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Influence of Weather, Time and Pollution Level on Amount of Particulate Matter Placed on the Leaves of *Nerium oleander* and *Ligustrum lucidum* Grown along the Roadsides of Quetta City

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Abstract

The PM accumulation process by plants is quite energetic, and even after one day, fluctuations in PM load on foliage can be significant. Rain and, to a lesser extent, wind influenced PM deposition on leaves, with the latter being more species-specific. This research explored the temporal and spatial variations in the concentrations of Particulate Matter (PM) collected on two evergreen plant species (*Nerium oleander* and *Ligustrum lucidum)* leaves commonly grown along with the roadside Quetta city Balochistan, Pakistan. The impact of wind and rain on the quantity of PM collected on vegetation was investigated. The PM ($g{\cdot}m^{-2}$) concentrations held by *N. oleander* and *L. lucidum* leaves considerably varied among the places (from 7.70 - 10.7 & 6.24 - 9.53) with significant variation and over time (from 5.94 - 18.0 & 5.32 - 16.5). The highest PM concentrations on the foliage of N. oleander and L. lucidum growing at the most contaminated site, Saryab road, were determined. The largest and lowest levels of accumulation PM followed in August and January, respectively, throughout the year. Rainfall events eliminated a significant percentage of the accumulated PM on leaves (30%, 42% and 55% of PM from leaves of *N. oleander* and 40, 62 and 95% from *L. lucidum* leaves) and strong winds (20%. 35% and 47% of PM *N. oleander* and 25%, 45% and 71% from *L. lucidum*), It's also possible that heavier precipitation or a higher maximum wind speed will help to eliminate more PM from the leaves. Rainfall primarily cleared coarse and large particles, but small fragments clung to the foliage more tenaciously. These findings suggested that when assessing total PM accumulation on leaves, the influence of regional weather circumstances (such as strong wind or rainfall), altered seasons, and levels of pollution should be judged.

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Introduction

Unlike many other pollutants, particulate matter (PM) cannot be defined by the fluctuations in mass concentrations of a particular chemical over time and space. PM movement and its environmental and health impacts are influenced by a number of important elements. The fine fraction has gotten the most attention since it has an impact on health, visibility, and radiative forcing. Long-distance migration of fine particulate matter can have global, regional, and local consequences. Air pollution is becoming a greater hazard to the environment, animals, plants, and human health in metropolitan areas (EEA, 2015; Leghari, 2019). PM, which is made up of liquid and solid organic and inorganic particles, is the most dangerous pollutants among all taken from the inhalation route (Bell *et al.,* 2011; Kim *et al.,* 2015). There are both human-made and natural sources of it (Juda-Rezler *et al.,* 2011). Particles having an aerodynamic diameter ranging from 0.001 to 100 m have different ecological effects and lifespan (Farmer, 2002). Chronic PM exposure can start with a variety of health issues (Kim *et al.,* 2015). Because organisms are subjected to an extensive array of uncontrollable variables such as parasites, climate factors, and a complex pollutant mixture, estimating the impact of air pollutants is difficult (Leghari *et al.,* 2018a). Air pollution in cities has become a major environmental issue in the last several decades, particularly in developing countries and their main cities (Leghari and Zaidi, 2013). Since the last few decades, it has been noted that as the human population grows, so does industry and the number of automobiles. These automobiles and industries emitted a range of air pollutants, which might lead to environmental degradation, the destruction of all forms of roadside crops, and a reduction in tree lifespan. Depending on the pollutant and the species' tolerance, the nature of adverse effects can vary to some extent (Mughal *et al.,* 2018).

The increased usage of vehicles in urban areas has contributed to rising levels of air pollutants in recent years. PM pollution is one of the environmental challenges. (Kardel *et al.,* 2010; Saebo *et al.,* 2012). Polycyclic aromatic hydrocarbons, black carbon, heavy metals, and other compounds are found in atmospheric PM, which is primarily anthropogenic in origin (such as industrial and building activity, residential heating, and road traffic) (Saebo *et al.,* 2012). Further that there are potential dangers to condition, vegetation, and wellbeing from the inappropriate treatment of strong squander. In numerous urban regions, the private strong waste transfer practices comprise of open-consuming utilizing barrels or other comparative gadgets rather than, or notwithstanding, transfer to civil landfills or metropolitan strong waste combustors. The inspirations for families that open-consume their trash may incorporate comfort, propensity, or landfill and cost evasion. Emanations from consuming strong private waste are discharged at ground level bringing about diminished weakening by scattering (Leghari *et al.,* 2015). Furthermore, the expanding technologies and human population are causing one of the most serious problems we face today, namely, air pollution. A key role is played by pollen grains in plant fertility and proper insemination. A plant's fertility declines in severe air pollution circumstances due to direct and indirect impacts on the propagative system (Leghari *et al.,* 2018b). Momentum administrative and examine activities, including PM, are propelled by its impacts on human wellbeing (like a malignant growth, coronary illness, cardiovascular infection, eye aggravation, respiratory ailment, and asthma) Pope III *et al.,* (2004), on deceivability, and on the capacity of oversaw and normal biological systems (Grantz *et al.,* 2003). As a result, one of the essential protection responsibilities at the moment is to reduce PM concentrations in the ambient air. In addition to minimizing PM sources, phytoremediation is considered an additional and useful strategy for reducing air pollution by filtering and absorbing some PM through forest crowns and leaves (Kardel *et al.,* 2010; Escobedo *et al.,* 2011; Saebo *et al.,* 2012; Nowak *et al.,* 2013; Popek *et al.,* 2013). Numerous different investigations have been directed in various zones of the world. For example, in the United States, urban vegetation might expel around 21.49x104 t of PM every year (Nowak *et al.,* 2006).

