International Journal of Civil Engineering and Technology (IJCIET)
Volume 8, Issue 8, August 2017, pp. 581–589, Article ID: IJCIET_08_08_059
Available online at http://http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=8&IType=8
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

STUDY OF CONCENTRATION OF CARBON MONO OXIDE POLLUTANT IN DELHI CITY USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT

India, a developing economy is standing in front of a treacherous crisis of air pollution. Today, time of modernization relocation of peoples, transportation, industrial discharge, pollutant dispersions and dilution in a particular area is main causes of air pollution in a city. Chemical modification of pollutants in the atmosphere depends on the climatic and topological parameters of that particular area. Delhi, one of the pollutant city of the world due to different causes and sources of pollutants is suffering from raise in concentration of pollutants present in air and making air unsafe for pleasant living. CO the main pollutant present in air causes many health's and environmental issues. The breakpoint concentration of CO helps us know the minimum concentration of pollutant in environment. This paper presents an artificial neural network based system for the efficient predication of the CO concentration one day ahead. The proposed system has been trained with the previous one year CO data with five different inputs. It is reported that the short term prediction efficiency of the developed system is very high with very less prediction error of about 0.1095%.

Key words: pollution, CO, AQI.

Cite this Article: Monika Singh, S.P Mahapatra and S Nigam, Study of Concentration of Carbon Mono Oxide Pollutant in Delhi City using Artificial Neural Network. *International Journal of Civil Engineering and Technology,* 8(8), 2017, pp. 581–589.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=8

1. INTRODUCTION

India is growing economy. With expansion of industries and ardent vehicles and, the concentration of redundant substance in environment is rising and taking us to the harmful level of pollution. In at present epoch, air pollution is one of the important issues for reflection towards the protection of our environment. The foremost causes of air pollution are

immigration of peoples, increased numbers of industries and high birthrate over death rate, vehicle exhaust.[1] Pollutants such as Carbon Monoxide (CO) and Hydrocarbons (HC) and Nitrogen Oxides (NO), total suspended solids (TSP) non-methane volatile organic compounds sulphur di oxide are causing pollution. Air pollution is also due to insignificant transportation, untreated industrial wastes ended freely in environment, forest and agriculture land fire, and other burning of fuels, and garbage's, e -waste ,exhaust from diesel generators etc. Lack of technology and unawareness toward air policy management among the peoples are major concerns to ward this issue. Emission from combustion of fossils fuels and biomass reduces the local air quality and affects the global troposcopic chemistry of the particular area . The air pollution path in a particular area consists of major process of emission and transmission and dilution of the pollutants. Dispersion and dilution of air pollutant is influenced by meteorological conditions such as wind direction, wind speed turbulence, and atmospheric stability of particular area. Chemical interaction between the pollutants also depends on ambient weather conditions [2] In this paper, we give more emphasis on pollutant "CO" due its destructive property. Carbon dioxide (CO_2) is the primary greenhouse gas. Carbon dioxide is naturally present in the atmosphere due to the natural circulation of carbon among the atmosphere (oceans, soil, plants, and animals). Human actions are changing the natural carbon cycle by adding more CO_2 to the atmosphere by human activities such as transportation, industrial waste, in complete combustion of fossil fuels, deforestation. Carbon dioxide is constantly exchanged among the atmosphere, ocean, and land surface. It is both produced and absorbed by many microorganisms, plants, and animals. Carbon monoxide enters the bloodstream through the lungs and binds chemically to hemoglobin, the substance in blood that carries oxygen to cells. In this way, carbon monoxide reduces the amount of oxygen reaching the body's organs and tissues. People with cardiovascular disease, such as angina, are most at risk from carbon monoxide. These individuals may experience chest pain and more cardiovascular symptoms if they are exposed to carbon monoxide, particularly while exercising. People with marginal or compromised cardiovascular and respiratory systems (for example, individuals with congestive heart failure, cerebrovascular disease, anemia, chronic obstructive lung disease), and possibly fetuses and young infants, may also be at greater risk from carbon monoxide pollution. In healthy individuals, exposure to higher levels of carbon monoxide can affect mental alertness and vision. The most successful way to decrease carbon dioxide (CO_2) emission is to reduce fossil fuel utilization. Many practice are in use for sinking CO_2 emissions. use of eco-friendly fuels combustion methods, use of modern means of transportation with well defines engines, public means of transportation and Carbon monoxide: An odorless, colour less gas, inhalation of CO blocks the blood ability to carry oxygen. Because, of its chemical structure, it can easily attach to hemoglobin, the oxygen carrying pigment in RBC. High levels of CO results in dizziness, severe headache and nausea[3]

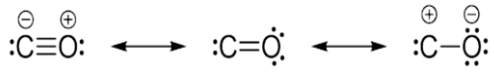

Figure 1 Carbon monoxide.

