International Journal of Advanced Research in Engineering Technology & Science
ISSN: 2349-2819
Impact Factor: 7.10
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Email: editor@ijarets.org Volume-11 Issue-12 December-2024 www.ijarets.org

Assessing the impact of environmental stressor on plant diversity in urban ecosystems.

Dr. Kanupriya

Assistant Professor, Gaur Brahman Degree College

Rohtak, Haryana

Abstract

There are a number of environmental stressors that are increasingly being applied to urban ecosystems. These stressors include air pollution, habitat fragmentation, soil contamination, and climate change, all of which have a substantial influence on the variety of plant life. The purpose of this study is to investigate the ways in which these stressors affect the urban flora in terms of species richness, composition, and ecological functions. The data collected from a variety of urban green spaces, including as parks, roadside vegetation, and abandoned lots, are analysed in order to determine the primary causes that are responsible for the loss of plant diversity and the changes in the organisation of communities. Our research demonstrates that certain species are able to withstand the effects of urban pressures, while at the same time indicating that native and uncommon plant populations display weaknesses. A comprehensive understanding of these processes is essential for the development of sustainable urban planning policies that encourage the preservation of biodiversity and the health of ecosystems in cities that are experiencing fast expansion.

Introduction

Sustainable urban ecosystems are dynamic landscapes that are shaped by the interaction of natural and manmade influences, which in turn shapes patterns of biodiversity and ecological functions. The rapid urbanisation that has occurred in recent years has resulted in the fragmentation of habitats, pollution, deterioration of soil, and changes in climate, all of which are important environmental stresses experienced by plant variety. The expansion of cities results in the replacement of natural vegetation with manmade infrastructure, which in turn leads to the extinction of native species, changes in the makeup of communities, and the spread of invasive species species. The ecological balance is not the only thing that is impacted by these changes; they also have wider-reaching ramifications for ecosystem services, such as the conservation of carbon, the purification of air, and the management of climate. For the purpose of sustainable urban planning and the preservation of biodiversity, it is essential to have a solid understanding of the influence that environmental stresses have on the diversity of urban plants. It has been demonstrated in a number of studies that while certain plant species are able to adjust to the stresses imposed by urban environments, others incur a drop in population, which disrupts the ecological balance. Changing patterns of plant variety in urban contexts are caused by a number of factors, including but not limited to air pollution, soil contamination, the impacts of heat islands, and changed hydrological cycles. On the other hand, an insufficient amount of detailed study has been conducted on how these stressors jointly impact urban vegetation and what measures might be utilised to minimise the consequences of these stressors. Through the examination of species composition, resilience, and ecological function, the purpose of this study is to determine the extent to which significant environmental stressors have an effect on the variety of plant life in urban environments. We want to uncover patterns of biodiversity change and offer solutions to promote urban resilience by conducting an analysis of various urban green areas, such as parks, roadsides, and sites that have been abandoned. The findings of this research will give policymakers, urban planners, and conservationists with useful insights that will allow them to devise methods that encourage biodiversity protection in cities while also assuring ecological sustainability.

Impact of Environmental Stressors on Urban Plant Diversity

It has been established by a great number of studies that urbanisation causes changes in the structure of plant communities by increasing the fragmentation of habitats, decreasing the quality of soil, and introducing contaminants. In his study, McKinney (2006) underlined the fact that urban environments have a tendency to favour generalist and invasive species, while simultaneously contributing to the decrease of native and specialised species. Similarly, Shochat et al. (2010) highlighted the fact that increasing pollution, heat island effects, and decreased water availability all have a detrimental influence on the species richness and plant health of environmental systems.

The influence that air pollution, particularly that which comes from emissions from vehicles, has on urban flora has been the subject of a massive amount of research. There is a correlation between high levels of sulphur dioxide (SO2) and nitrogen oxides (NO2) and decreased photosynthetic efficiency and increased leaf damage in urban plants, according to research conducted by Kularatne and De Silva (2013). According to Chen et al. (2015), soil pollution, which is predominantly caused by heavy metals such as lead (Pb), cadmium (Cd), and zinc (Zn), has also been distinguished as a significant stressor that has an impact on the growth of roots and the metabolism of plants.

Urban Vegetation Adaptation to Stressors

In spite of these obstacles, there are certain plant species that are able to adapt to urban environments and demonstrate persistence. Kendal et al. (2017) conducted research that suggests that species that are able to withstand stress, such as some grasses and ruderal plants, are able to flourish in ecosystems that are disturbed. According to Williams et al.'s 2019 research on plant functional features, species that have high phenotypic plasticity, drought tolerance, and quick growth rates are more likely to thrive in urban environments. This is the conclusion that can be drawn from the findings of the research.