To improve air quality in extremely polluted places, Plants have a high potential to absorb PM in the air. This research was conducted in Quetta's urban areas, which are located in a semi-arid climate and have seen considerable development. *N. oleander* and *L. lucidum,* a joint perennial plant species, are nominated as the examination material for the reason of their occurrence in metropolitan regions in the study zone. So these species were chosen to detect variations in PM deposited on leaves over a year in various urban settings, as well as to explore the impact of weather (rain and wind) and time on PM clearance from leaves.

Materials and methods

Study region

Presenting research was performed in Quetta city, which is a historic city and capital of Balochistan province Pakistan. Where more than 3 million afghan refugees are staled from last three decades. Moreover, 5 million people live in the city, and the city's traffic is heavy. In addition to that, it is the main root for the Afghan trades and UNTO supply in Afghanistan.

This area has a semi-arid climate. The city has more traffic than its capacity is considered one of the most polluted cities in Pakistan. As a result, it was chosen as a sampling location. During the study period, climatological data from Quetta's climatological station were downloaded from the Quetta metrological sharing service system (Quetta Meteorological Data Sharing Service System). During the study period and last five-year average, the daily precipitation, wind speed, the daily mean temperature and daily mean relative humidity were noted.

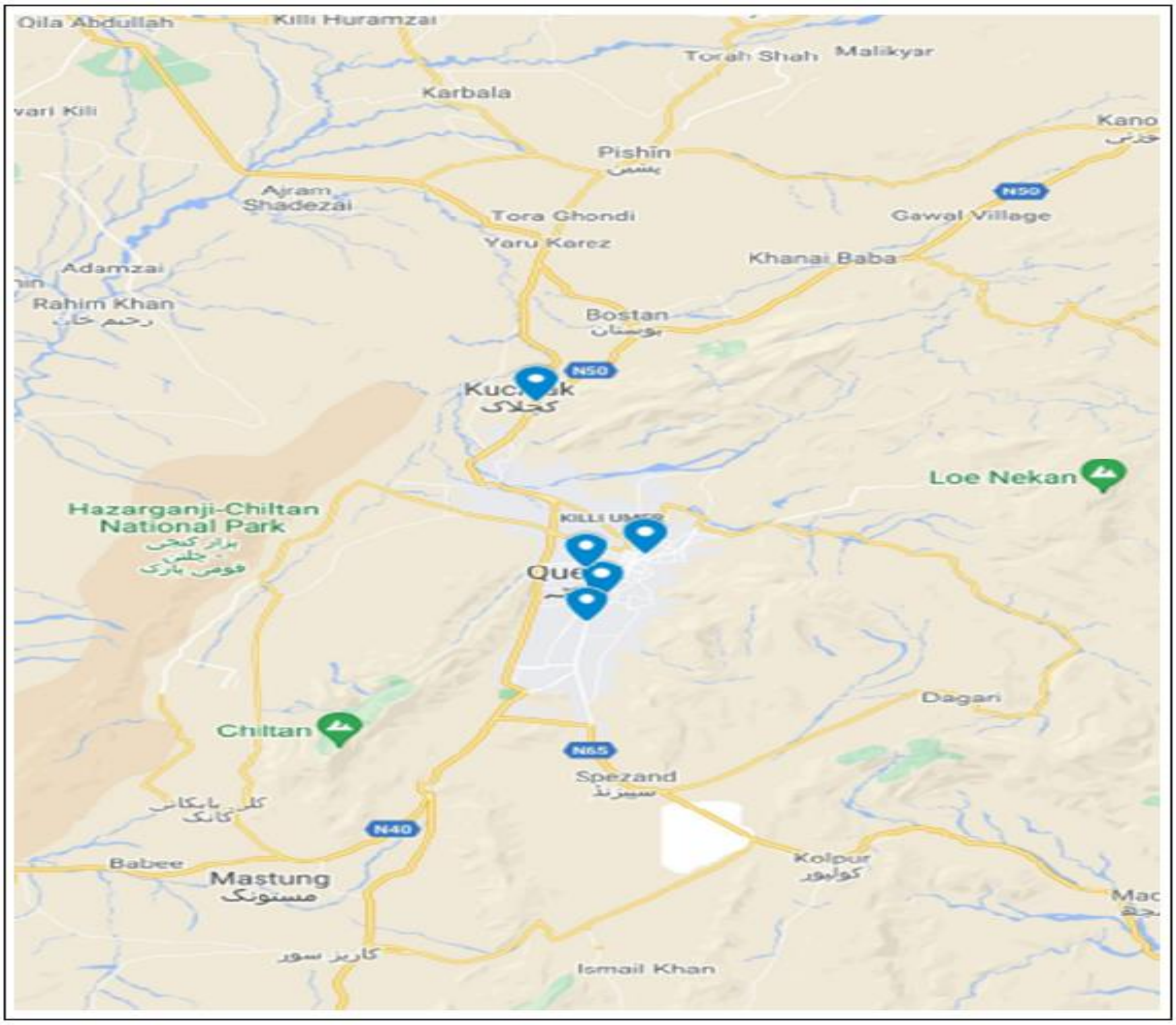

Fig. 1. Googol map of study sites.

