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Temporal variation and prediction of air pollution: A case study of Ludhiana City

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Abstract*— From the past few years more and more emphasis has been laid by the public on day to day air quality and the pollutant levels to which they are exposed. People are becoming more aware and concerned about their health thus a forecasting model is required which can predict the Air Pollution in future, so that we can implement strict rules to decrease the pollutant level. Data of 4 monitoring stations was collected from Central Pollution Control Board (CPCB) and Punjab Pollution Control Board (PPCB) and temporal variations is figured out. Results show that concentration of air pollutants are higher in winters (December, January and February) and post monsoon period (September, October and November) in comparison to summers and monsoons. In order to predict the future air quality annual average (2001-2018) of RSPM, NO_X and SO_2 had been examined and prediction of next 7 years (2019-2025) air quality parameters is carried out. Time series analysis is used to forecast the future trend and it shows that the RSPM level will increase to significant level with maximum concentration going to 296.08 ppm by 2025 which is 5 times the NAAQS limits of 60 ppm. For NO_x the concentration will be 42.04 ppm by 2022 thus exceeding the NAAQS limits of 40 ppm. The maximum error in forecasting by 2018 data by ARIMA is 2.06% for RSPM, 6% for NO_x and 0.824% for SO_2 in comparison to actual results of 2018.

Keywords*—ARIMA, Time series, Temporal variation, Air pollution

I. INTRODUCTION

For humans so far the clean air is treated as a plentiful and free natural resources. In any case, these days clean air cannot be taken for granted. Air contamination is characterized as a condition where certain substances are available in such concentrations that they may be harmful for people and environment. Regular air toxins are carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), lead (Pb), PM10 and PM2.5. The majority of these substances happen normally in low concentrations, when they are harmless; they become pollutants just when their concentrations are relatively high compared to the background value and begin to cause adverse effects [1].With increment in urbanization and modern development the air quality is declining day by day. Henceforth the issue of air contamination has turned out to be severe to the point that there is a requirement for convenient data about changes in contamination level of a place. In this manner determining about air quality has happened to most extreme significance because of the adverse impacts brought about by these air contaminations in urban zones during various seasons. Although many forecasting models exist and some of them are in use but there is a need to develop more accurate models in order to predict the future pollution concentrations. The Gaussian dispersion models are generally used in the air pollution studies. Even though the model has some physical basis but information about the source of the pollutants and other variables are generally not known. Thus, in order to overcome these limitations statistical models are used, which facilitate the prediction of pollutant concentrations [2, 3]. Various studies based on statistical models have been carried out in different regions to identify local meteorological conditions, most strongly associated with air pollutant concentrations, and to forecast their values [4, 5, 6]. The time series estimating approach is valuable for anticipating future air quality status. The forecasting method analyses the sequence of historical data in a period of time to establish the forecasting model.

Study Area & Methodology

Ludhiana is an agricultural and industrial town in Punjab with a population of more than 2.0 million. It is a house for several small and medium scale industries producing, appliances, auto parts, apparel and machine parts. It is the largest hub for bicycle manufacturing in Asia and produces over more than 10 million cycles each year. Ludhiana has been on the most polluted list, drawn by the World Health Organisation for multiple years. The distributed industries, generator use, agricultural burning, increase in vehicles and adverse meteorological conditions i.e. inversion especially in the winter, are responsible for its bad air quality. Ludhiana lies between latitude 30.9°N and longitude 75.85°E having total geographical area of 310 sq.km. Ludhiana is one of the most polluted cities in India and world, with particulate matter being over six times the World Health Organization recommended standard, making it the 13th most polluted city in the world.[7]