Interactions between plants and microbes in urban areas have been the subject of a number of research. According to Zhao et al. (2021), mycorrhizal fungi improve plant stress tolerance by increasing nutrient absorption and decreasing metal toxicity. This has been demonstrated by their presence. In addition, measures that encourage plant adaptability and biodiversity conservation have been proposed (Tzoulas et al., 2007). These initiatives include urban forests and green roofs, among other environmentally friendly infrastructure projects.

Strategies for Urban Biodiversity Conservation

The restoration of habitats, the reduction of pollution, and the creation of environmentally responsible landscapes are the focal points of conservation efforts for urban plant variety. Aronson et al. (2014) conducted research that reveals urban green spaces, when managed appropriately, have the potential to act as refuges for biodiversity. These places can provide support for native species while also lessening the effects of environmental stresses. According to Francis and Chadwick (2013), urban rewilding initiatives, which include the restoration of native plant species and the establishment of ecological corridors, have been successful in increasing the extent of urban biodiversity in places such as Singapore and Berlin. In addition, urban design initiatives that incorporate nature-based solutions, such as permeable surfaces, green walls, and enhanced tree cover, have demonstrated that they have the potential to reduce environmental stress while simultaneously supporting biodiversity (Kabisch et al., 2016). According to Peters et al.'s research from 2020, effective community engagement in urban greening programs has been recognised as a vital aspect in maintaining long-term efforts to conserve biodiversity.

Character states of species within a flora

Through the course of the last century, functional adaptations to environmental stressors (such as aridity, temperature, and overgrazing) within a taxon have consistently been a significant topic of discussion in the field of geobotany. It has been determined that the autecology of vascular plants has been unravelled (for example, Raunkiaer, 1910; Braun-Blanquet, 1951; Walter, 1951). This was done in an effort to discover universal links. This procedure had significant repercussions for the hierarchical categorisation of ecological communities as well as taxonomic groups. Both Du Rietz (1931) and Raunkiaer (1934) identified significant techniques that plants employ in order to adapt to the circumstances of their environment. As a result of the fact that density estimations are dependent on the scale of measurements, botanists began to concentrate on common characteristics that could be easily identified in the field. Within the continent of Europe, there was a fast growth in the attention paid to these functional groupings of plant species. Not only is the placement of the perennating buds in a plant, the seasonality of the leaves, and the mean plant lifetime (also known as the specimen history) extremely important in terms of competitiveness and survival in the face of natural environmental stress, but it is also likely the most important factor in determining whether or not a plant is able to successfully respond to pollutants. A comprehensive survey of morphological, anatomical, and phenological characteristics that are appropriate for a quantitative environmental risk assessment is presented in Table 1. One may deduce, based on the computed multi-substance Potentially Affected Fraction (msPAF sensu Posthuma et al., 2002) for Cd, Cu, and Zn in the Netherlands, that character states play a significant role in the habitat–response connection of a particular taxon. This indicates that character states play a major role in the relationship between habitat and response. These results are used both in the derivation of Environmental Quality Criteria (EQCs) and in (Probabilistic) Environmental Risk Assessment (ERA) to quantify toxic stress (expressed as Potentially Affected Fraction, PAF) at contaminated sites and water bodies. Species Sensitivity Distributions (SSDs) are used at contaminated sites and water bodies to take into account differences in the sensitivity of different taxa to toxicants. The data that is used to generate SSDs is comprised of experimental toxicity data from a single species, and statistical distribution theories are used to assess these data in conjunction with one another. In its own right, the SSD is a statistical explanation of variations across species that have been actually observed in terms of their sensitivity to toxicants. The mean value of the log (NOEC) and the standard deviation of log converted NOECs are the two characteristics that define the distribution. With the logistic density function, one may do an analytical evaluation of the cumulative distribution for all species, denoted by f(x), through the process of integration. This is a significant benefit.

$$f(x) = 1/\{1 + \exp[(\alpha - x)/\beta]\}$$

Where

---

is proportional to the standard deviation of the distribution, and is equal to approximately 0.5(

= [(√3)/x)]) x is the logarithm of the concentration of the chemical, often known as the bioavailable concentration, in the environment. Either in the form of a probability density function or a cumulative distribution function, it can be expressed.