Plant Material and sampling procedures

To see how effective different evergreen plant species are at capturing PM during various seasons, weather, time, and pollution levels. Two evergreen plant species *N. oleander* and *L. lucidum* were designated as the exam material (Fig.2). These plant species were commonly cultivated along with the roadsides of (study area) Quetta city. Both plants had been growing for several years in the chosen areas and were in good shape. Five sampling points were placed at random along the sampling path for each species. As test material, leaves from the canopy's uppermost layers that immediately confronted the road were taken from each sampling location. At each sampling station, the sampling height was between 1.5 and 2 meters above the ground. From March 2020 to February 2021, samples were obtained once a month, and these were taken five days after a continuous rainfall with cumulative precipitation of 15 mm of rain. This procedure was carried out since the majority of particles (around 70%) on the surface of the leaf of the outmost canopy had been fully washed away (Wang *et al.,* 2015a; Xu *et al.,* 2017a). All of the plants in the sample were in similar stages of development, and all of the leaves were healthy and free of disease or pests. Leaves were harvested through the pinching of the petioles, and disposable gloves were utilized to prevent further contamination. As a final step, all of the samples were placed into a valve bag and preserved in a clean laboratory refrigerator at 8 °C for future laboratory investigation according to the technique used by He *et al.* (2019). To explore the impact of pollution levels on leaf PM accumulation, five sampling locations were chosen (sampling 1). Among them, one was the university's Quetta campus, where traffic intensity was lower than at the other four sites (Jinnah Road, Saryab Road, Kuchlack Road and Sabzal Road), where plants flourished on the roadside. Pollution levels are directly proportional to traffic density, as some studies have demonstrated (Pal, *et al.,* 2002; Prusty *et al.,* 2005) and diverse human activities were associated with different land-use categories (Shao, *et al.,* 2008). In this study, the pollution level was determined by combining the traffic density with the surrounding environmental factors. On each sampling day, the density of traffic at each site was measured during 7:00–9:00 a.m., 11:30–14:00 p.m., and 17:00–19:00 p.m.

Weather and Time Effects on PM Kept by Leaves

There were three samples taken from the Campus University of Balochistan to determine the impact of time (sampling 2) and weather (sampling 3) on the PM's accumulation on leaves. Saryab Road is a busy road in the city's center, and as a result, the plants were exposed to a lot of dust from urban roads, exhaust from motor vehicles and sources of natural dust.

Sampling of Leaf

Nerium oleander and *L. lucidum* were sampled from April 1 to 6, 2020. From March 2020 to February 2021, leaves were collected on a monthly basis for sampling 2. After 6 and 12 consecutive days of clear skies, precipitation events of 10mm, 20mm, and 30mm, and under windy weather (with maximum speeds of wind as 10 ms1, 15 ms1, and 20 ms1), leaves were collected for sampling 3. On every selected sampling day and from each site, five plants of the same species were sampled. There were no evident pests or diseases on any of the plants that were sampled, and they were all of the same age. The leaves were harvested when they were fully blown and turgid. In order to gather them with a pruner, at the height of 1–2m above the earth, they were eliminated from the internal and external canopy of E, S, W, and N-facing trees. At each sampling day and from every sampling site, a total of 30–50 leaf pieces were taken from each plant and subsequently bulked to give 150–250 leaf pieces. As well as throughout transportation, all collected leaves samples were stored in a cold container in the laboratory until they were analyzed. Wang *et al.* employed the same methods to gather leaf samples in samples 2 and 3 (2015c).

Quantitative Assessment of PM Kept on Leaves

Agreeing to Prusty *et al.* (2005), it comprised of three sets of 15–20 leaves in each of the three samples.

Firstly, 250mL of distilled water was poured over the plant material. Using a no-hair-loss brush, each leaf was tweezed into place and the PM on the leaf's surface was wiped away.

