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DEGREE OF PROTECTION OF PEDESTRIAN ULTRAVIOLET LEVEL BY USING TREE CANOPIES

R. BHATTACHARYA, S. PAL, P. BARMAN, A. BHATTACHARYA

1. Department of Environmental Science, University of Kalyani, Kalyani 741235.
2. M.G.M. Medical Collage, Kishanganj, 855108.

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Abstract: Absorption of too much UV exposure leads to skin cancer. Pedestrian UV level depend on several factors such as temperature, humidity, cloud, aerosol, insolation and human behavior. Though sunscreen products that contain avobenzone, ecamsule, zinc oxide, titanium dioxide can provide some protection from UVB and most UVA rays but trees can also prevent UV exposure by providing obstruction to direct sun rays. A case study is conducted to quantify the exposure level and degree of protection using tree canopies within Kalyani University campus in the district of Nadia, West Bengal where average human load at peak hours from 10:00hrs to 14:00 hrs is around 1800. Among the fourteen tree species studied so far at Kalyani (22.58°N, 88.26°E) 68 km away from Tropic of Cancer (23½º), Radhachura (Peltophorum pterocarpum) is found to give best obstruction to pedestrians. Moreover the exposure level also depends on tree cover. Depending on the tree species the shade ratio varies from 0.012 to 0.317.

Keywords: Pedestrian, Ultraviolet exposure, Sky view, Tree species

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INTRODUCTION

The detrimental effects of solar ultraviolet radiation exposure has become a subject of concern after the realization that protective ozone layer was at risk due to anthropogenic activities. The UV health impacts are mainly sun burn, cataract, ageing, skin cancer *etc*. However there might exits a complex relationship between sun exposure and skin cancer [1-6].

Ultraviolet radiation spectrum is broadly classified into three categories- UVA (315-400nm), UVB (280-315nm), and UVC (200-280nm). Stratospheric ozone layer has blocked UVC totally. A part of UVA and UVB penetrating the atmosphere and reaches the ground. UVA damages the dermal layer of the skin and responsible for skin tanning. UVB causes damage to the epidermal layer. Average UVB irradiance has been reported to enhance by 4% to 6% due to stratospheric ozone depletion [7, 8]. However the impact depends on aerosols, cloud cover and insolation along with environmental condition and human behavior [9, 10]. Meteorological parameters such as temperature, cloud cover and insolation have significant role in estimating amount of UV exposure. In summer, people use shade for comfort but in winter they seek sunlight, although they are also exposed to the harmful effect of UV. Researchers have showed that erythermal UV in shade is higher in winter months compared to summer [11-15].

Open environment exposures of UV radiation at different sites are investigated by several researchers over the globe [16-18]. Nine outdoor occupational groups from postman, construction, horticulture, landscaping, sawmilling, roading, forestry, farmers and viticulture were surveyed and observed that only one third workers use UV protective equipments and sunscreen. Hence action taken in the workplace may be the key in reducing UV exposure. Impact of UV rays depend on the types of human skin as indicated in the Table 1.[19,20].It is observed that solar UV radiance is influenced by tree canopies [18, 21-24].The degree of exposure depends on the species denseness and of the tree because of the obstruction of direct sun by plant cover and also by environmental conditions [25-28]. Use of tree shade may be one of the ways to deplete human UV exposure [29-34]. Sun protection factor (SPF) ranges from 5 to 10 may achieved from tree shade. UV Index is high over the equatorial region. Hence computation of pedestrian UV exposure level in Tropics is highly significant [22]. In this paper an assessment of the degree to which trees may influence pedestrian UV exposure level is made.

Table 1. Impact of solar radiation on skin

Skin Type	Colour	Optimum level J/m^2	Time to burn (min)	Remarks
I	White	150-300	5-10	Burns easily, high risk of developing skin cancer
II	Whitish	250-350	8-12	Burn
III	Brownish	300-500	10-15	Tan, occasionally burn
IV	Brown	450-600	15-20	Tan, occasionally burn
V	Deep brown	600-1000	20-35	Tan, rarely burn
VI	Black	1000-2000	35-70	Very rarely burn, Tan

2. Materials and Method

Study Area: Kalyani University Campus (22.58 ^{o}N, 88.26^{o}E) is chosen as study area to assess the pedestrian UV level. It is situated at Nadia district of West Bengal in India and has sub tropical humid climate. The daily temperature over the year ranges from 11.9^{o}C (winter) to 36.9^o C (summer). The site is only 68 km. away from the tropic of cancer and hence has the opportunity of getting sufficient amount of solar radiation [35, 36]. Observation points are choosen along the four major roads within Kalyani University Campus as shown in Figure 1. Roads from the University gate to Folklore Department, Gymnasium to Chemistry Department, University Health Centre to Zoology Department and Folklore Department to PG Hostel are assigned codes R1, R2, R3 and R4 respectively.