In order to properly handle the pollution due to the CO concentration in the environment, the researchers all around the world trying to develop the systems which can predict the CO concentration prior, based on the past available data. To address this problem this paper presents an efficient artificial neural network based short term prediction system for the accurate CO concentration prediction.

The rest of the paper is organized as follows. In section 2, the major concerns of pollution in the Delhi have been presented along with a brief description of Air Quality Index. Further,

the description of study area and data utilized in the proposed work including the modelling and development of the proposed ANN based short term prediction system have been presented in section 3. In section 4, the obtained short term prediction results from the proposed system have been extensively reported, which is followed by the conclusion of the present work in section 5.

2. POLLUTION IN DELHI AS A MAJOR CONCERN

Delhi, a capital of India is a polluted city. According to the records, survey of 1600 cities, Delhi is announced as the pollutated city in the world. Air pollution every year kills 1.5 million people every year. India has the world highest death rate from chronic respiratory disease and asthma. Delhi is one of the most polluted cities in the world is spread over 1484 square kilometers is officially declared world's dirtiest air, This pollution is caused by vehicular growth in the past 2–3 decade.[4] One of the reasons is con tinuoeus uses of old non-modified engines in vehicles with little emphasis on their service. Even with new vehicles, the focus is on emission limits not on the limit on ambient air quality. The containment of vehicular pollution requires an incorporated approach, with combined use of transport policies and air pollution control instruments . The capital of India also faces heavy pollution due to large population, high vehicular exhaust, industrial emissions and burning crops in adjoining states. To reduce to level of pollution Delhi government has undertaken many policies intended odd even car driving, car pools are taking in existence, etc. To improve the air quality, improvement programs and control instruments and awareness programs implemented in Delhi Different programs adopted to spread awareness among people to reduce outdoor and indoor pollution. Old vehicles running on diesels are also in eye because of pollution concentration is increasing by them. Many air quality management programs runned by government in Delhi, under which air quality monitoring stations are established and play important part in measurement of pollutant concentration . They helps in forecasting of pollutants which aides government in alarming people of adverse effects of specific pollutant and take necessary action to prevent them .There is a direct need for proper action and control strategy for the effects of air quality. This scheme predicts the next day's AQI level and helps in giving warning as per the situations. Air quality warning systems is needed to notify that the ambient air quality standard may exceed the given standard limit and proper actions should be taken for the same in time. Urban air quality management and proper information and alarming is necessary to aware the people after prediction of pollutant concentration of forthcoming days and for providing proper control management and air quality warning systems which are required in order to get accurate advance notice that the ambient air concentration levels might exceed the air quality guideline or the limit value. Alerts are required by the health care department and by traffic and environmental management system to minimize the adverse effect of particular pollutant .These warning systems should be easily understandable, reliable and accepted by the society .Several deterministic models exist to evaluate and predict the pollutant dispersion in urban areas and the Gaussian dispersion models are generally used in most of the air pollution studies for predicting the concentration of air pollutants .

2.1. Air Quality Index

Air quality in cities is a result of complex interaction between natural and anthropogenic environmental conditions [5]. Air quality large data often do not convey the air quality status to the scientific community, government officials, policy makers, and in particular to the general public in a simple and straightforward manner. This problem is addressed by determining the Air Quality Index (AQI) of a given area. AQI states that how polluted our air

is today and what precaution we have to take for our health protection AQI, which is also known as Air Pollution Index [6] or Pollutant Standards Index (PSI) [7]has been developed and disseminated by many enviromrntl agencies., ,[8]. An "Air Quality Index" may be defined as a single number for reporting the air quality with respect to its effects on the human health [9] In most elaborate form, it combines many pollutants concentrations in some athematical expression to arrive at a single number for air quality. AQI is an integral part of the Environmental Quality Index (EQI), the daily PSI is determined by the highest value of one of the five main air pollutants: PM10, O_3, SO_2, CO and NO_2 the main objective of AQI is to measure the air quality in relation to its impact on human health, the Environmental Protection Agency (EPA) of U.S. revised the previous method to calculate daily AQI in 1999. The EPA method is based on concentrations of five criteria pollutants: carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM) and sulphur dioxide (SO_2). The concentration values are converted into numerical indexes. The overall AQI is calculated by considering the maximum AQI among the monitored pollutants corresponding to a site or station. The scale of the index (0- 500) AS shown in Table 1 is subdivided into six categories that are associated with various health messages [10]

