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ORIGINAL ARTICLE

Role of Urban Vegetation in Particulate Pollution Control in Urban Areas of Gwalior City with Special Reference to SPM

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ABSTRACT
Air pollution affects the quality of life of humans and other living beings. Inhaled air pollutants possess serious impact on respiratory system. Vegetation enhances quality of life in urban areas, where half of human population lives, alleviating global warming and filtering of air pollutants. Urban trees can mitigate gaseous and particulate pollutants emission from urban transportation, thus reducing overall emissions from different sources. This article revealed that how urban trees influence the level of ambient particulate air pollutants that exists in common urban areas and the importance of urban vegetation, including trees and shrubs etc., is emphasized, with particular consideration given to the impacts on particulate air pollution. Four urban areas of Gwalior were selected for this study to represent the city. For sampling and assessment, the guidelines of central pollution control board India were followed. The correlation between temperature, relative humidity, wind speed and suspended particulate matter (SPM) concentration was studied from the analysis of the monthly concentrations of this particulate pollutant.
Keywords: *Urban areas, Vegetation, Air pollution, Suspended particulate matter*

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INTRODUCTION

Air pollution affects the quality of life of humans and other living beings. Rapidly increasing urbanization and industrialization sectors affects forests adversely because of contamination of air, water and soil by growth inhibiting substances like particles, acids and gases etc. Inhaled air pollutants possess serious impact on respiratory system [32] of human beings in every age [33]. Vegetation enhancing quality of life in urban areas, where half of human population lives, alleviating global warming [31, 2, 3], carbon storage [23] and filtering off air pollutants [24, 25, 13]. It has been estimated that the temperature in surrounding rural areas on a clear summer afternoon can be 2.5º C lower than a typical city with little vegetation [3]. Temperature and other meteorological parameter are deeply associated with air pollutant concentrations [10]. Plants serving as carbon dioxide sink and particle deposition sites for purifying air and by removing CO_2 from environment through photosynthesis, trees also help to reduce the green house effects, therefore alleviating global warming.

Dust interception capacity of plants depends on their surface geometry, phyllotaxy, leaf external characteristics, such as hairs, cuticle, length of petioles, height and canopy of trees etc [19, 20]. The patterns of particle deposition by plants were determined by structure and micro-roughness of their leaves [6, 7], plants with small or hairy leaves also possess higher ability to capture ambient air particles [8]. It was observed earlier that dust trapping capacity differed considerably with plant species [18, 4, 5]. It is observed in previous studies that fast growing species store more carbon through photosynthesis before they are 10 years old than slow growing species [21, 29]. Evergreen species can perform photosynthesis continuously throughout the year and the amount of carbon uptake by plants increases with leaf longevity [15]. Previously estimated that the woodlands of a specific area of Britain account for

an annual reduction particulate matter of 385700-596900 [26]. Suspended particulate matter as well as several gaseous air pollutants also removed by vegetation.
Urban vegetation act as porous bodies which influence local dispersion patterns, and aid the deposition and removal of ambient air pollutants [12, 13, 35, 23, 16]. Studies have shown that larger leaf surface areas have higher SPM removal efficiency [20]. Particulate matter decrease photosynthetic activity of plants, accelerating internal physiological changes leading to growth inhibition and cause visible injury and death [20]. Due to particulate matter leaf surface structure alteration was found in some common plants [28] and metabolic activity disturbance also caused by air pollution in plants (Govindraju 2010). When exposed to particulate pollutants, plants experience physiological changes before exhibiting visible damage to leaves [18]. SPM exhibits many type of effects on plant like chromosomal aberration [32], reduction of leaf area and petiole length [11], growth and productivity inhibition [2, 3, 4, 5], size reduction of flowers [17], reduction of chlorophyll content [34, 1] and damage seed germination [22] etc.
The direct removal of SPM by trees is affected by ecological factors as well as the biophysical characteristics of trees [36]. Factors such as urban morphology, weather conditions, and concentrations of SPM have a significant impact on the quantity of SPM intercepted by trees [6, 30]. The main purpose of this study is to obtain and understanding of the relationship between air pollutant concentrations and vegetation on different sites in this area. Four urban areas within Gwalior were selected for this study to be representative of the city. The four areas are Morar, Gast Ka Tajiya, Gole Ka Mandir, and Jiwaji University campus, respectively, designated as residential, commercial, high traffic, and greenery-rich areas. The monitoring was conducted during four seasons namely pre-monsoon (March–May), monsoon (June–August) post-monsoon (September–November), and winter (December–February) during the year.