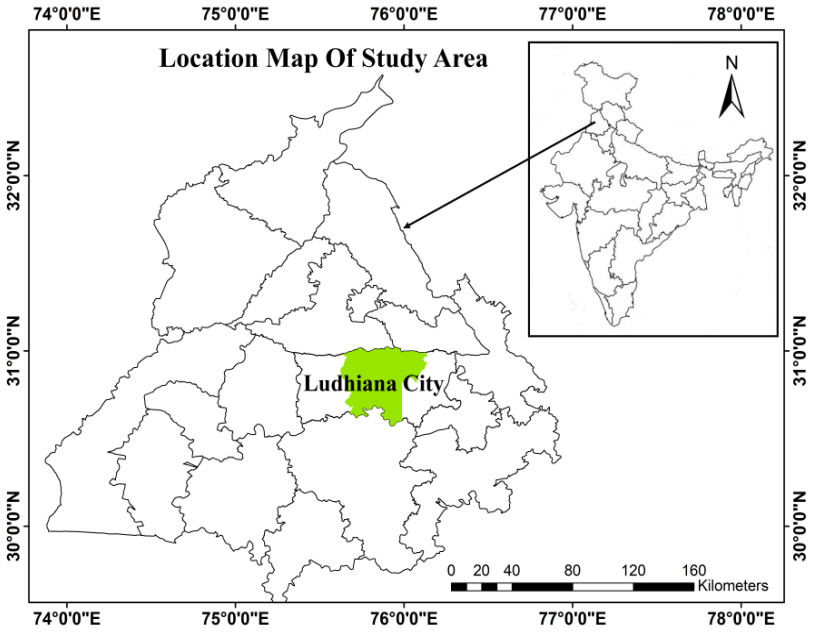

Fig. 1: Study Area (Ludhiana city)

B. Methodology

To achieve the objectives field data and relevant software has been used and discussed in the following paragraphs:

Temporal Variation: Temporal variation refers to changes occurred with elapsing time. The temporal variation is analysed considering 4 seasons i.e. Post Monsoon (September, October and November), Winters (December, January, February), Summers (March, April, May) and Monsoon (June, July, August). The average concentration of RSPM is shown below of 4 different monitoring stations of Ludhiana city and their seasonal variations are depicted in the following graphs.

Forecasting by time series

Air Pollution Data for the past 18 years is obtained from Central Pollution Control Board (CPCB) and Punjab Pollution Control Board (PPCB) sites and offices. Three critical pollutants RSPM, NO_x and SO_x are considered because each of the data sets cover atleast 18 years with no missing data in between as they shows an apparent trend ,seasonality or both of them. Researches have proved that these three major pollutants are very harmful to human health and can lead to many diseases.

Method used: BOX Jenkins ARIMA modelling for time series analysis for forecasting is used; Monthly data covering periods of 2001-2018 were acquired from CPCB and PPCB. ARIMA stands for AutoRegressive Integrated Moving Average, with various steps required in the construction of model.

Identification Step: The statistical software package MINITAB was used in this study. The data used for the first consideration is to ensure the stationarity condition, if the n values fluctuate with a constant variation and a constant mean μ, this shows that the particular time series is stationary. Autocorrelation function can be used to determine the stationary time series value $x_b, x_{b+1}, \ldots, x_n$. If the auto correlation function (acf) of the time series value either cuts off fairly quickly or falls down fairly quickly then the time series value should be considered stationary.

II. RESULTS AND DISCUSSIONS

A. Temporal variation of 4 monitoring stations of Ludhiana city for 2 years (2016 and 2017) has been shown in the following graphs. The RSPM concentrations at all the monitoring stations are exceeding the NAAQS limits of 60 ppm. Winters and post monsoon were the time periods during which the concentrations were maximum. Vishwakarma chowk and Nahar spinning mill are the stations which are highly polluted and RSPM concentration as high as 286 ppm during post monsoon season. This is 43% higher than average RSPM concentration of 162 ppm for the year 2017. The NO_X concentrations are constant during the whole year and is in the range of 23 to 32 ppm with minimum concentrations at Milk plant and highest at Nahar spinning mill and vishwakarma chowk. The SO_2 concentration ranges between 8 to 16 ppm in 2016 and in 2017 the maximum concentration has been 12 ppm thus SO_2 emissions decreased by 25% from 2016