Maximum Operator Function method was used for calculating the AQI. Suggested by Tiwari and Ali(1987) and followed by Kuashik et. al. [9] The AQI value for each pollutant is calculated by the formula given. This method has een used by USEPA and also by CPCB (Central Pollution Control Board) for AQI estimation. CPCB uses excedance factor in this formula where a factor of 100 as multiple is not used. According to this method,

$$\text{AQI} = \frac{\text{Pollutant} \times 100}{\text{Pollutant Standard Concentration}} \qquad (1)$$

Table 1 Level of Health Concern/ AQI of CO

Index Values	Levels of Health Concern	Health Concern Statements
0-50	Good	None
51 - 100*	Moderate	None
101 – 150	Unhealthy for Sensitive Groups	People with asthma should consider limiting Outdoor exertion.
151 – 200	Unhealthy	Children, asthmatics ,and people with heart or lung disease should limit outdoor exertion
201 – 300	Very Unhealthy	Children, asthmatics, and people with heart or lung disease should avoid outdoor exertion; everyone else should limit outdoor exertion
301 - 500	Hazardous	Children, asthmatics, and people with heart or lung disease should remain indoors; everyone else should avoid outdoor exertion

3. STUDY AREA AND DATA

3.1. Reasons for Pollution in Delhi

DELHI, capital of India is located at 28.61°N 77.23°E, and lies in Northern India. Delhi is the most polluted city in the world and according to one estimate; air pollution causes the death of about 10,500 people in Delhi every year. Rising air pollution level has significantly increased lung-related ailments (especially asthma and lung cancer) among Delhi's children and women. . Most of Delhi's residents are unaware of alarming levels of air pollution in the city and the health risks associated with it. I. have selected ITO SQUARE because of its busiest area .it have be recognized as a area of industrial, rural and residential area Based on air quality data of Department of Environment, Delhi, and air pollution in Delhi's National Capital Region

(NCR) is complex mix of pollution from both human activities (vehicle emissions, construction, industry and residential fuel burning) as well as natural sources like sea salt and dust [6]. The heavy concentration of Carbon Mono Oxide (CO) is greatly affected by meteorological conditions in the winter; cool air causes inversions that stagnant the air, which traps pollution close to the ground [7]. Air flowing from Afghanistan and Pakistan pick up emissions as they move over the densely urbanized regions of Punjab and Haryana where farmers burn the straw in their fields and pull this pollution into Delhi. Pre-monsoon dust storms also contribute to air pollution in this region CPCB has an automatic monitoring station in ITO interaction in New Delhi. At this station respirable suspended particles, carbon monoxide, ozone, sulphur di- oxide, nitrogen dioxide and suspended particulate matter are being monitored and information is weekly updated. The data used for this experiment is collected from CPCB's website.

Table 2 Year wise frequency of occurrence of AQI by CO in each category.

Year/fre.	1	2	3	4	5	6
2007	1	49	36	9	4	1
2008	2.5	95	2.5	0	0	0
2009	2	37	35	13	9	4
2010	15	52	15	7	5	6
2011	33.5	39.5	16	6	4	1
2012	18	43.5	13	3	12	1
2013	11	65	22	2	0	0