MATERIAL AND METHODS

Study area

The present study was carried out in Gwalior, a historical city in Madhya Pradesh (M.P.). Madhya Pradesh is one of the largest states of India according to its geographical area. Gwalior is the fourth largest city of the state of Madhya Pradesh. The city of Gwalior is said to have been named after saint Maharishi Galav. The city is situated at the junction of Malwa plateau in the southwest and Gangetic plain in the northeast. It is situated in the northern area of M.P., extended from 26.22 N latitude to 78.18 E in the state of Madhya Pradesh, Gwalior district is elevated from 663 ft. in the NE (lowest) to 1360 ft. in the SW (highest) as height increases from east to west. According to 2011 Census, the district has an area of 5614.00 sq km, and a population of 2,030,543. Gwalior District is bounded by the districts of Bhind to the northeast, Datia to the east, Shivpuri to the southwest, Sheopur and Morena to the northwest. It is a part of Gwalior Division and one of the fifty-one districts of Madhya Pradesh state in central India.

Climate: Temperature and rain

The city of Gwalior has a humid subtropical type of climate. From late March to early July, Gwalior shows a sub-tropical climate with hot summers. From late June to early October, the city has a humid monsoon season and from early November to late February, it has a cool dry winter. In terms of precipitation, Gwalior comes under the semi-rainfall area. Rain occurs mostly during the monsoon season.

Site selection

The study was done on four sites of Gwalior City which included four areas are Morar, Gast Ka Tajiya, Gole Ka Mandir, and city centre, respectively designated as residential, commercial, high traffic, and greenery rich areas.

Monitoring and Analysis

Gravimetric method adopted for Suspended Particulate Matter analysis [9]. For sampling, the guidelines from the CPCB of India were followed. SPM concentration and meteorological parameters were evaluated for the duration of March 2016-Feb. 2017. The meteorological parameters were monitored by Envirotech Weather Monitor WM271, which is available through the Department of Environment Science.

Abbreviations

GKM: Gole Ka Mandir, MRR: Morar, CC: City Centre, GKT: Gast Ka Tajiya Conc.: Concentration , r : Correlation Coefficient, STDEV: Standard Deviation, STDERR: Standard Error, T: Temperature in degree centigrade, H: Humidity in Percentage,WS: Wind Speed (km/h).

RESULTS

During observational period 2016-2017 the monthly average concentrations of SPM was found in the range of 109.57-306.18 μg/m^3 (Table 1). The site wise monthly averages of SPM concentrations in 2016-2017 are plotted in Figure 1 showing the monthly trends in site wise concentration. As seen in Figure 1, the maximum SPM concentration is on GKT site. The GKT and GKM sites have shown elevated concentrations of SPM comparatively MRR and CC sites because GKT and GKM site are in commercial and traffic rich area respectively but MRR site and CC site are residential and greenery rich areas. The status of monthly average concentration of SPM is presented in Figure 2 that shows a fluctuating trend in different months of observational period 2016-2017. Figure 2 depicts that average monthly SPM concentrations was higher in November, December, January and February months and lower in August, July and June months of the observational period. The seasonal averages of suspended particulate matter concentration are presented in Figure 6. It is observed from the Figure 6 concentration of SPM was comparatively higher in winter season than other seasons of the year. Seasonal concentrations are higher than the standards of CPCB India that was 140 μg/m^3 for residential area. The correlation of monthly SPM with meteorological parameters is plotted in Figures 3, 4 and 5. Figure 3 presents the correlation of temperature with monthly average SPM concentrations and reveals that temperature has significant negative correlation (r=-0.888) with monthly concentrations of suspended particulate matter, it means SPM concentration decreases with increasing temperature. The correlation between monthly average concentrations with humidity was graphed in Figure 4. Humidity has very weak positive correlation (r=0.112) with average monthly concentrations of suspended particulate matter. The correlation between wind speeds with average monthly concentration of suspended particulate matter has graphed in Figure 5. Wind speed has negligible negative correlation (r=-0.040) with average monthly concentration of SPM. It is observed from the Figures 3, 4 and 5 that temperature has negative significant correlation with suspended particulate matter concentrations but the humidity wind speed have very weak and negligible correlation with average monthly concentration of suspended particulate matter respectively.