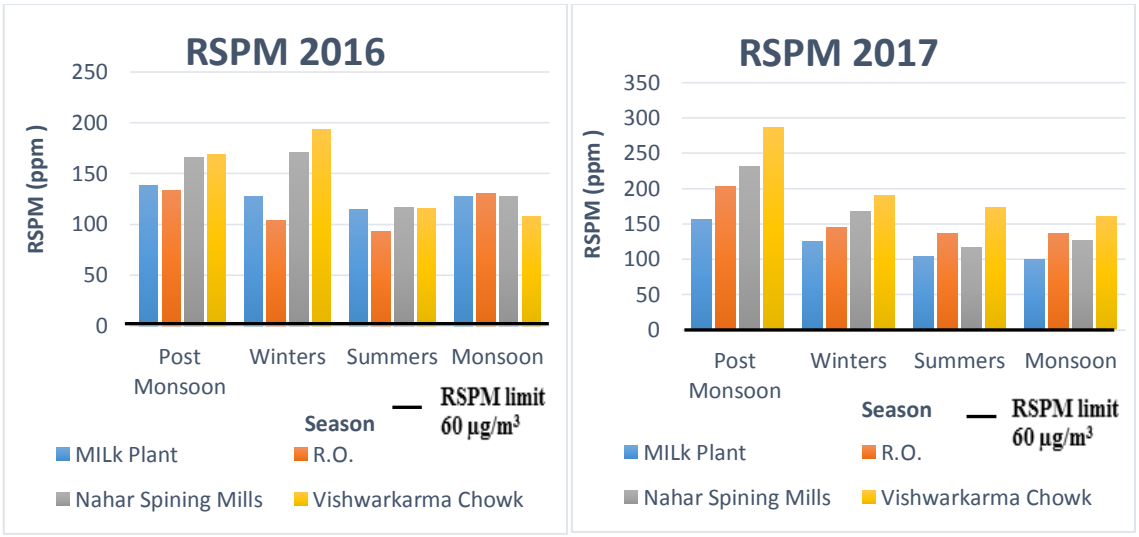

Fig 2: Temporal variation of RSPM for the year 2016 and 2017

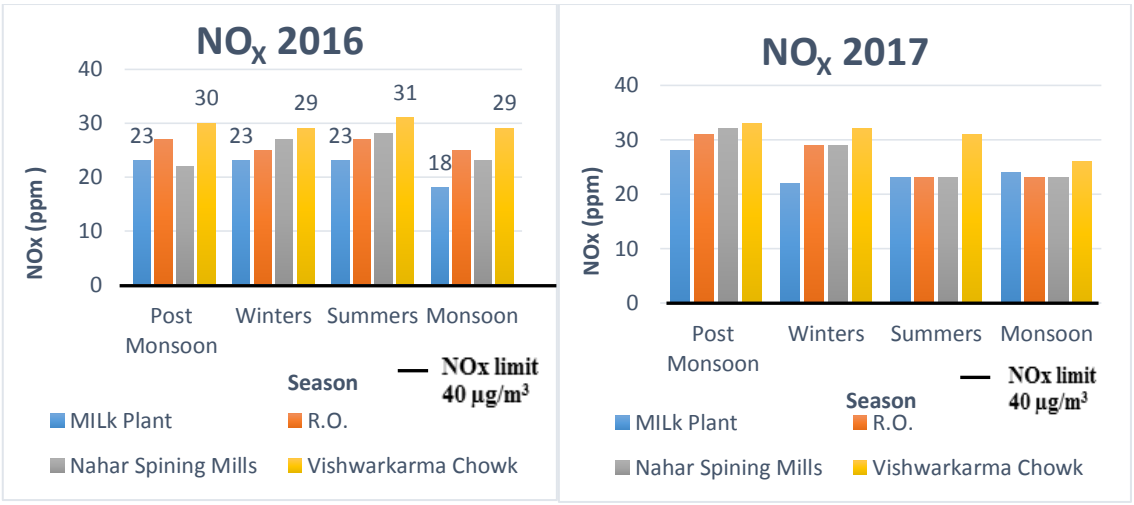

Fig 3: Temporal variation of NO_X for the year 2016 and 2017

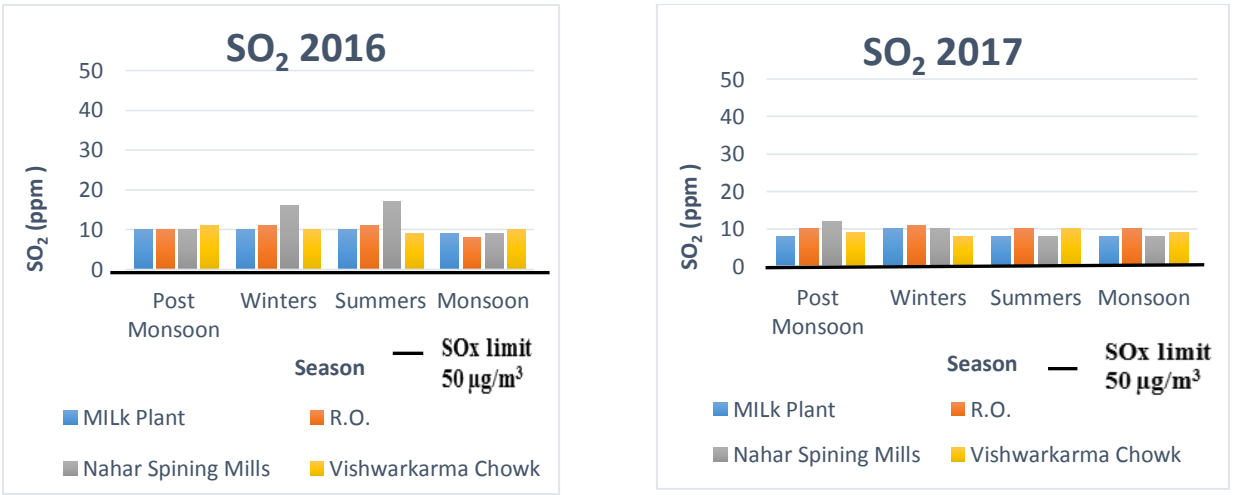

Fig 4: Temporal variation of SO_2 for the year 2016 and 2017

B. With the help of ARIMA modelling the annual average forecast for the year 2018 is done and is compared with the actual results for the validation of the results. Same way the prediction of pollutant level of RSPM, NO_X and SO_2 is predicted to understand the trends in pollutant concentration level in future. Following are the tables and charts which show the forecasted pollutant concentration.

Table1: Accuracy and Validation of ARIMA Model

Accuracy of ARIMA Model			
	2018(ppm)	2018(ppm) (forecasted)	% age error
RSPM	183	179.215	2.06%
SO_2	10	9.9176	0.824%
NO_x	33	30.97	6%

Table2: Forecasted Pollutant Concentration by ARIMA Modelling for next 7 years (2019-2025)

Forecasted Pollutant Concentration by ARIMA			
Year	RSPM (ppm)	SO_2 (ppm)	NO_x (ppm)
2019	188.92	9.9070	32.98
2020	200.95	9.9294	35.64
2021	215.31	9.9807	38.8
2022	232.00	10.0603	42.04
2023	251.08	10.1681	45.5
2024	272.40	10.3402	49.34
2025	296.08	10.4685	53.42

It is clear that by 2025 the RSPM concentration will be 5 times the Indian Standards of 60 ppm. Similarly the NO_x concentration will be above Indian Standards of 40 ppm by 2022. The SO_2 concentration will remain almost same for next few years i.e. around 10 ppm .Following are the graphs which show the forecasted pollutant concentration till year 2025 by ARIMA modelling. The graph shows three values upper limit, forecasted result and the lower limit. We are interested in only forecasted result thus we will take only this into consideration.

