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The Impact Of Urbanization On Air Quality And The Solutions For Sustainability

Lasitha. K[1], Dr.Arul sheeba Rani[2]

Department of Botany,

Nirmala College for Women,

Affiliated to Bharathiar University,

Coimbatore-641018, Tamil Nadu.

Abstract

According to the studies conducted by the University of Chicago's Energy Policy Institute, urbanization is a major cause of air pollution, but it is inevitable. This study aims to determine the impact of air quality on land conversion in urban areas and propose a solution for enhancing the quality of air. This study examined variations in air quality resulting from different land use patterns in Bengaluru, including residential areas, forest areas, wide-open spaces, farmland, barren layouts, and plotted layouts that had vegetation. To calculate the air quality index, particle matter, PM2.5, and PM10 were measured using a Plat tower PMS5003 air quality sensor. The plotted layout with vegetation is considered the center, around the radius of 500m to 2000m surroundings with different land-use areas AQI was measured. The values are plotted and analysed. In comparison to other populated areas, the plotted layout with vegetation shows a better AQI. For the betterment of AQI, we need to design a layout in such a way that the planted trees in the layout will absorb the maximum possible PM particles from polluted air. Our proposal says that choosing trees for the layouts and planting them in the right place helps to improve the air quality index.

Keywords

Urbanization, air quality, PM particle, environmental degradation, AQI.

Introduction

Over the last few decades, urbanization has increased rapidly in India, with almost 4% of the population moving out from the cultivation land to a "modernized" area to improve their economic growth and lifestyle change. An urban area is an integral part of industrialization and creates employment opportunities. Besides, people are attracted by urban infrastructure like the ambiance of the workplace, digitalization, residential areas, urban parks, and efficient urban mobility. Consequently, people migrate to urban areas from rural, leading to an increase in the population of a particular area. About one-third of India's entire population now resided in cities in 2020 (Aaron O'Neill, 2020). As a result, land conversion and spatial extension. Many cultivated lands, forest areas, and ponds are rising into commercial sites, buildings, industries, plots, and government projects (Das and Das, 2019).

Overgrowth of the population in a particular area impacts the environment more stressful in all aspects. Indian cities are facing different environmental challenges. Air pollution poses a major risk to Earth's stability, causing global climate change, and ecosystem destruction and affecting human health (Rockstrom *et al*., 2009). Air pollution exposure has been found to be the cause of 16 % of worldwide mortality even at low concentrations (Landrigan *et al*., 2017). The world health organization (2018) reported that 3.8 million people a year suffer serious health issues from inhaling dust particles.

Researchers paid more attention to novel pollutants in the twentieth century, such as particulate matter PM10 and PM2.5. When the PM particles combine with gaseous pollution, it makes severe atmospheric air quality changes and the health of urban dwellers (Guerrero and de Omenaca Gonzalez, 2014). In addition, excessive $PM_{2.5}$ concentrations decrease atmospheric visibility and disturb the radial equilibrium of the earth (Aklesso *et al*., 2018). Fine diameter and toxicological properties of PM released from terrain, transport, industries, and domestic sources contain hazardous heavy metals and are tiny particles to penetrate into the lungs deeply. It is the leading cause of lung cancer in urban areas (Zhao *et al*., 2010; Cao *et al*., 2011). Several epidemiological studies have substantiated that long-term exposure to airborne particles damages the cardiovascular and respiratory systems (Ruckerl *et al.,* 2011). According to the research, in 2019 India had the highest concentration of PM particles at 70.3 $\mu g/m^3$, which is seven times higher than the recommendation of (10 $\mu g/m^3$) by the World Health Organization. The impact of particulate matter reduces 2.5 to 2.9 years from the average human life span. The AQI data indicates that the pollutant has to be reduced to comply with the WHO recommendations then the average person would live for 5.6 years longer (Pollution impacts). The aim of the study is to determine the impact of air quality on land conversion in urban areas and to propose a solution for the improvement.

Materials and methods

Study area

The study was carried out in Sarjapura, village located in southeast Bengaluru, Karnataka State, India. Sarjapura is a fast-developing area surrounded by diverse farmland, industries and residential area with spatial extent of the total area 7.47 Ha, is currently experiencing rapid urbanisation. Recently, cultivating lands are converted in to plots and smart townships. Some plotted layout consists of lush of green, and some are without plantation. The total population in the area was 11,807 as per 2011 census.

Location

Shriram Malhar is a plotted layout consist of 30 acres. It was a cultivated land before the layout formation. After plot formation, the area was planted with 821 trees and covered with grass and weeds. The layout encircles with more exotic trees than the indigenous trees (180 exotic trees,580 decorative and 60 indigenous trees).