Table 1 SPM concentrations and meteorological parameters during Mar. 2016 - Feb. 2017

Months	GKM	MRR	CC	GKT	Average Conc.	STDEV	STDERR	T (ºCent.)	H (%)	WS (km/h)
Mar	150.38	141.23	122.78	192.28	151.67	29.41	14.70	26.6	48.6	1.3
Apr	168.84	125.94	113.49	210.1	154.59	43.95	21.97	32.4	35	1.9
May	175.3	145.68	129.36	199.39	162.43	31.12	15.56	34.9	40.6	2.4
June	143.56	143.17	121.85	193.88	150.62	30.57	15.29	35	52.9	1.4
July	169.19	135.28	117.38	172.6	148.61	26.78	13.39	29.7	82.1	3
Aug.	137.45	149.31	109.57	163.04	139.84	22.73	11.36	28.6	84.8	4.1
Sept	162.85	132.45	112.54	204.58	153.11	40.07	20.03	29.3	73.1	3.2
Oct	182.32	138.15	142.21	207.61	167.57	33.31	16.66	26.6	57.9	2.5
Nov	266.01	154.61	144.3	306.18	217.78	80.69	40.34	19.9	58.3	2.7
Dec	301.57	169.42	150.34	293.16	228.62	79.83	39.92	15.8	72.3	1.2
Jan	252.36	165.65	152.39	297.68	217.02	69.69	34.85	14.6	75	0.8
Feb	278.75	177.21	131.87	283.92	217.94	75.54	37.77	18.5	59.9	5.5