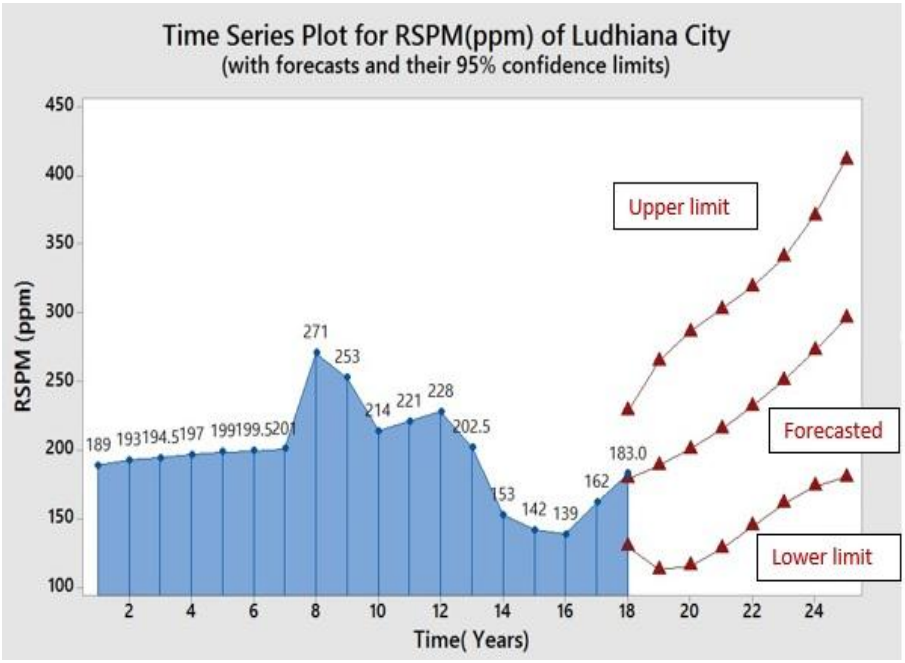

Fig.5: Time series plot of RSPM for Ludhiana city by ARIMA

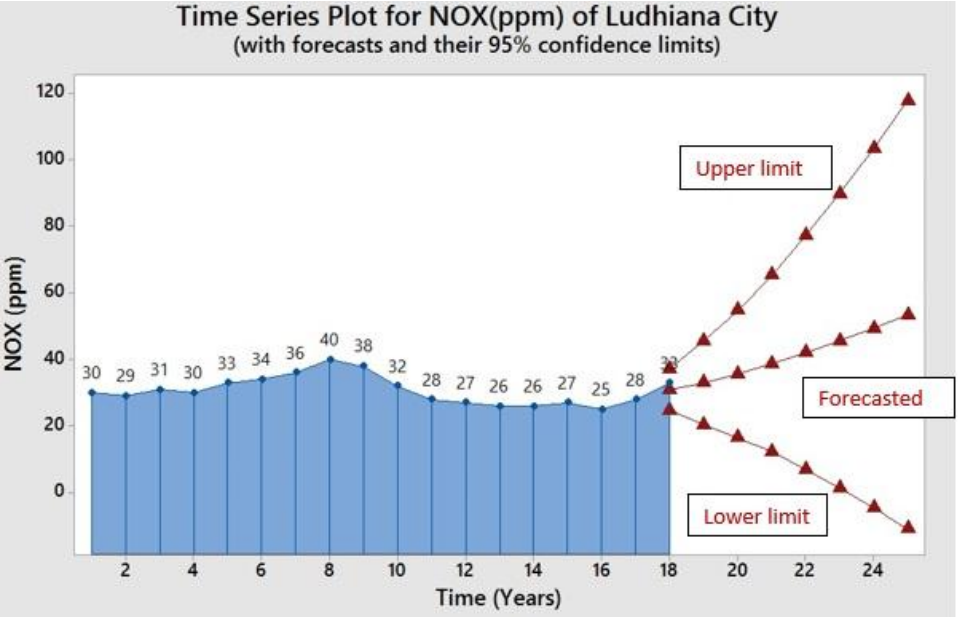

Fig 6: Time Series Plot for NO_x of Ludhiana City by ARIMA

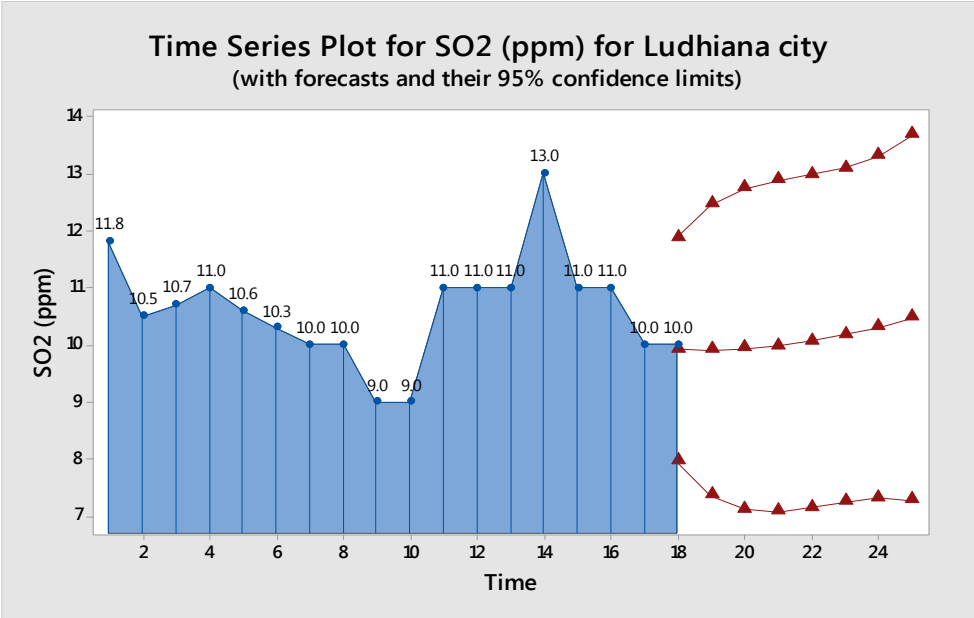

Fig7: Time Series Plot for SO_2 of Ludhiana City by ARIMA

III. CONCLUSIONS AND RECOMMENDATIONS

The whole study had been divided into two parts. First is to find the temporal variation from year 2016-2017 of 4 different monitoring stations of Ludhiana city and second is to predict the pollutant concentration of RSPM, NO_X and SO_2 for the next 7 years i.e. from 2019 upto 2025 with the help of ARIMA by averaging data of past 18 years (2001-2018). Thus following conclusions can be drawn

- The RSPM concentration was maximum in 2008 and it keeps on declining but in 2017 the concentration is increased.
- Summers and Monsoon are the time period in which the RSPM is less as compared to winters and Post monsoon season.
- The reason for increase in concentration of RSPM is because of increase in stubble burning and burning of firecrackers during the month of October, November and during winters due to inversion conditions.
- The forecasting results shows that the RSPM concentration has been increasing in the city with time, the concentrations already 3 times higher (183 ppm in 2018) than NAAQS limits and by the year 2025 this may be as high as 5 times (296.084 ppm) the NAAQS limits of 60 ppm
- The city of Ludhiana needs at least 10 continuous air monitoring stations to determine the pollutant level statistically, temporally and spatially, and to represent the mix of sources and the amount of pollution level in the city (current status – 4 manual and 1 continuous)

- Strict emission standards are required for the thermal power plants (coal-fired) near the vicinity of Ludhiana city which will help to reduce the share of harmful pollutants.

