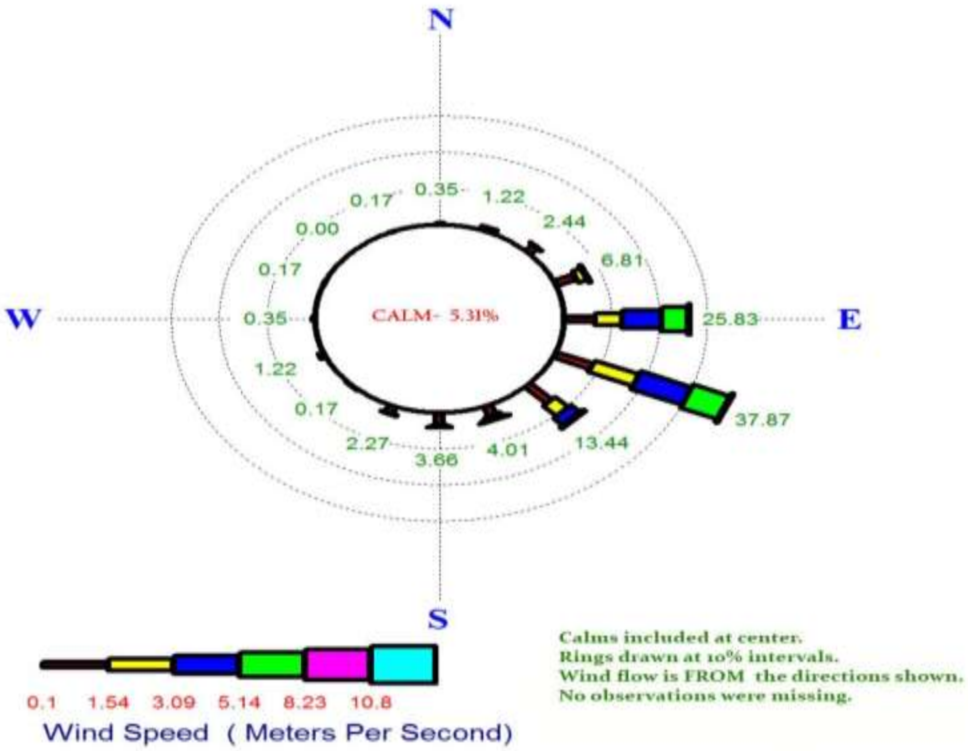

Fig 3 Wind rose- January 2015

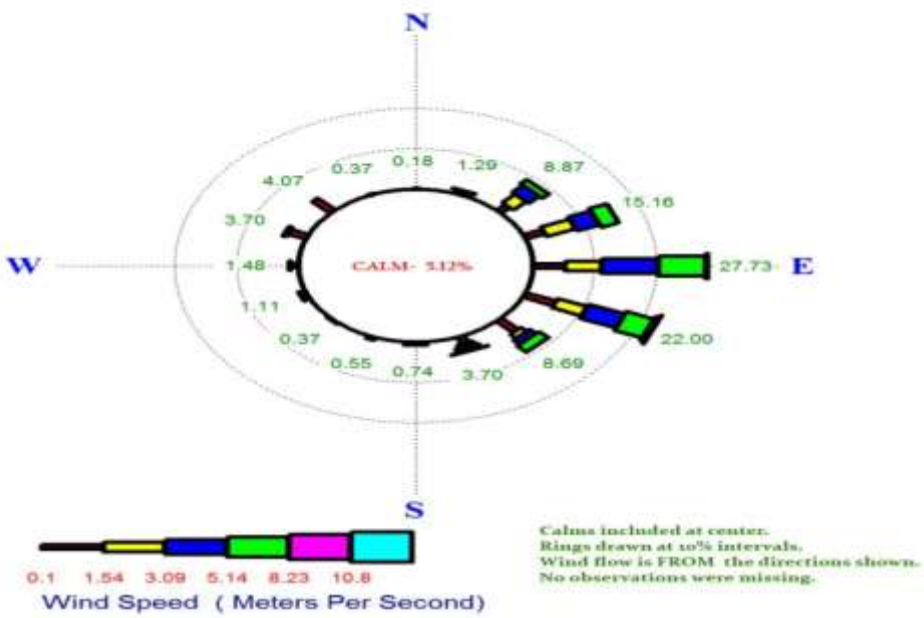

Fig. 4 Wind rose- February 2015

VIII. ATMOSPHERIC STABILITY

Results of frequency analysis enumerates that 643 number of occurrences of hourly worst stability class A, B and C out of 1080 cases and remaining comes under favorable D class of better dilution (SO_2) in the downwind side. Frequency distribution of stability class during entire study period consolidated in the Fig 5.