When a local ambient chemical concentration is known, it is possible to extract PAF from solid-state drives (SSDs). It is possible to determine the proportion of species for which the NOEC is exceeded (PAF) based on the quantity of a toxicant in water, soil, or sediment. This may be done by using the formula:

$$PAF = 1/\{1 + \exp[(\alpha - x)/\beta]\}$$

Toxic stress is frequently the result of the existence of mixtures of toxicants, and multisubstance PAF values are computed in order to evaluate the possible ecological impacts that might be caused by exposure to these combinations. The multisubstance PAF is computed under the assumption that the concentration is additive. This implies that the relative toxicities of many compounds may be combined together. This type of calculation is used for compounds that have comparable mechanisms of action. It is generally accepted that groups of chemicals that exhibit distinct hazardous modes of action will produce effects in a cumulative manner. The multi-substance PAF may be obtained from the following sources for heavy metals:

$$PAF_{hm} = 1 - \prod_i (1 - PAF_i)$$

The toxic stress caused by heavy metals is not a differentiating feature that may explain the prevalence of the majority of plant species, according to Bakkenes et al. (2002), who used a data set consisting of 95,529 field relevés including 690 species. The majority of these field relevés were found in open landscapes and grasslands. With that being said, the toxic stress plays a significant role in at least 191 different species. In point of fact, if we take into consideration the character states that are presented in Table 1, we can see that the sensitivity of these vascular plants to contaminants demonstrates a far greater physiological limitation. While the PAFhm is relatively low, the sensitivity distributions of these plant species, which can be shown in Figures 1 (upper right corner) and 2 (on the left), indicate that there is a far fewer number of PAF-sensitive species reported within the sample.

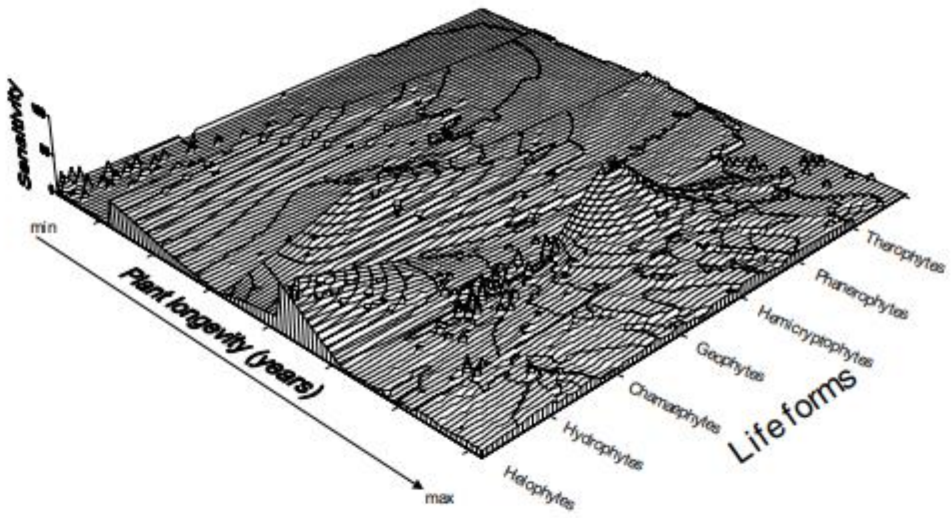

Figure 1. Vascular plants that are susceptible to PAF are ranked by their life form and lifespan, as per Raunkiaer's 1934 study and the literature. Based on data from Bakkenes et al. (2002), this wireframe map models the radial basis function of an anisotropically re-scaled analysis of variance (ANOVA) with life form (x-axis), lifespan (y-axis), and sensitivity (z-axis) for 191 vascular plants. According to Carlson and Foley (1991), the smoothing factor R 2 for a multiquadratic function is 0.0128.

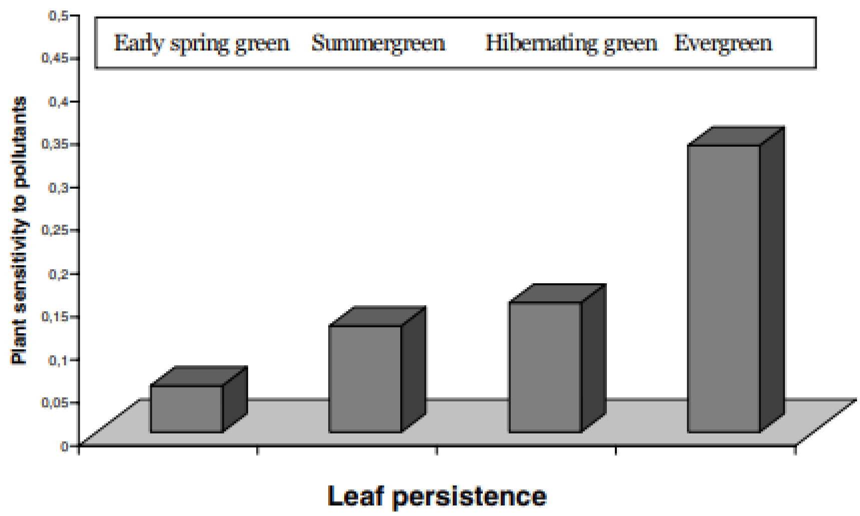

Figure 2. The average heavy metal sensitivity of Dutch grasslands according to the growing season of the vascular plants that were studied (categories as in Ellenberg et al., 1992).