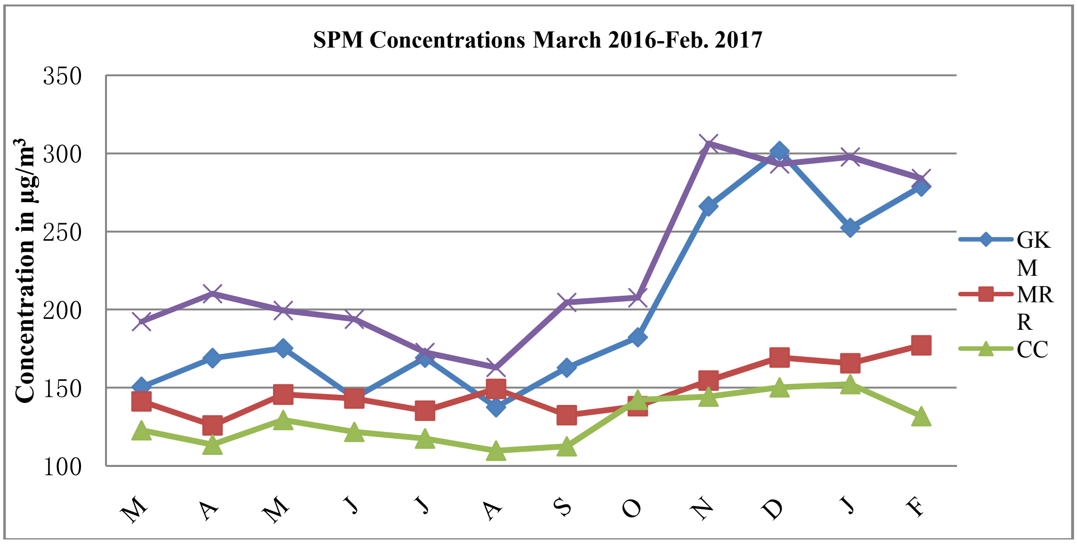

Figure: 1 Site Wise SPM Concentrations in Different Months March 2016-Feb. 2017

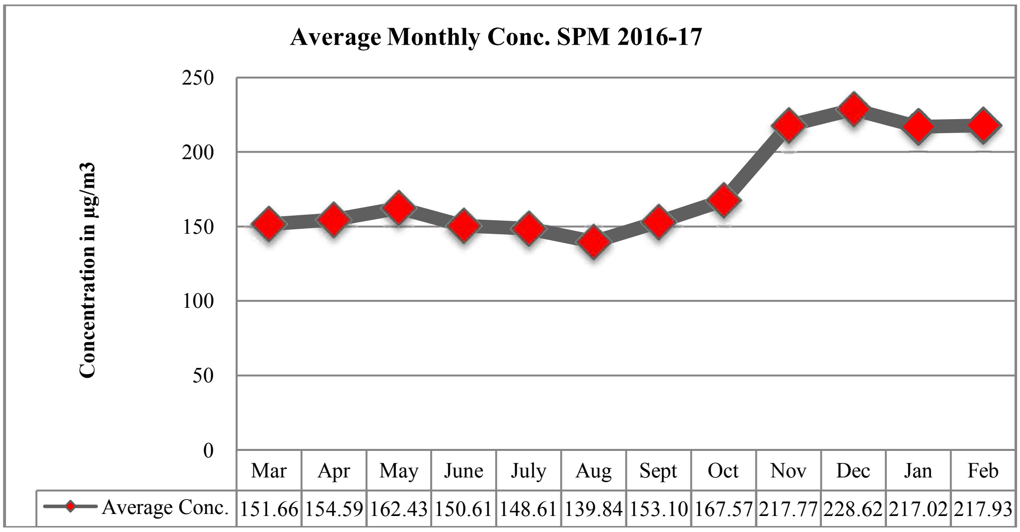

Figure: 2 Averages Monthly Conc. of SPM Mar. 2016- Feb. 2017

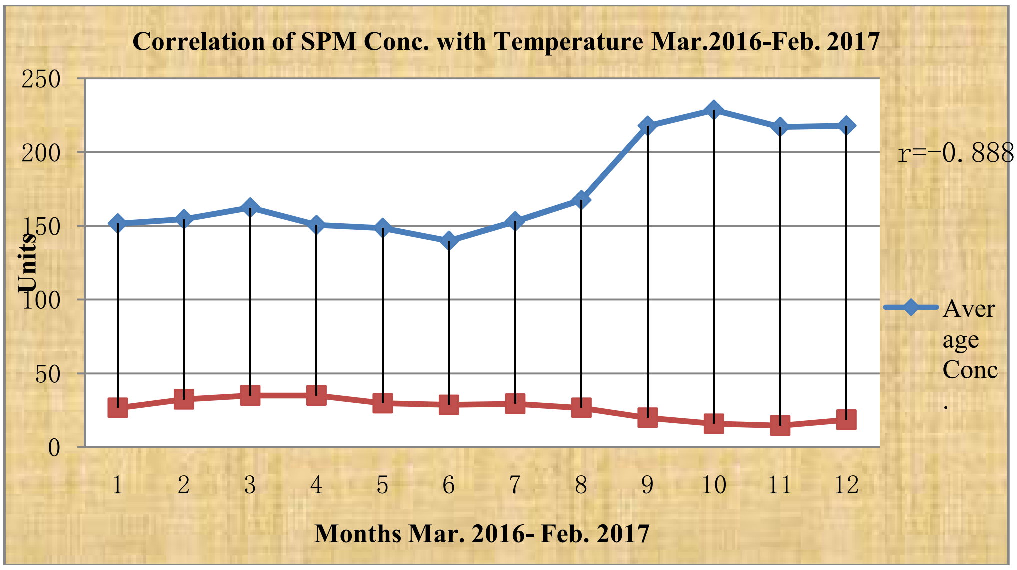

Figure: 3 Correlations between Temperature and Average Monthly SPM Concentration