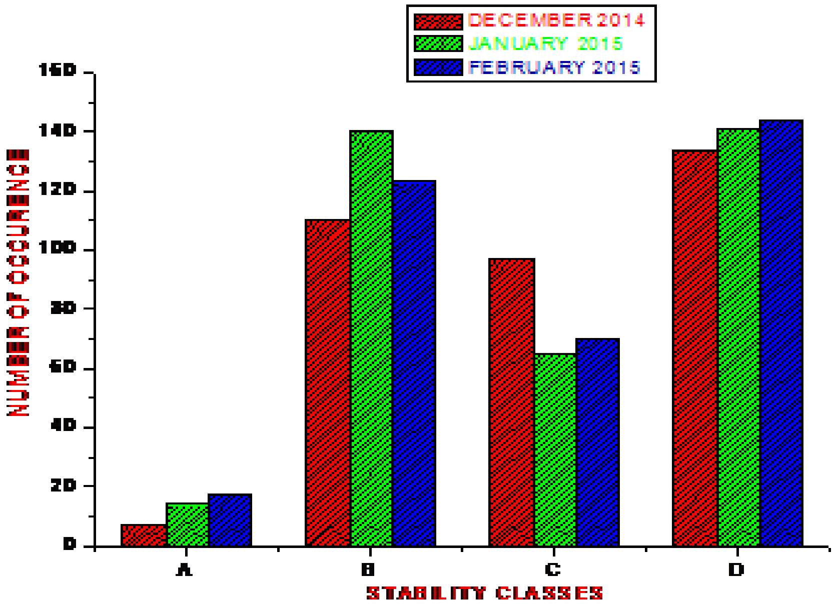

Fig. 5 Cumulative Frequency Distribution of Stability

IX. WIND SPEED AT STACK HEIGHT

Wind speed at stack level u_{275} is influencing the plume rise and dilution and their characteristics has analyzed by means of monthly frequency distribution. There are five ranges at an interval of 4m/sec is fixed. The ranges and categorization are 0.00-4.00(low), 4.01-8.00 and 8.01-12.00(moderate), 12.01-16.00 and16.01-20.00(high) m/sec. As wind speed is taken in to account 459 number of lower range occurrence leads to high GLC in the nearby source because of high plume rise (H) and reflection with mixing height (z_i). Moderate range of 426 existence build up high GLC in the middle portion of study area and 41 cases lie in the high range causes better dilution in the longer downwind distances. The u_{275} for whole study period is well characterized and illustrated in Fig 6.