The leaves were then rinsed with 5ml of distilled water. Water-soluble particles are minimized by completing the treatment in less than 10 minutes. After scanning, the total leaf area (A, m2) on the hemi surface (one side) was calculated utilizing Image J software (1.46 Version) (HP Scanjet G2410, Japan). Filtration was carried out using a 0.45-micron membrane in our filtration stage (H.C.S.J Filtering Equipment Ltd, China). Following 24-hour drying at 400C, the filter membranes were weighed (W1, g) using a scale with a precision of 0.1 mg (Shanghai Precision Instruments FA2004, China) positioned in a balanced room. Several seconds were spent shaking the washing solution by hand to re-suspend all of the washed particles before filtering. A vacuum pump and 47mm glass filter funnel (Millipore Corp., Bedford, MA, USA) were used for the filtration process (SHB-III; China). Particles in the solution having a diameter of 0.45m and water-soluble particles were eliminated from this investigation. Afterward, they were dried in an oven at 60°C for 30 minutes to create a constant weight, stabilized for 30 minutes in a balance chamber, and weighed again. The given formula was applied to compute the quantity of PM retained on leaves (in grams per square meter). $W = (W1 - W2)/A$

Statistical analysis

With the help of SPSS ver. 19.0 software, statistical evaluations were carried out. Using analyses of variance, it was examined if there were significant changes in the proportion of leaf-deposited PM between sampling locations and sampling times. An honest significant difference (HSD) test for Tukey was conducted when the analysis of variance revealed significant differences between sample locations and sampling times. ANOVA and Tukey's HSD were also used to determine the differences in PM amounts among different weather situations. At p0.05, an effect was considered significant.

Results

Effect of pollution level on PM retained leaves

After a walkthrough survey of the study area, 5 different study sites (Fig. 1) were selected for sampling to explore the impacts of pollution levels on the accumulation of leaf PM where both plants grow on the roadside (Sampling 1). These sites were Campus University of Balochistan Quetta, Jinha road, Saryab road, Kuchlack road and Sabzal road.

Table 1. The traffic density and environmental features in areas around sampling locations.

Study sites	Traffic density/(h^{-1})	Surrounding environmental conditions
Campus University of Balochistan Quetta	102 ±18	Less traffic, traffic movement slow, smoke and dust were less, thick plantation on both sides of the Road, Road was neat and clean, and the environment was good. Well greenery environment around, no evident pollution resources
Jinha road	1200 ±68	Heavy traffic density, mostly 4 & 3-wheeled vehicles (cars and rickshaws), traffic moment, was slow. Main Road of the city, mostly banks, office, shopping plaza are there, nearby was smoky but less dusty
Saryab road	2300 ±410	Tremendous traffic density, mixed traffic mostly 4, 3 and 2 wheelers vehicles (cars, buses, rickshaws, and bicycles), a speedy moment of traffic, large flow of people, building construction material, university and different colleges were located, the environment was smoky and dusty.
Kuchlack road	2500 ±105	Tremendous traffic density, mostly 16, 10, 4-wheeled vehicles, traffic moment, was high, car showrooms, workshops, many hotels were along the Road, Road also led to the Afghan border (Chamen), the road also lead to the other province of Pakistan, Punjab and KPK. Environment was smoky
Sabzal road	1800 ±100	Heavy traffic density, mostly traffic was 4, 3 & 2-wheeled vehicles (cars, buses, rickshaws, and bicycles), kabaries woks hopes/storage on both side of the road, most shops and building were made up of muddy material (Kachi), large flow of people, the environment was heavy smoky and very much dusty. Excessive rubbish accumulates in the area; waste incineration may be necessary for some instances—very less plantation along the roadsides.

In this experiment, the pollution level was determined by integrating the traffic density with the ambient conditions (Pal *et al.,* 2002; Prusty *et al.,* 2005; Shao *et al.,* 2008). The traffic thickness at each site was observed at 7:00–9:00, 11:30–14:00, and 17:00–19:00 on each testing day (Wang *et al.,* 2015). Table 1 shows the density of traffic and environmental features of the sampling sites.

Table 2. Average weather conditions in the study area during different seasons of the study year.

Seasons	Precipitation (mm)	Temperature (◦C)	RH (%)	Wind Speed ($m{\cdot}s^{-1}$)	Wind Direction (◦)
Spring	25 – 30	23 – 25	33 – 35	5.1 – 16.4	NW/SE
Summer	11 – 17	30 – 37	22 – 28	5.2 – 17.6	SE
Autumn	28 – 33	21 – 30	37 – 41	4.4 – 12.7	NW
Winter	32 – 36	2 – -16	40 – 43	6.5 – 18.8	NW

Weather conditions in the study area during different seasons of the study year

During spring, summer, autumn, and winter, the seasonal average rainfall fluctuated between 25-30mm, 11-17mm, 28-33mm, and 32-36mm, respectively. The temperature and relative humidity were 23 – 25 & 33 – 35, 30 – 37 & 22 – 28, 21 – 30 & 27 – 41 in spring, summer, autumn and winter season respectively. The maximum wind speed was noted from 6.5 – 18.8$m{\cdot}s^{-1}$ during winter and the minimum was found 4.4 – 12.7 in autumn (Table 2).

The annual average Precipitation, Temperature, RH and Wind Speed during the study period was reported 27.25 mm, 21.58 ◦C, 34.83% and 10.75 $m{\cdot}s^{-1}$ respectively (Fig. 3).

Table 3. Five sampling sites with various levels of pollution were sampled for PM deposition on leaves of *Nerium oleander* and *Ligustrum lucidum* (mean ± SD).