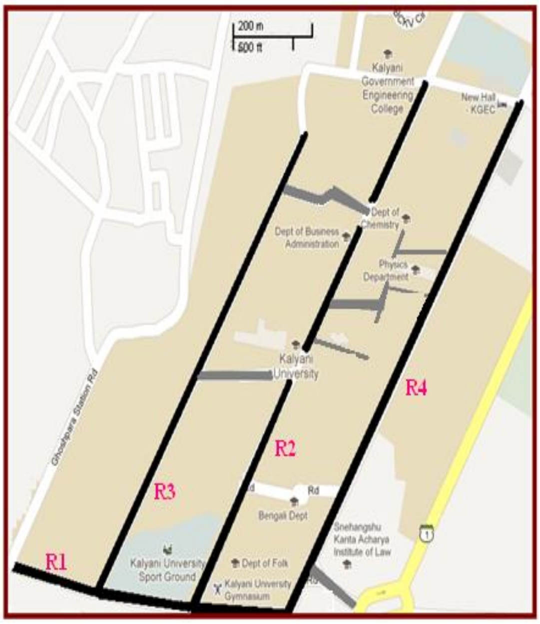

Fig 1: Roads of Kalyani University Campus (courtesy: Google maps)

Observation points are chosen at different grid points as indicated in Figure 2. The points along the length are 10m apart whereas breadth is divided into two equal parts. All the roads are divided in a similar way along this spread.

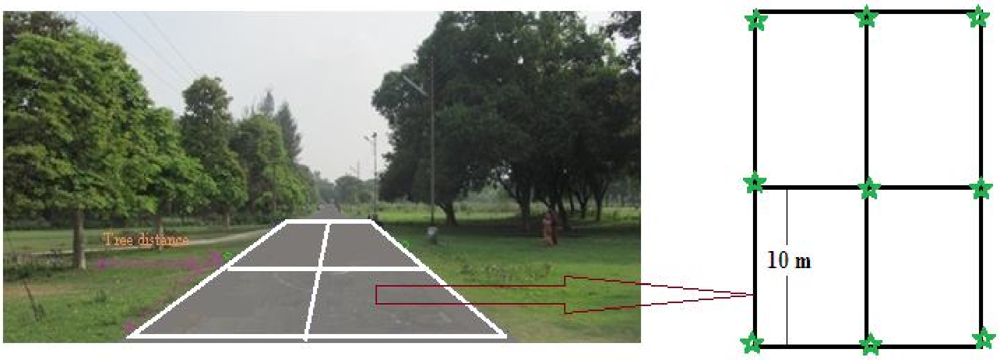

Fig 2 Observation point on road is shown in grid point (marked by the symbol ☆)

Tree Selection: Fourteen tree species that are common on both sides of the roads within the University campus and well adapted in that environment are selected randomly. The main features of the trees are cited in Table2.

Table 2 Characteristics of the trees

Name/ code	Scientific name	Origin	Foliage
Jarul/ T1	*Lagerstromia indica*	Native	Deciduous
Radhachura/ T2	*Peltophorum pterocarpum*	Native	Deciduous
Eucalyptus/ T3	*Eucalyptus* sp.	Non Native	Evergreen
Kalojam/ T4	*Syzygium cumini*	Native	Evergreen
Kotbel/ T5	*Lemonia acidissima*	Native	Deciduous
BaksaBadam/ T6	*Sterculia foetida*	Non Native	Deciduous
Segun/T7	*Tectona grandis*	Native	Deciduous
Banyan/ T8	*Ficus benghalensis*	Native	Evergreen
Mehogini/ T9	*Swietenia mahagoni*	Non Native	Semi-Evergreen
Chatim/ T10	*Alstonia scholaris*	Native	Evergreen
Debdaru /T11	*Polyalthia longifolia*	Native	Evergreen
Belati-Jhau/ T12	*Casuarina equisetifolia*	Non Native	Evergreen
Korui /T13	*Samanea saman*	Non Native	Semi-deciduous
Mango/ T14	*Magnifera indica*	Native	Evergreen