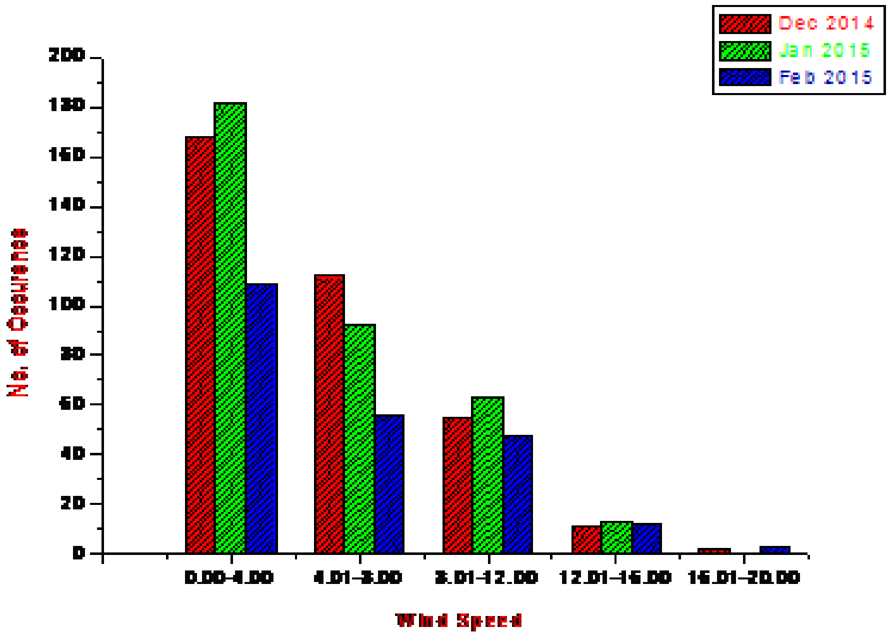

Fig. 6 Cumulative Frequency Distribution of Wind Speed

X. MIXING AND EFFECTIVE HEIGHT

Mixing height generally fixing the available volume of air to dilute the pollutant dispersion and also in association with effective height causes plume reflection and leads to building up of high SO_2 in the downwind distances. Possible numbers of plume reflections have been assessed by the combined plot of effective height and mixing height. In the month of December 5 number of hourly reflection were identified at lower mixing and effective height in the range of 170-670m, plume reflection of 70 times were occurred at the interval of 671-1171m is well described in the frequency distribution plot in Fig. 7. January month 15 times of plume reflection comes under 110-610m level, 40 times at 611-1111m level and 60 times in the interval of 1112-1612m height are clearly indicated in Fig. 8. Study period of February month 5 plume reflection were possible even at highest mixing height in between 2645 to 3145m, 10 times at lower range of 140-640m and about 25 times at the interval of 641-1141m height and corresponding frequency distribution is depicted in Fig. 9.