Sampling Sites	Amount of Particulate matter retention ($g{\cdot}m^{-2}$)		Significant Level
	Nerium oleander	*Ligustrum Iucidum*	
Campus UoB, Quetta	7.70 ±0.02	6.24 ±0.02	*
Jinha road	9.10 ±0.04	7.81 ±0.01	*
Saryab road	10.7 ±0.04	9.53 ±0.04	*
Kuchlack road	9.64 ±0.03	8.22 ±0.05	*
Sabzal road	10.0 ±0.01	8.50 ±0.04	*

Leaf PM Retention Quantities at Various Sampling Locations

The levels of PM retained on the leaves of *N. oleander* and *L. lucidum* differed significantly between sampling sites (Table 3). The volume of deposited PM on leaves of N. oleander ranged from 7.70 gm^2 (sample location Campus UoB, Quetta, an urban green area) to 10.7 gm^2 (sampling site Saryab road, a polluted urban region) across all of the tested sites. On *L lucidum* leaves, it was from 6.24 – 9.53 $g{\cdot}m^{-2}$ with significant variation between two plants (Table 3). The average PM retention amount ($g{\cdot}m^{-2}$) on *L. lucidum* and *N. oleander* leaves at all 5 locations of the study was found 9.4 and 8.0 $g{\cdot}m^{-2}$, respectively (Fig. 4).

Variation in Leaf PM Retention Amounts during the Seasons

Throughout the year, *N. oleander* and *L. lucidum* leaves accumulated different amounts of PM (Table 4). From March 2020 to February 2021, the concentration of accumulated PM on leaves varied from 5.94 to 18.0 $g{\cdot}m^{-2}$ on *N. oleander* leave and 5.32 – 16.5 $g{\cdot}m^{-2}$ on *L. lucidum* leave. The PM concentration kept on leaves was maximum in August and lowest in January on both investigated plants, with the lowest and highest precipitation (Table 4). Among plant species, the highest amount was noted on the leaves of *N. oleander* and the lowest on *L. lucidum*. Results presented in Fig. 5 indicated that during October, November, December, January, and

February the rainfall increased and the PM retention amount (g·m⁻²) on both plants decreased accordingly.

Precipitation and wind effects on leaf PM retention

During heavy rains, *N. oleander* and *L. lucidum* leaves were stripped of considerable amounts of particulate matter (PM). Totally, 30%, 42% and 55% of amassed PM were cleaned off from *N. oleander* leaves with 10mm, 20mm and 30mm precipitation, while from *L. lucidum* leave PM removing %age was 40, 62 and 95%, respectively. Wind at speeds with $10 m \cdot s^{-1}$, $15\ m \cdot s^{-1}$ and $20\ m \cdot s^{-1}$ could puff off the deposited PM on the *N. oleander* leaves by 20%. 35% and 47%, while from *L. lucidum* leaves blow off the PM was 25%, 45% and 71% (Fig. 6).

Table 4. *N. oleander* and *L. lucidum* leaves were used to compare the temporal fluctuations of monthly precipitation totals (mm) and mean leaf buildup of PM amounts (gm^2, data is mean ± SD).

Months	PM retention amount ($g \cdot m^{-2}$)		Precipitation
	Nerium Oleander	*Ligustrum Iucidum*	
March	10.2 ±0.2	8.33 ±0.3	10.5 ±0.10
April	12.3 ±0.2	9.42 ±0.1	0.00 ±0.00
May	13.4 ±0.4	12.5 ±0.2	0.00 ±0.00
June	15.3 ±0.1	14.2 ±0.4	5.42 ±0.02
July	17.4 ±0.3	15.8 ±0.6	0.00 ±0.00
August	18.0 ±0.2	16.5 ±0.5	0.00 ±0.00
September	17.0 ±0.3	15.3 ±0.2	0.00 ±0.00
October	14.8 ±0.3	14.3 ±0.7	7.72 ±0.20
November	13.9 ±0.7	12.7 ±0.9	40.5 ±2.41
December	9.53 ±0.5	8.21 ±0.4	41.0 ±3.45
January	5.94 ±0.6	5.32 ±0.3	75.2 ±2.47
February	7.61 ±0.3	7.14 ±0.2	72.1 ±4.34

Discussion

More PM was observed on the plant's foliage that was cultivated in a more polluted area. Air PM concentration has been established as a significant determinant in the development of leaf-level PM deposition (Prusty *et al.,* 2005; Tallis *et al.,* 2011; Saebo *et al.,* 2012; Nowak *et al.,* 2013; Przybysz *et al.,* 2014). Przybysz *et al.* (2015) showed that three evergreen species, *Pinus sylvestris*, *Hedera helix*, and *Taxus baccata* deposited greater PM on their leaves at a moderately contaminated site than at less polluted sample sites.

Fig. 2. Plant species under-investigated.