UV Measurement: Pedestrain UV level and illumination levels are measured at each grid points using UV-340 meter and luxmeter (MS6610) respectively. UV measurement under open sky conditions are taken at the sport ground of the University. To observe the sun protection factor, UV levels are monitored beneath the trees at two locations- surrounding the trunk and at least 5m inside the tree shadow. Readings are generally recorded from 10:00 hrs to 14:00 hrs during winter and summer months on locally clear days from the year 2009 to 2012.

Population load: All major roads within the campus have heavy human traffic from 10.00 hrs to 14.00 hrs (IST). Students, staffs of the University and others are usually used roads R1, R2, R3 and R4.The populations are counted during the above mentioned time. Population of trees and shrubs on both sides of the major roads are also noted.

Sky view: Sky views are taken at each grid points on the roads. Sample sky views on the roads under different percentage of tree cover are shown in Figure 3. Sky views are also recorded

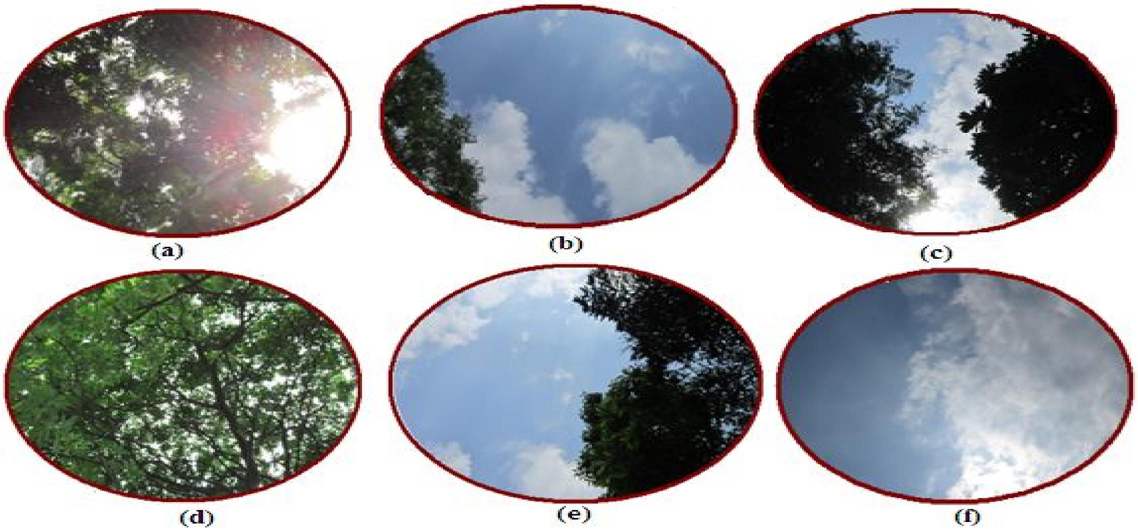

Fig 3. Sky view from the roads (a) partially covered by the branches from both side of the road, (b) Tree shade from left side, (c) trees are present on both side of the road, (d) fully covered, (e) right side covered and (f) no tree shade on the road

beneath of each tree species at two locations *viz.* near the trunk and 5m inside the shadow boundary.The relative irradiance are compared under the trees for different species. The experiments are performed on clear days (cloud amount ≤ 2 okta) from 11:00 hours to 15:00 hours (IST).

3. Data Analysis

Figure 4 represents the variations of UV pedestrian level at each grid points on roads R1, R2, R3 and R4. Illumination levels are also plotted in the same graph. The degree of UV level on the road mainly depends on the fractions of tree cover. Sky view at each grid points is analyzed to assess the obstruction of the direct sun by tree cover. Tree covers are classified according to their fraction of obstruction of direct sun into four categories — (I) below 25%, (II) 25% - 50%, (III) 50% - 75% and (IV) 75% - 100%.

The average UV level under different conditions of obstruction is depicted in Figure 5. It is clear from the graph that UV level beneath the tree depends on the amount of tree cover beside the roads. Summary of the features of major roads on University Campus is depicted in Table 3.