REFERENCES

[1] Rao CS (1991) Environmental Pollution Engineering, Wiley Eastern Limited, NewDelhi Haritash
[2] Zabalza J, Ogulei D, Elustondo D, Santamaría JM, Alastuey A, Querol X, Hopke PK (2007) Study of urban atmospheric pollution in Navarre (Northern Spain).Environ Monit Assess 134:137–151
[3] Tiwari TN, Ali M (1987) Air quality index for Calcutta and its monthly variation for various localities. Indian J Environ Prot 7: 172-176.
[4] Mayer H (1999) Air pollution in cities. Atmos Environ. 33: 4029–2037.
[5] Mohan M, Kandya A (2007) Analysis of the annual and seasonal trends of Air Quality Index of Delhi. Environ Monit Assess 131:267–277.
[6] Molina MJ, Molina LT (2004) Mega cities and atmospheric pollution. J Air Waste Manage Assoc 54: 644–680.
[7] World Health Organization (WHO) (2011) WHO air quality guideline update.
[8] Kaushik CP, Ravindra K, Yadav K, Mehta S, Haritash AK (2006) Assessment of ambient air quality in urban centres of Haryana (India) in relation to different anthropogenic activities and health risks. Environ Monit Assess 122: 27–40.
[9] Reddy GS, Ruj B (2003) Ambient air quality status in Raniganj-Asansol area, India. Environ Monit Assess 89: 153–163.
[10] Sharma M, Maloo S (2005) Assessment of ambient air PM10 and PM2.5 and characterization of PM10 in the city of Kanpur, India. Atmos Environ 39:6015–26.
[11] UNEP/WHO (1992) Urban air Pollution in mega cities of the World. Blackwell, Oxford.
[12] UNCHS (1996) An urbanizing world: global report on human settlements, 1996.
[13] UN (1992) Agenda 21: Rio Declaration, Rio de Janeiro: Final text of the agreement negotiated by governments of the United Nations Conference on Environment and development.
[14] Punjab Pollution Control Board (PPCB), Patiala.
[15] Central Pollution Control Board (CPCB)