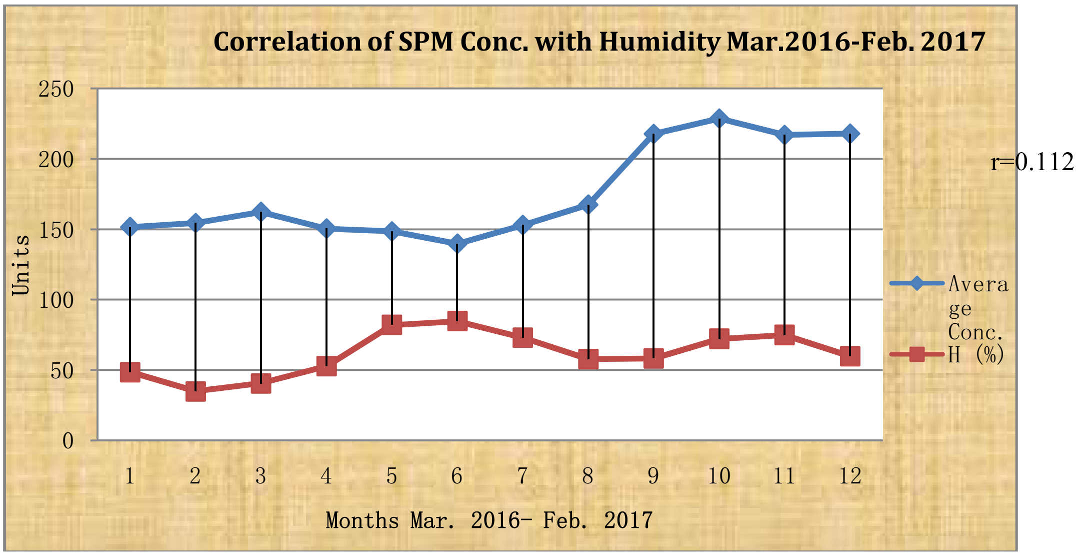

Figure: 4 Correlations between Humidity and Average Monthly SPM Concentration during March 2016- February 2017

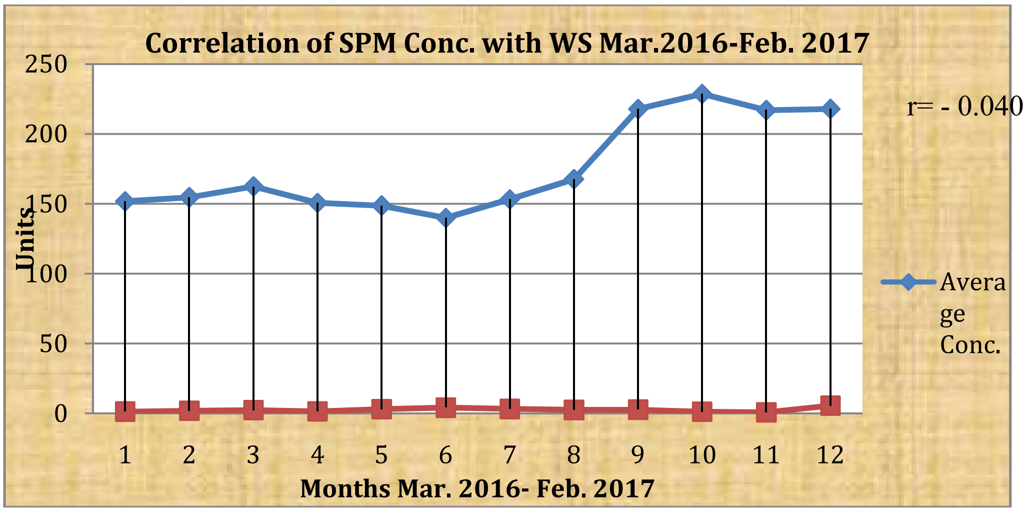

Figure: 5 Correlations between Wind Speed and Average Monthly SPM Concentration during March 2016- February 2017