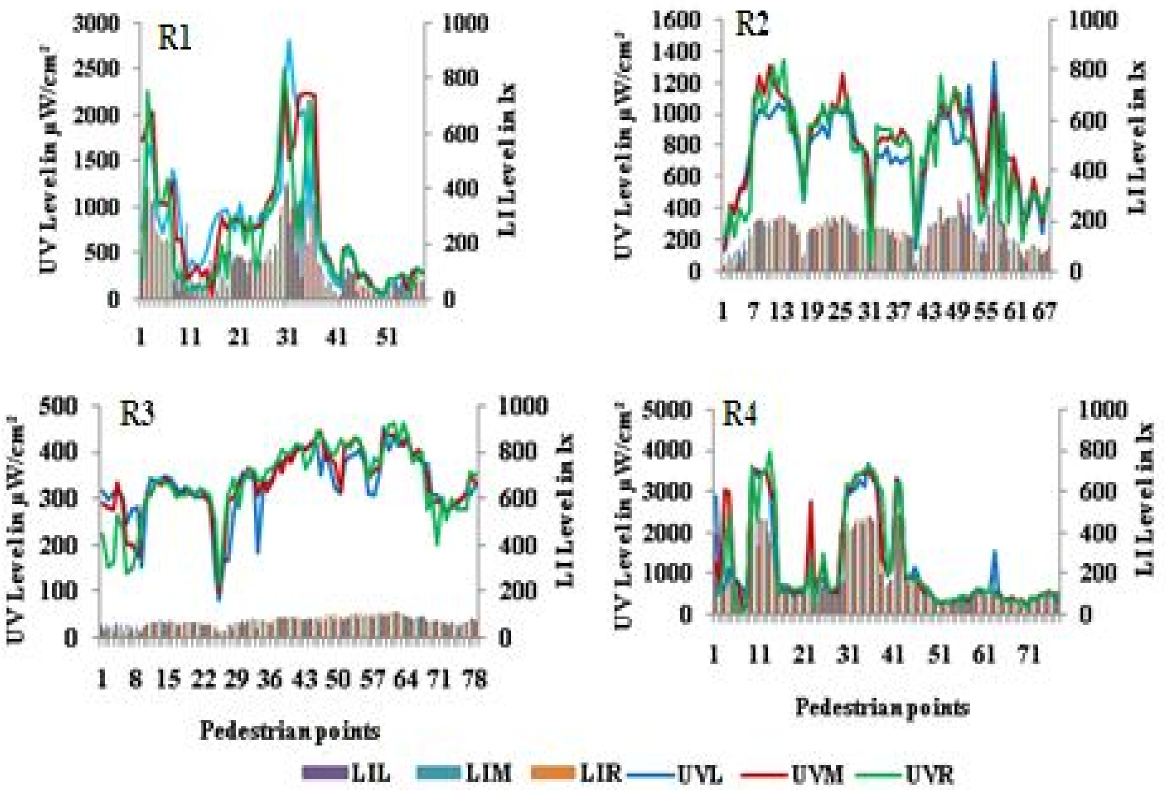

Fig 4. Pedestrian UV level at differ points on the roads R1, R2, R3 and R4

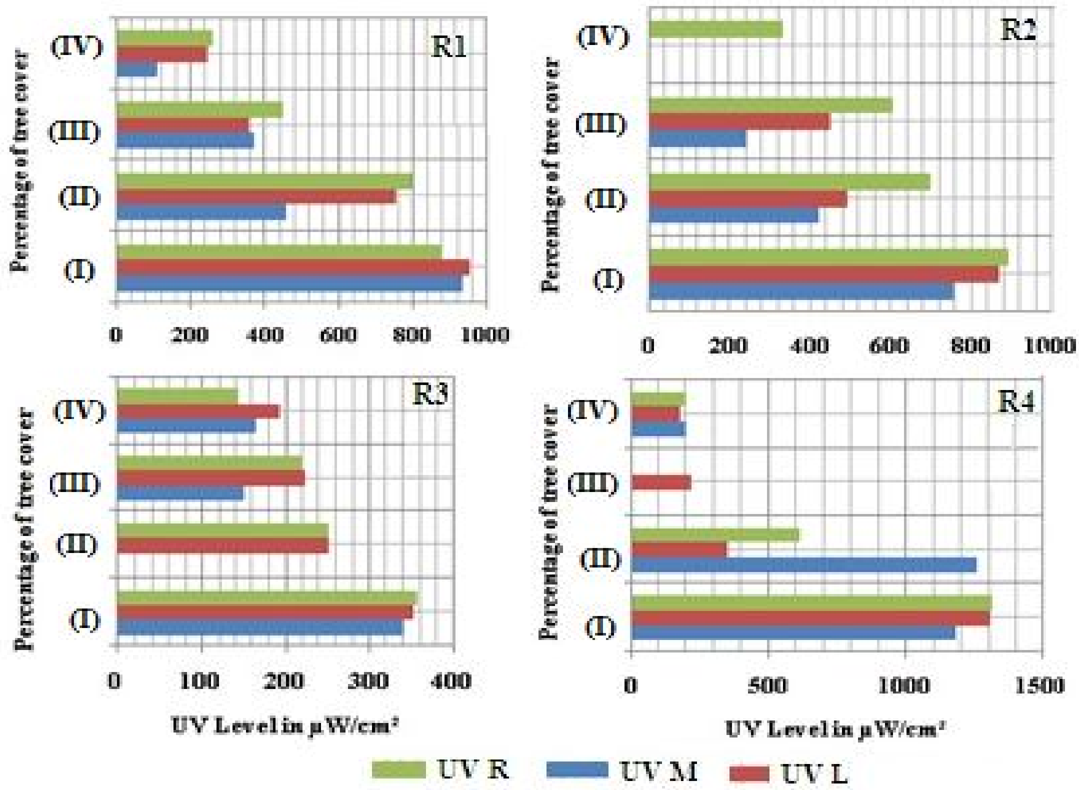

Fig 5. Average pedestrian UV level on the roads R1, R2, R3 and R4 at different tree cover obstruction

However no clear pattern of degree of UV protection factor is obtained because of the different physio-optical properties of the trees beside the roads. From critical analysis of UV load beneath the tree species, it is observed that the shade ratio UV $_{shade}$ /UV $_{open}$ at extreme inside (trunk) is