The concentration of leaf-deposited PM in Poland was larger than in Norway, according to Sb *et al.* (2012), which is consistent with Poland's higher air pollution levels. A study of leaf-deposited PM near a national highway in Sambalpur, India and Pakistan indicated that the ratio of leaf-deposited PM increased as the number of vehicles on the highway increased (Prusty *et al.,* 2005; Leghari and Zaidi, 2013). Micro-environmental and microclimatic factors influence leaf attributes, such as stomatal properties, and generate an individual variation. During the growing season, we detected changes in retention of PM on N. oleander and *L. lucidum* leaves. As reported in earlier studies, in months with less precipitation, the readings were higher (e.g., August) while lower values were recorded in February (Matzka and Maher, 1999; Prusty *et al.,* 2005; Rodrıguez-Germade *et al.,* 2014; Przybysz *et al.,* 2014).

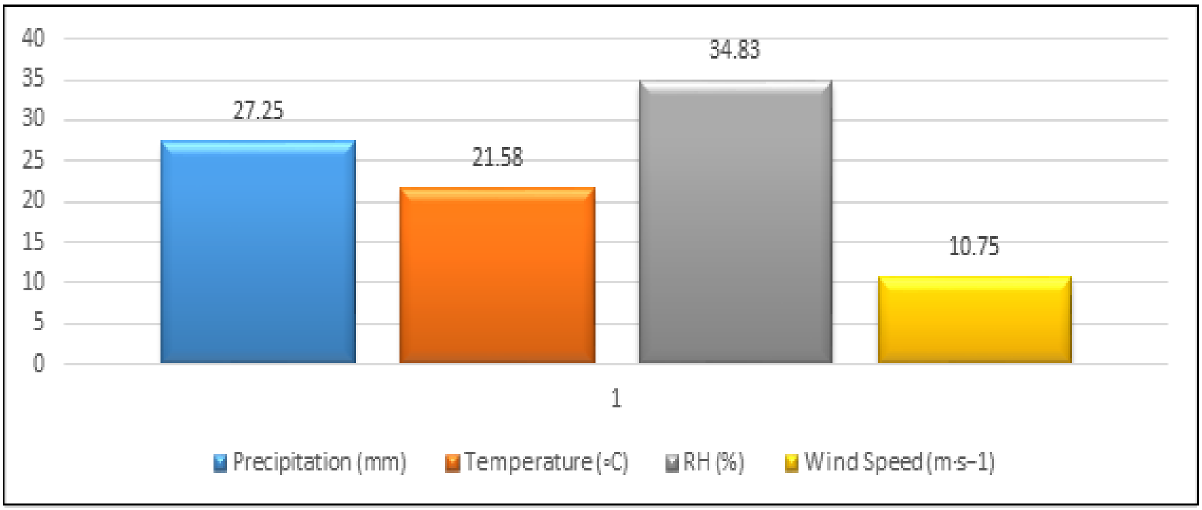

Fig. 3. Annual average weather conditions in the study area during different seasons of the study year 2020-21.

In addition to the varying frequency and severity of rainfall events, this could also be due to the inconsistent PM emissions into the atmosphere over the course of the experimentation period. In the rainy season, Prajapati and Tripathi, (2008) observed that less PM was collected than in the summer and winter, which they linked to the washing effect of precipitation. Leaf surfaces that are wet during lighter rainfall events could assist in capturing PM, while mild winds and foggy circumstances could minimize PM dispersion in the winter months (Prajapati and Tripathi, 2008).

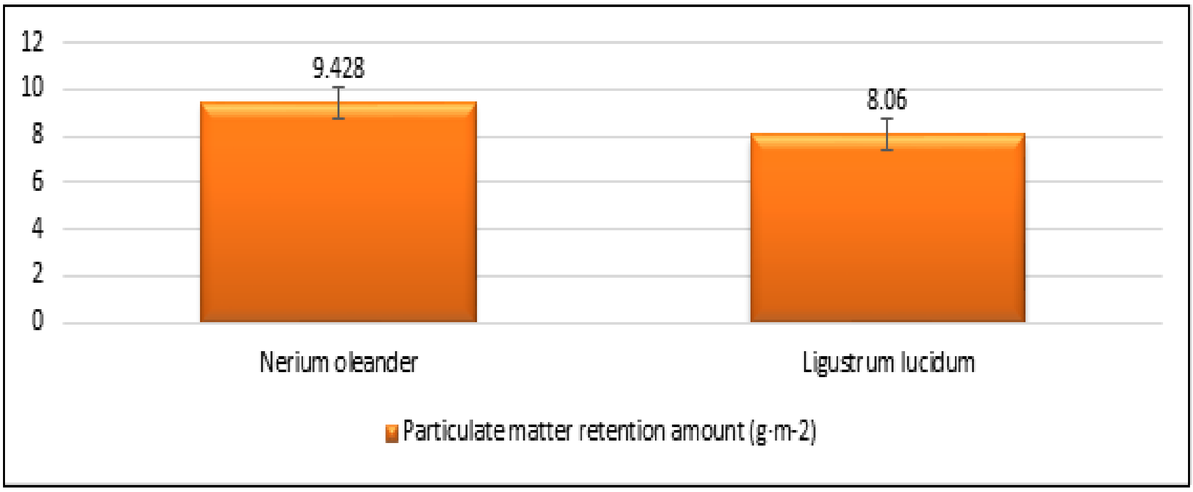

Fig. 4. The average amount of PM retention (g·m-^{2}) at all 5 locations of study on leaves of *N. oleander* and *L. lucidum.*