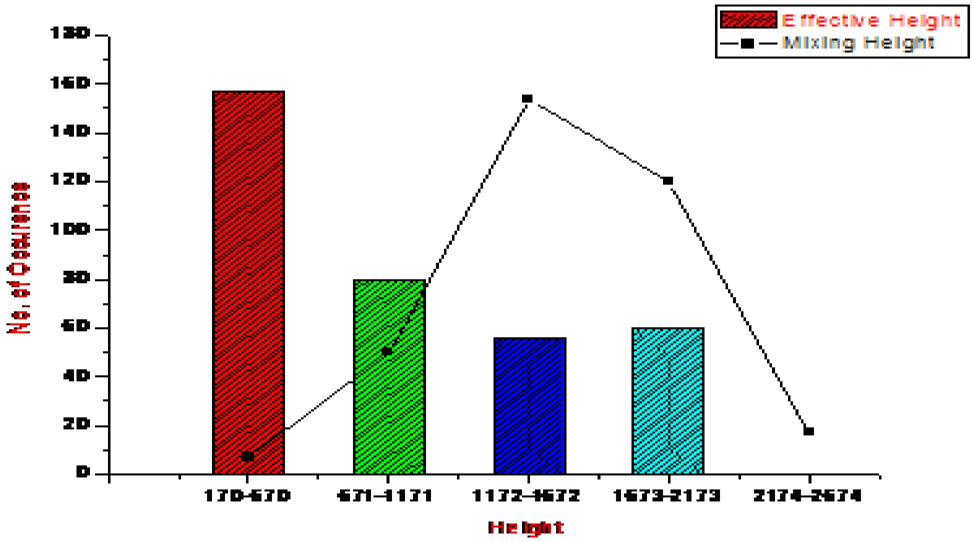

Fig. 7 Frequency Distribution of Effective and Mixing Height of December 2014

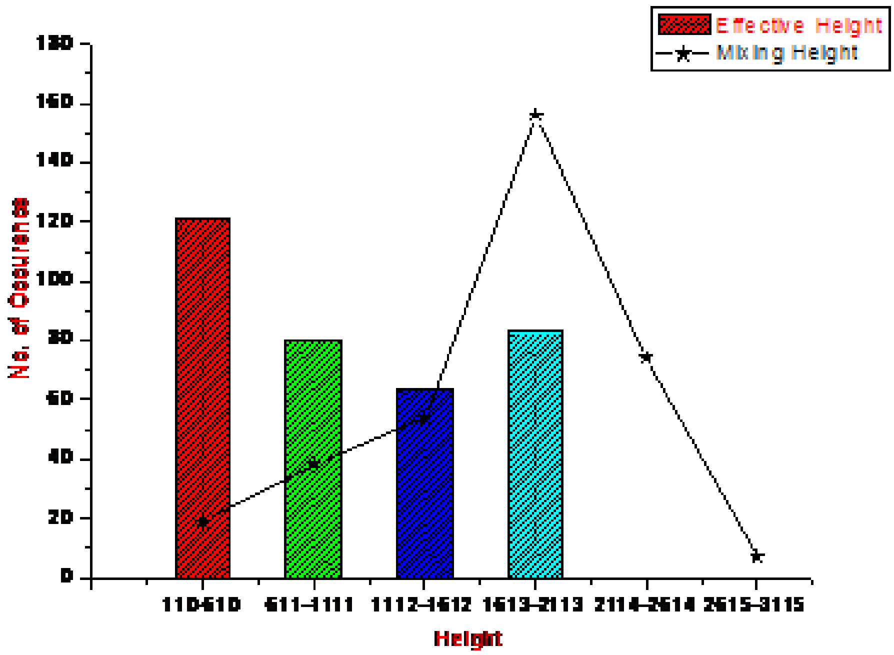

Fig. 8 Frequency Distribution of Effective and Mixing Height of January 2015

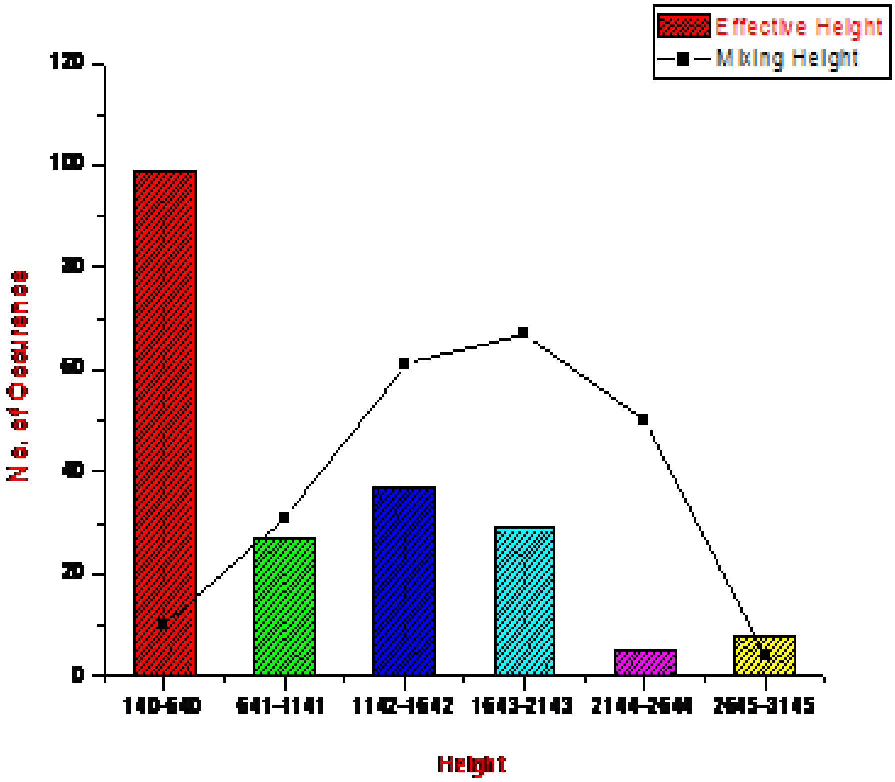

Fig. 9 Frequency Distribution of Effective and Mixing Height of February 2015

XI. CONCLUSION

The influence of the wind from NNW having the feasibility to develop High GLC Pichavaram at 7 Km and mangroves which extends from 7 km to 14 km in the same direction if the wind from SSE the SIPCOT, Cuddalore from 7 km to 17 km and causes high GLC. The Cuddalore Town also affected at 24 km in the same direction. Since the wind blowing from NNE Chidambaram Nadarajar Temple at 15 km and Health Resort of Rajaih Muthaiyah Medical College at 15 km may also has the probability of to be affected. Easterly wind has higher feasibility to develop high GLC in addition to that of Neyveli Lignite Corporation , Thermal Power Plants at Twenty-five Kilometer.

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