Species diversity

The layout is encompassed by 821 trees of 20 different species and weed grass. The planted tree species in the layout are *Delonix regia* (Hook.) Raf., *Macarena lagenicaulis* (L.H.Bailey) H.E.Moore, *Cassia spectabilis* DC.,*Spathodea campanulata* P. Beauv.,*Millingtonia hortensis* L.f., *Bauhinia variegata* L.,*Roystonea regia* (H.B.K) O.F.Cook,*Grevillea robusta* Cunn. Ex R. Br., *Cassia fistula* L., *Tabebuia impetiginosa* (Mart. Ex DC.) Standl., wherein 80% of the trees are dominant: *Thespesia populnea* (L.) Sol. ex Correa, *Filicium decipiens*(Wight &Arn.) Thwaites, *Acacia auriculiformis* A. Cunn. Ex Benth., *Senna siamea* Lam.) H.S. Irwin &Barneby, *Lagerstromia speciosa*(L.) pers., *Markhamia lutea* (Benth.) K. Schum., *Tabebuia aurea* (Silva Manso) Benth. & Hook. f. ex S. Moore, *Tabebuia rosea* (Bertol.) Bertero ex A. DC. *Tectona grandis* L. f., *Artocarpus heterophyllus* Lam.

Air quality sensor

The present study has used Air quality sensor-"Plat tower pms5003" version 2.3 to obtain the number of suspended particles in the air and output them as a digital value. This sensor is used with Raspberry pi to read the digital output. (Fig 1)

Monitoring PM particle (PM2.5 and PM10) with direction

The PM2.5 and PM10 particle was monitored in all the direction from the layout (East, West, North and South). The layout considered as control due to lush of green cover. Each 500 m radius the PM particle value was recorded with each 1-hour duration. The value was taken maximum to minimum range and the average was calculated. According to the AQI (Indian standard), the values were described (Table 1).

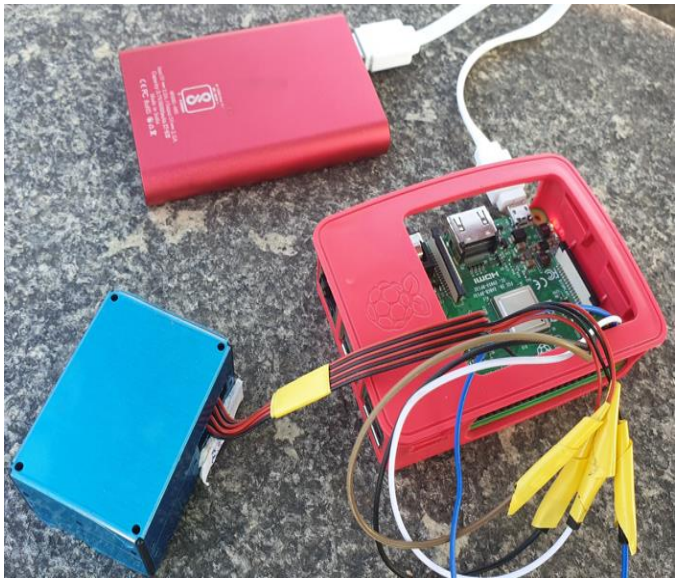

***Fig1*: Plant tower pms5003 sensor with Raspberry pi**

Table 1: Types of land with direction and radius

Direction	500m	1000m	1500m	2000m
East	Farm land (FL)	Farm land (FL)	Forest area (FA)	villa on the road side(V)
West	Barren land urbanizing area (BL)	Village with low vegetation (VL)	Village (VL)	Barren land (BL)
North	village (VL)	Empty plot (EP)	Plot with less vegetation (P)	Empty plot (EP)
South	Barren land (BL)	Villa(V)	Populated area without vegetation (PA)	Populated area without vegetation (PA)
Center	Layout with Good vegetation (LV)			

Result and discussion

Among the recorded values, the maximum value got recorded in L-S 2000m which was the densely populated area, the values are PM2.5 = 73.6 µg/m^2, PM10 = 94 µg/m^2, AQI = Satisfactory (Han *et al* ., 2018) reported that density of population, anthropogenic activities and high energy consumption leads to pollution emissions and effect air quality of the area. The Minimum values got recorded in the Forest area, PM2.5 = 30 µg/m^{2,} PM10 = 34.15 µg/m^{2,} AQI = Good. The remaining values are recorded like FA < FL < P < VL < V < BL < EP < PA (Table 2&3). The trees reduce the maximum impact of PM based particles by their density of the canopy, leaf traits (Chen *et al*., 2016). Which act as filters to reduce the pollutant by absorption, adsorption, detoxification and accumulation. In India 21.67% is the forest area and its being decreased as per the In the Indian State of Forest Report (ISFR). From 2001-2019 considered the peak of urbanization, 4.5% of trees population loss occurred in urban areas.