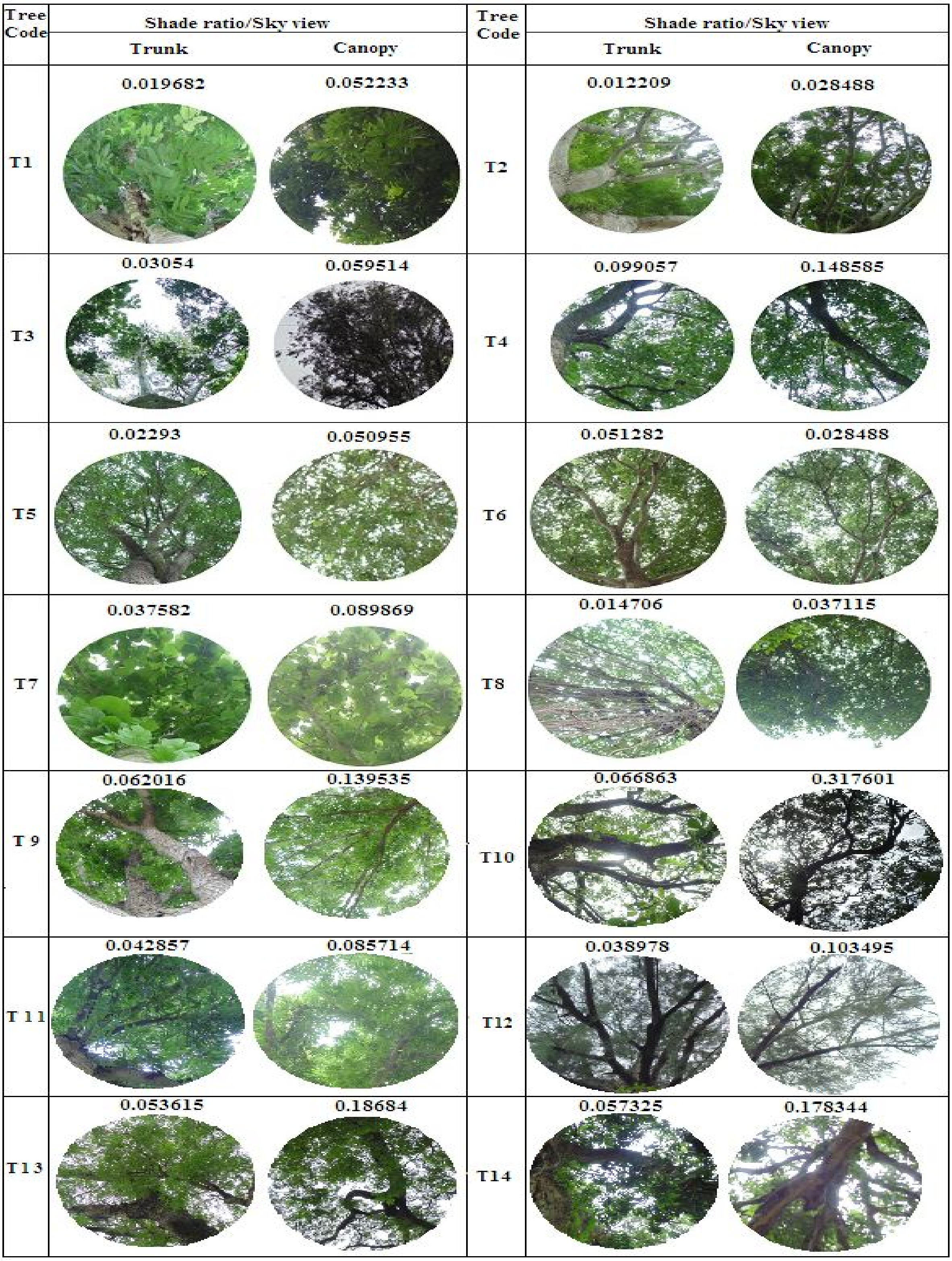

Fig 6. Sky views and Shade ratio under different tree species

different from other points as indicated in Figure 6. Shade ratio is found to vary from 0.019% to 0.317%.

Table 3 Mean pedestrians on major roads

Features		R1	R2	R3	R4
Directions of Reading		W>E	SW>NE	NE>SW	SW>NE
Average UV load(µw/cm^2)	RH	609.02	549.71	222.92	672
	LH	831.53	357.22	302.11	1587.72
Average UV under open sky (µw/cm^2)		730.56	837.945	348.805	1153.74
Total no. of trees		254	46	51	58
Average distance of trees from the road (m)	RH	3.81	3.71	3.33	6.5
	LH	5.35	4.89	3.94	5.36
Average human traffic (10 am to 2 pm)		2308	1676	1413	1418

4. Conclusions

The shade under built area or tree canopies is one of the best ways to minimize UV exposure of

anyone. *SSSW (**S**lip on a shirt, **S**lop on sunscreen, **S**lap on a hat and Wrap on sunglasses)* is the catch phrase to remember [37, 38]. UV rays reach the ground throughout the year, even on cloudy or hazy days, but the intensity of UV rays depend on the time of year and other environmental factors. Sunscreen products that contain avobenzone, ecamsule, zinc oxide, or titanium dioxide can provide some protection from UVB and most UVA rays. The sun screen lotion or cream having SPF number 15+ to 100+ indicates protection against UVB rays varying from 93% to 99%. However hypoallergenic or dermatologist test should be done for at least three successive days by the user before use the product. A shade cap with about 18 cm of fabric draping down the sides and back will provide more protection for the neck and ear where skin cancers are commonly developed. UV-blocking sunglasses are important for protecting the eyes. Moreover skin makes vitamin D naturally from the incoming solar radiation depending on the age, skin type and time of exposure in the sun. Vitamin D has many beneficial impacts on health even lower the risk for some cancers. So a lot of research is going on to quantify the optimal level of Sun exposure.

However protection from UV exposure on road or field can be made by using tree cover. Depending on the obstruction of direct sun, pedestrian UV level varies from 48µw/cm^2 to 1300 µw/cm^2 within the University Campus. The results are in agreement with previous works on UV protection provided by trees [39]. Shade ratio under trees depends on tree species. It was reported that protection factor is less than 2 for 50% tree cover [40]. In our study we have found that UV level has decreased by a factor of 0.38 to 0.50 when tree cover is increased from 50% to 75%. Increasing tree density along the roads will compensate the pedestrian UV level. The shade ratio is found minimum for Chatim (*Alstonia scholaris*) and maximum for Radhachura (*Peltophorum pterocarpum*). Therefore Radhachura can give best protection from ultraviolet radiation among the fourteen tree species selected randomly from the ground of university.

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