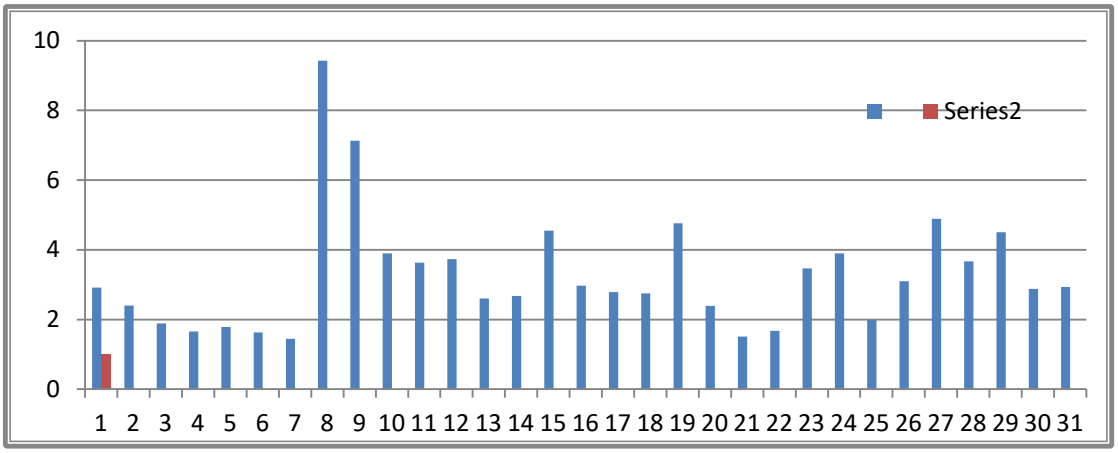

Figure 2 Average concentration CO Jan 2007

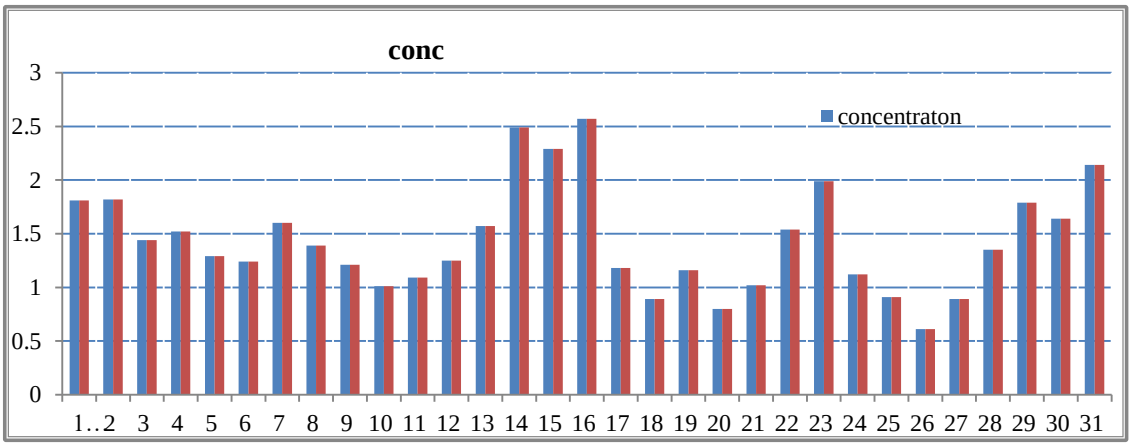

Figure 3 Average concentration CO Jan 2013

3.2. Proposed Artificial Neural Network based Short Term Prediction System

The computational methods are one of the useful tools for the forecasting purpose. An artificial neural network (ANN) is a computational model based on the structure and functions of the biological neural networks [11]. Information that flows through the neural network affects the structure of the ANN because a neural network changes or learns in a sense based on that input and output. ANN is considered as nonlinear statically data modeling tools where the complex relationships between input and outputs are patterns. ANN has many advantages and is used in various fields. It can actually learn by observing data. In this paper the authors have utilized the learning and adaption capabilities of the ANN to efficiently predict the CO concentration for one day ahead prediction.[12] The complete specification of the proposed ANN short term prediction model is described in the following sections.

3.2.1. Neural network predictor development specifications

To develop an efficient ANN based short term prediction system for CO concentration, the proposed system consists of five different inputs, viz.

- Day of Weak
- Month of Year
- Previous day CO Concentration
- Maximum Temperature (T)
- Minimum Temperature (T)
- Average Wind Speed
- Rain Fall

The basic requirement of these five different inputs lies on the fact of acquiring the proper pattern of the previous one year CO characteristics. Finally the proposed prediction system generates one output which provides the one day ahead predicted value of the CO concentration. The structure of the proposed ANN based short term prediction system is shown in Figure 4. The proposed system is initially designed to predict the CO concentration on date 1st July 2014 as we have used the training data of previous one year from this date for the training and development of the proposed prediction system. Moreover, after successful training and development we can use this system for the prediction on any date based on the availability of the previous data.