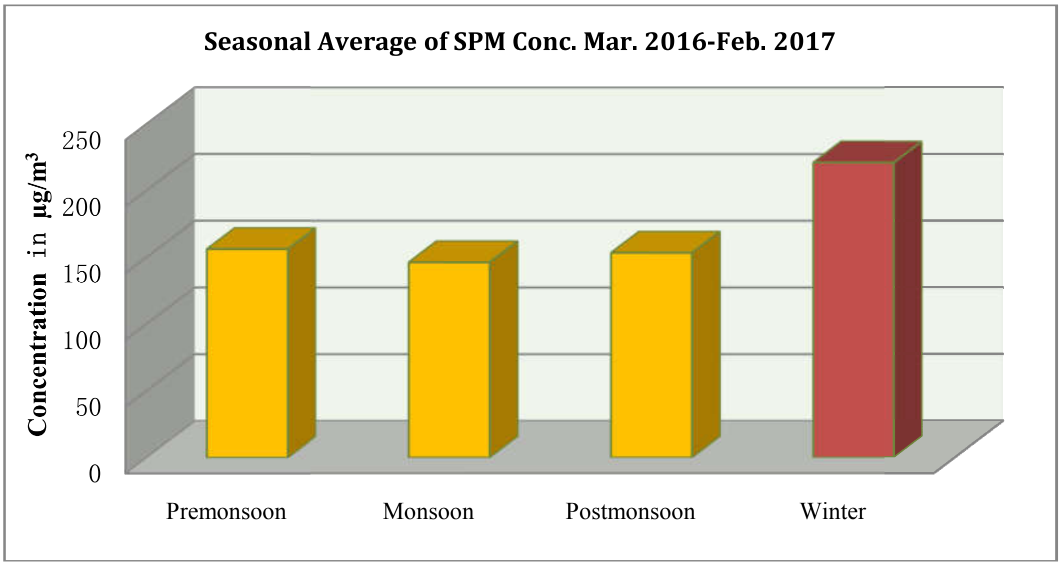

Figure: 6 Seasonal Average of SPM Conc. during 2016- 2017

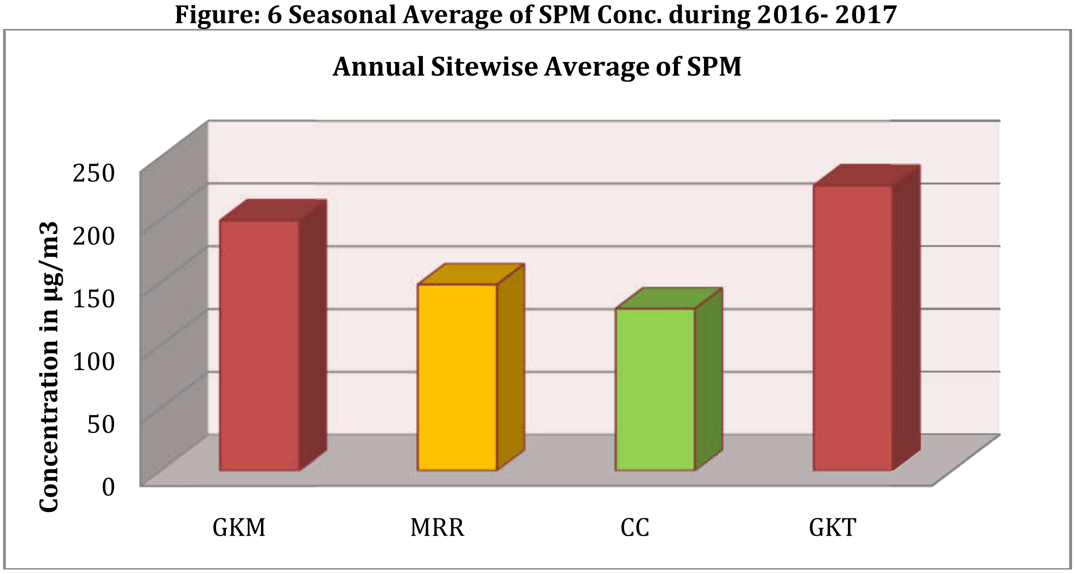

Figure: 7 Annual Site Wise Average of SPM during Mar. 2016- Feb. 2017

CONCLUSION

Study concludes that urban plant and vegetation plays major role in air pollution control because site wise and monthly concentration during the observational period was found lower at City Centre. SPM concentration on City Center which is a greenery rich area was consistently less during whole observational period. The effect of plants and vegetation on SPM concentration was not influenced by meteorological conditions of the study area. Monthly SPM concentrations have negative significant correlation with Temperature but other meteorological parameters were not correlated significantly.

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