Summer and rainy days had lower ambient PM concentrations, while winter had greater concentrations (Xian Environmental Protection Bureau, 2010). There may be greater deposition and more PM on leaves in the winter because of the higher concentrations of PM in the sky. Przybysz *et al.* (2014), Rodrguez-Germade and colleagues (2014), and Wang *et al.* (2006) describe the process through which PM accumulated on leaf surfaces is washed or blown off in nature by rain or wind. *L. lucidum* leaves collected under different environmental circumstances were found to have a significant amount of PM eliminated by rainfall and high winds. PM removal from leaves could increase with greater precipitation or a higher wind speed. Upon splashing/impacting with leaf surfaces, wind or raindrops possessed such high-level kinetic energy that they could dislodge a lot of particles (Neinhuis & Barthlott, 1998). According to Przybysz *et al.* (2014), simulated rainfall washed off 30–41% of the PM from *P. sylvestris* in Stavanger, Norway (20 mm). It was the large particle fraction that accounted for the largest mass proportion (33–42%), trailed by the coarse particle fraction (25–36%) and the fine particle fraction (21–30%), in that order, respectively. *Platanus hispanica* leaves were washed off by rainfall in research done in Madrid, Spain (Rodrguez-Germade *et al.,* 2014). About half of the PM in another sample was washed away by rainfall (14.5 mm) (Wang *et al.,* 2006).

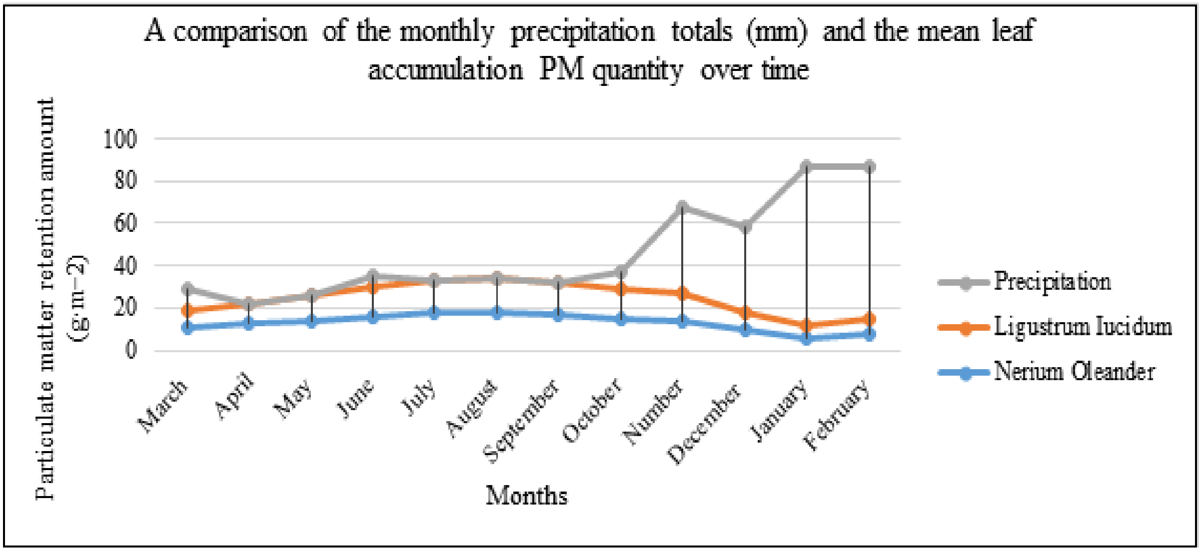

Fig. 5. Monthly precipitation totals (mm) and mean leaf buildup of PM quantity (gm2, data are mean) by leaves of *N. oleander* vs. *L. lucidum* are compared throughout time.

As a result of this data, Freer-Smith and colleagues (2005) concluded there was no significant difference between the levels of rough and fine PM on foliage before and after precipitation. The leaves of *Euonymus japonicus* could not be cleaned by simulated rainfall because the particles had a diameter of fewer than 5 micrometers and even less than 1 micrometer (Wang and Li, 2006).

The wind's ability to resuspension PM should also be considered while analyzing PM accumulation. 5ms1 of wind can re-suspend a small amount of PM, according to Ould-Dada and Baghini (2001). In Beijing, China, the proportion of leaf-deposited PM was not substantially different before and after a strong wind event (10.4ms1) (Wang *et al.,* 2006). According to Janhäll (2015), N. oleander's high PM accumulation may be due to oil-producing glands on the leaves. This confirms the theory that leaf shape and morphological characteristics, such as greater levels of pubescence and rougher surfaces, promote PM deposition on the foliage (Janhäll, 2015; Nguyen and Popek, 2015; Sb and Popek, 2017; Sb and Mo, 2012; Mo and colleagues, 2015). Oil glands and leaf hairs are examples of traits that are significant, but there is still much to be done (Leonard *et al.,* 2016).