Table 2: Concentration of PM2.5 at the distance

Direction	Land Type	PM2.5 High	PM2.5 Low	PM2.5 Avg	AQI
L-Center	LV	37	26	**31.5**	Satisfactory
L-E 0500m	FL	47	37	42.2	Satisfactory
L-E 1000m	FL	55	40	45.75	Satisfactory
L-E 1500m	FA	46	15	**30**	Good
L-E 2000m	VL	100	41	49.3	Satisfactory
L-N 0500m	VL	62	41	50.4	Satisfactory
L-N 1000m	EP	83	64	71	Moderately
L-N 1500m	P	59	40	46.5	Satisfactory
L-N 2000m	EP	141	54	72	Moderately
L-S 0500m	BL	141	56	67.3	Moderately
L-S 1000m	V	95	41	58.5	Satisfactory
L-S 1500m	PA	88	65	72.8	Moderately
L-S 2000m	PA	125	61	**73.6**	Moderately
L-W 0500m	BL	234	45	62.1	Moderately
L-W 1000m	VL	59	42	46.8	Satisfactory
L-W 1500m	VL	83	26	48.3	Satisfactory
L-W 2000m	BL	112	64	70.7	Moderately

Table 3: Concentration of PM10 at the distance

Direction	Land Type	PM10 High	PM10 Low	PM10 Avg	AQI
L-Center	LV	43	27	**35.2**	Good
L-E 0500m	FL	61	39	51	Satisfactory
L-E 1000m	FL	66	45	55.8	Satisfactory
L-E 1500m	FA	35	16	**34.15**	Good
L-E 2000m	VL	104	49	60.9	Satisfactory
L-N 0500m	VL	82	44	62.4	Satisfactory
L-N 1000m	EP	101	84	91.7	Satisfactory
L-N 1500m	P	73	46	56.7	Satisfactory
L-N 2000m	EP	152	65	87.3	Satisfactory
L-S 0500m	BL	165	71	86.5	Satisfactory
L-S 1000m	V	111	44	75.5	Satisfactory
L-S 1500m	PA	105	83	93.7	Satisfactory
L-S 2000m	PA	136	79	**94**	Satisfactory
L-W 0500m	BL	241	58	74.6	Satisfactory
L-W 1000m	VL	76	45	56.4	Satisfactory
L-W 1500m	VL	105	30	58.7	Satisfactory
L-W 2000m	BL	121	83	92.6	Satisfactory

Proposal of the layout

The plotted layout with vegetation showed good in mitigating pollutants among the location due to more green cover. The AQI of the layout come under 0-50 µg/m2, and the value is described as Good. But the layout encircles with more trees (821) that have not been appropriately planted according to the environmental problem.

The community consist of 30 acres (1,21,406 sq.m^2), and each side has 348 m. The layout has designed 60 m (18.2 m) wide main road and 40 feet (12.9 m) width. The trees will be placed in the compound area at 3 m, so 116 trees can plant on each side. The total number of trees in a compound can be 464. Every plot of 40*60 feet can place a single tree in front. Accordingly, 286 trees can be planted in the sub road, on both sides of the road total of 232 trees and the main road of 60 feet with 3 m of the gap. The layout has a park, a playground, a pool and a citizens' park with a total area of 80 trees. Thus 464 + 286 + 232 + 80=1062 can be plant.

The proposed layout has given the suggested plant according to the 3 metrics, Native, Exotic, and Endangered trees. (Fig 2 & Table 4).

Table 4: Proposed layout

Location of model layout	**Diversity of trees**
Entrance	*Bambusa vulgaris* (control pollution); *(*Atanda,2015).
Right side - front corner	*Azadirachta indica* (control pollution); (Abdullateef *et al*.,2014).
Right side - back corner	*Ficus religiosa* (Worshiping tree, control pollution); Ramakrishnan *et al*., (2018).
Left side - front corner	*Michelia champac* (pleasent smell);
Left side - back corner	*Syzygium cumini*, Kumar *et al*., (2013)
Side of the layout	*Pithecolobium dulce, Dalbergia lanceolaria, Madhuca latifolia,* Tabebuia *avellanedae, Bombax ceiba*, *Cassia fistula* (Aesthetic value)
Backyard	*Albizia lebbeck, Anthocephalus cadamba*,(control pollution); Alotaibi *et al*., (2020)
Plot area	*Rhododendron falconeri, Rhododendron tanastylum, Nyctanthes arbor-tristis, Diospyros celebica, Actinodaphne lawson, Amentotaxus assamica, Ilex khasiana, Santalum album., Bombax ceiba, Cassia fistula, Bauhinia* purpurea, *Erythrina variegate* (control pollution,aesthetic); (Dadé et al., 2018; Chowdhury et al.,2009).
60 feet road	*Polyalthia longifolia*, Parkar et al, (2020)
Park	*Anthocephalus cadamba,Bombax ceiba, Cassia fistula, Bauhinia* purpurea, *Erythrina variegate,(*Aesthetic and control pollution); (Dadé et al., 2018; Chowdhury et al.,2009
Swimming pool	*Cycas beddomei*, ornamental; Singh, (2011)

***Fig*: 2 Proposed layout**

Conclusion

Trees have the potential to reduce maximum pollution. Urbanization is unavoidable. The proposed layout with effective trees can help to improve the health of urban dwellers as well as recreation and enjoyment. Nevertheless, provide benefits on the spectrum of social, health, environmental and economic. The selection of the right tree and proper adoption in the urban area will change the quality of the environment.

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