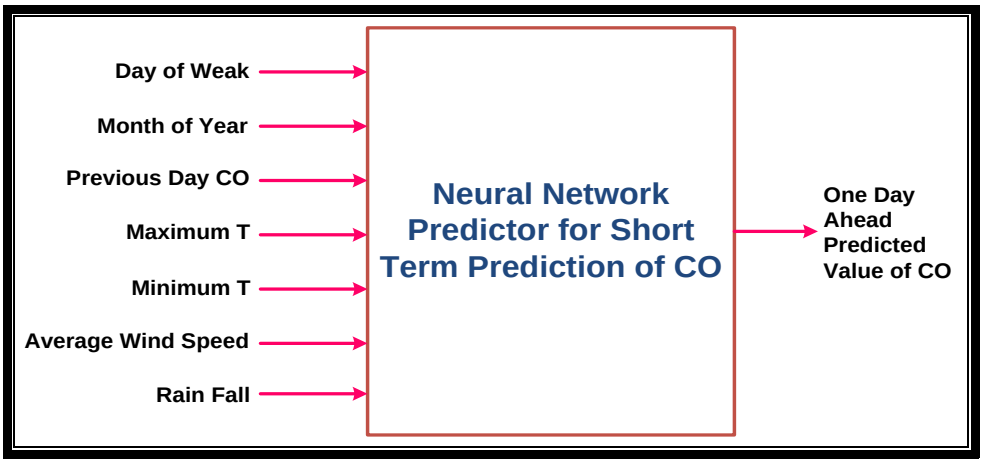

Figure 4 The basic structure of the proposed ANN based short term CO concentration Prediction system.

After the training and development of the proposed predictor on the MATLAB 2012(b) software platform, the technical description of the of the ANN is as follows,

- Type of Neural: Feed forward neural network
- Number of Hidden Layers: 1
- Number of Neurons in the input layer: 80
- Number of Neurons in the hidden layer: 20
- Input layer transfer function: 'tansig'
- Hidden layer transfer function: 'tansig'
- Output layer transfer function: 'poslin'
- Training error obtained: 0.00672

The final structure of the developed ANN simulation model is shown in Figure 5.

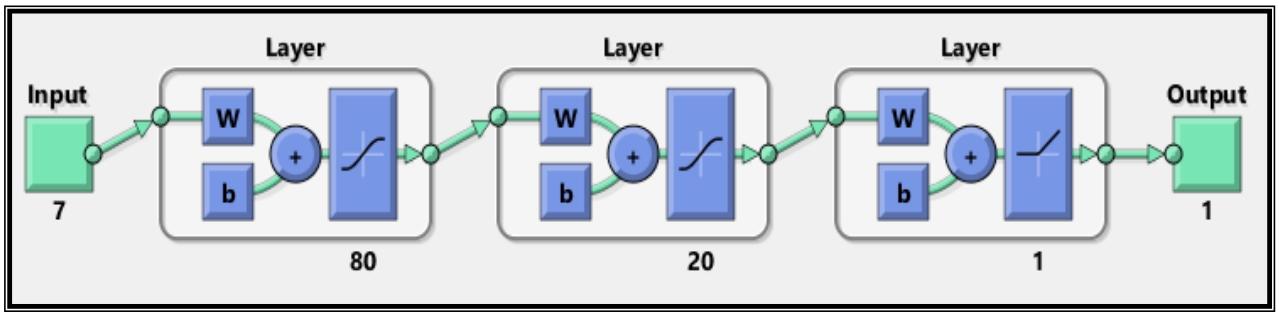

Figure 5 ANN system structure developed in MATLAB.

4. RESULTS AND DISCUSSION

This section presents the prediction results obtained after the performance evaluation of the developed ANN based short term prediction of the CO concentration. On very first stage of the present analysis, we present the testing results for the CO concentration prediction using the training data used for the training of the proposed ANN system. Figure 6 shows the prediction results using the training data.