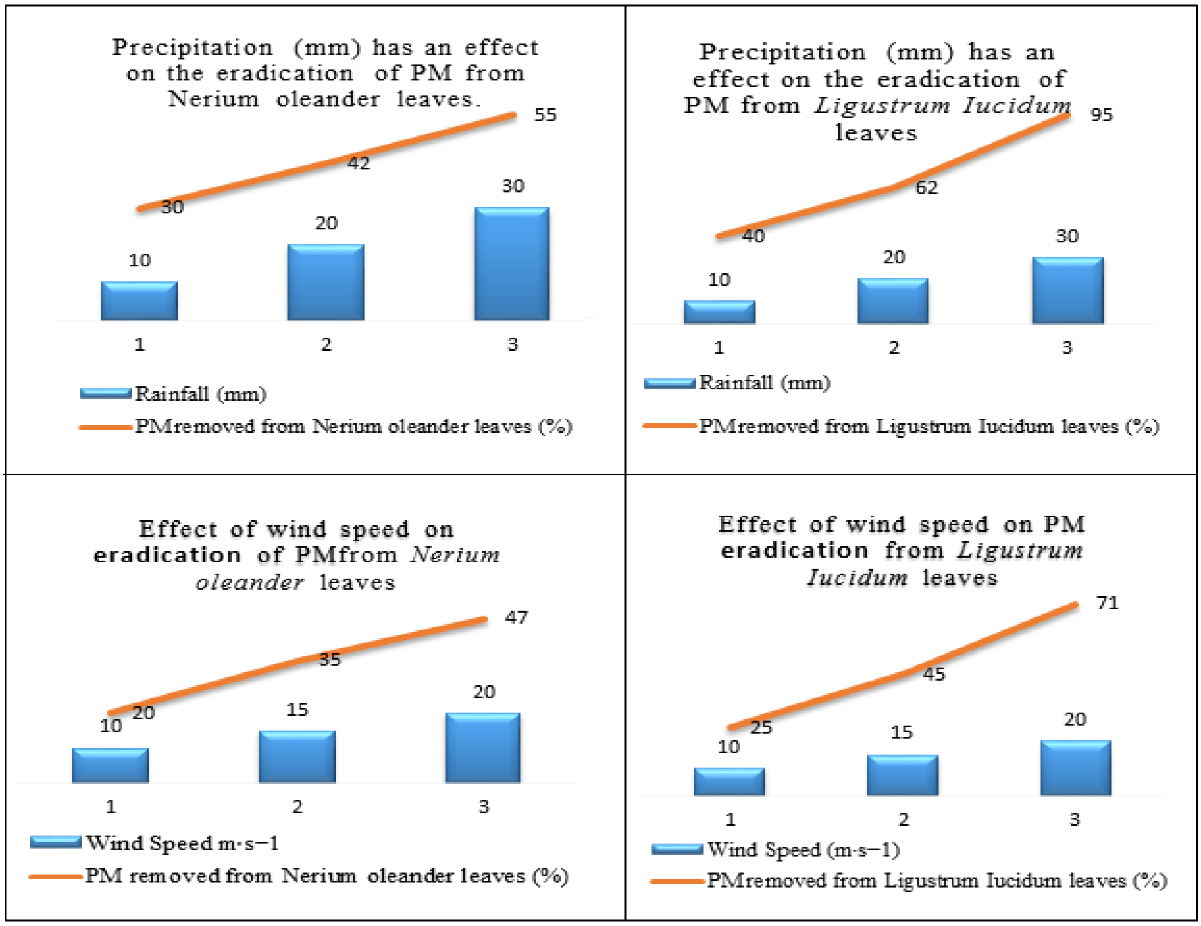

Fig. 6. Precipitation (mm) and maximum Wind Speed (ms1) had different effects on leaf PM retention levels (gm2, data are mean).

The opposite was reported by Weerakkody and colleagues (2018), who discovered no connection between features of the leaf surface and PM accumulation.

Conclusion

N. oleander and *L. lucidum* leaves were shown to retain different amounts of PM at different locations and over time. The most polluted location was planted with *N. oleander* and *L. lucidum*, which accumulate the highest quantities of PM. Most PMs were accumulated in August when rainfall was at its lowest. The least amount was accumulated in February when rainfall was highest. Leaves accumulated PM due to rain and high winds. It is estimated that rain washed away 40 percent of leaves, while the wind blew away 35 percent of them. For vegetation to have a significant effect on local air quality, it is essential to understand the regional and temporal differences in accumulation, blow-off, and wash-off. Researchers found that studying leaf-deposited particulate matter (PM) only partially explains leaves' ability to collect airborne particulate matter (PM). Retention of PMs is also affected by precipitation, which is surprising. The washing and resuspension of particulate matter (PM) on leaf surfaces should be regarded as a good activity, crucial to restoring plants' ability to collect PM and reducing phytotoxic consequences. Different pollution levels, seasons, precipitation, and wind speed should also be addressed when estimating the total PM removal capacity of plants to better understand PM deposition on leaves. When assessing the total PM removal capability of plants, different pollution levels, seasons, precipitation, and wind speed should be considered in order to better understand PM deposition on leaves. Although plants can store PM, more research is needed to determine how wind and rain affect the accumulation of leaf PM. Research has to be conducted on these themes in the future.

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