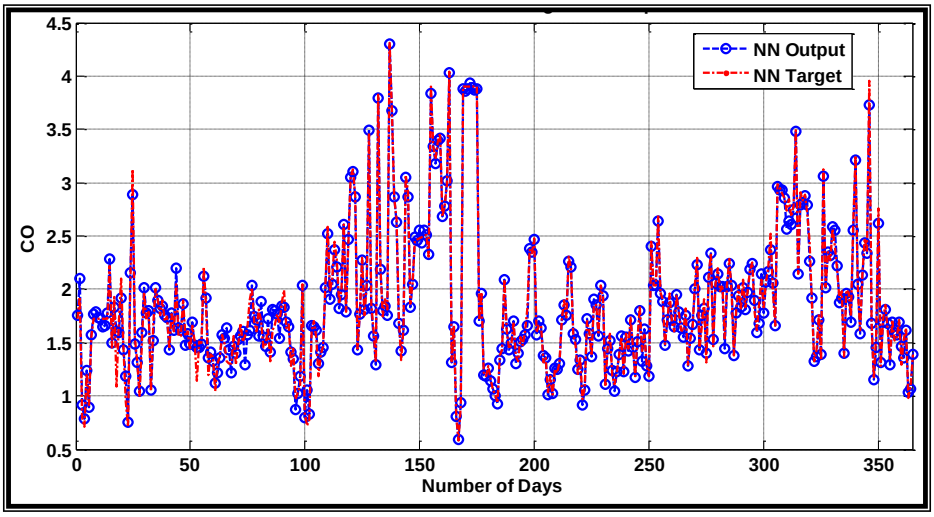

Figure 6 Training data based prediction results for proposed ANN system

Secondly, we are reporting the prediction performance of the developed prediction system for the designed date 1st of the July 2014. The resultant prediction characteristics on this date is follows,

Actual CO on date 1/07/2014 = 1.37

Predicted CO on date 1/07/2014 = 1.3685

Percentage Prediction Error = ((1.37-1.3685)/1.37)×100 % = 0.1095 %

Afterwards, the same developed ANN system has been utilized to obtain the CO concentration prediction for next six days of 2nd July to 7th July 2014. The prediction results obtained for this time span is tabulated in Table 3. This plotted in the Figure 7.

Table 3 CO concentration prediction results for next days.

Date	Actual value of CO	Predicted value of CO	Percentage Prediction Error
1-Jul-14	1.37	1.366	0.3248
2-Jul-14	1.97	1.963	0.3475
3-Jul-14	2.00	2.008	0.4059
4-Jul-14	1.86	1.872	0.6217
5-Jul-14	1.88	1.883	0.1746
6-Jul-14	1.83	1.860	1.6378
7-Jul-14	1.59	1.588	0.1300

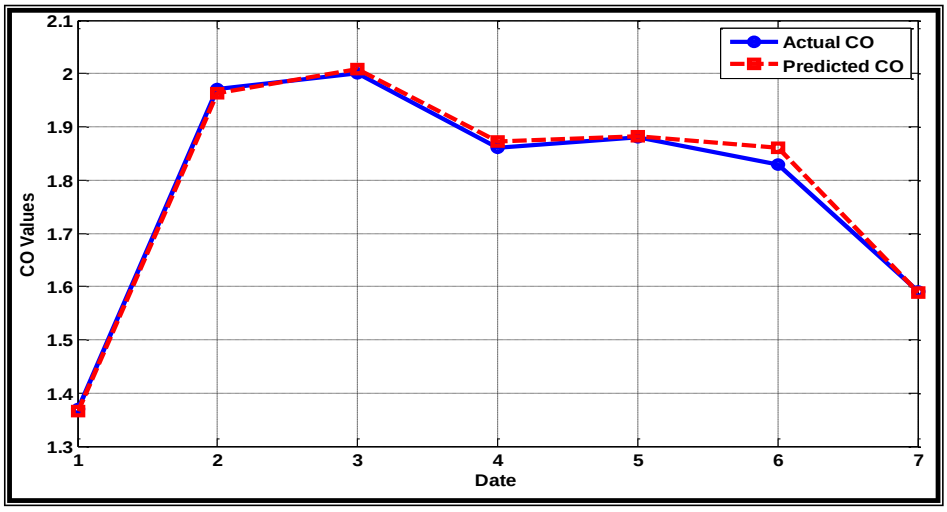

Figure 7 Plot of Actual and predicted CO concentration values.

5. CONCLUSIONS

In this paper an effective ANN based short term prediction system is developed for one day a head CO concentration prediction. The proposed prediction system has been designed on MATLAB 2012(b) software platform. The obtained results show that the developed ANN based prediction system is efficient in predicting the CO concentration one day ahead and consequently helps the society to predict and take appropriate action accordingly to maintain the pollution of the various regions in India.

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