Species of wood whose leaves become a verdant shade from the first days of spring throughout the heat of summer. A few inferences are possible. (1) Figure 2 shows that of the four categories of leaf persistence, early-spring green species (mainly herbs, crops, and weeds) have the lowest average value of sensitivity to pollutants. However, Figure 1 shows that there is a widespread tolerance-sensitivity range to Cd, Cu, and Zn. (2) There is a strong association between plant lifetime (and wooden life form) and [Cd, Cu and Zn]-msPAF. Figure 2 demonstrates that evergreen species are more sensitive to heavy metals. While there aren't many field recordings comparing evergreen species to early-spring green plants, there is a correlation between the two. Kernel density of hemicryptophytes (hibernating buds near the soil surface) in Figure 1 suggests a sensitivity distribution of hibernating green species (those whose leaves stay green throughout the winter) that is similar to a Gaussian distribution. Species that are most at risk in soils contaminated with metals include trees, shrubs that are either woody or herbaceous, and species that are short-lived and pass their seeds on to the next generation (minimum plant lifespan). The findings corroborate those of a previous research by Salemaa et al. (1999), which found that plants in contaminated settings had a mechanism to strengthen their resistance to heavy metals through fast re-growth, plastic branching, and heavy metal-induced shoot death. In heavy metal polluted soils, the energy devoted to reproduction is a key Life Support Function, according to these ecotoxicological results. This is because, as the mean age of the whole plant rises through the stages of phanerophytes, therophytes, and K-selection, there is a natural progression from slow growth and a smaller proportion of energy devoted to reproduction to rapid growth and a large proportion of energy devoted to reproduction, resulting in a high amount of relatively small seeds. Changes from obligate annuals to facultative annuals, shrubs to trees, and the reverse is also explicable by this generalised relationship, even though it is less pronounced in temperate biomes. This is because the resilience of phanerophytes to therophytes decreases as they progress through the growing season. Under specific environmental conditions, chamaephyte and phanerophyte growth can go on to later stages or stay stuck at early stages (Schulze, 1982; Woodward, 1986). The formerly ignored function of life-cycle traits in disturbance and enhanced ecosystem resilience has just lately been proposed as hypotheses by Eriksson (2000). Some character states, he said, should allow residual populations to grow, such as creeping rhizomes. These plant species are ideal bioindicators (or "ecosystem engineers" according to Jones et al., 1994) since their presence would increase the availability of essential conditions for other creatures (Eriksson, 2000) and their populations tend to be rather long-lived. There are a lot of climatic bioindicators based on the character states described in Table 1. For example, the relationship between temperature, rainfall, and atmospheric CO2 and the anatomy of different types of life and leaves. Additionally, they can be utilised as time proxies (e.g., tree rings in dendrochronological studies; see later in this chapter) and in ecotoxicological testing (e.g., rootlet development of lettuce-sprouts in hydroponic solution). Up until now, very few studies have taken into account the sort and mix of character states that identify a particular taxon, both as an evolutionary legacy of the studied taxon and—more importantly—as shifting fingerprints between various environments. Increasing functional diversity, which occurs when several character states coexist in a plant community, is thought to mitigate the effects of disturbances. The ability of plants to live and multiply in contaminated environments is perhaps still the most important test. Important events in plant life include seed germination and the time it takes for a seedling to mature into a blooming plant. According to Brej (1998), the majority of seedlings in contaminated soil do not react negatively to copper, zinc, lead, cadmium, and nickel. Vegetative reproduction is essential even in soils free of pollutants, however seedlings' future growth showed significantly poorer tolerance to metal contamination (slow rhizome bud development). Another factor that determines a plant's susceptibility to soil contaminants is the root-to-shoot ratio. The average NOEC of herbaceous plants (crops) is up to 20 times higher than that of woody species, with values of 58.8 mg/kg and 318.3 mg/kg, respectively, compared to the results of phytotoxicity assessments of the Ni and Pb content in (non-standardized) soils (Lijzen et al., 2002). Interestingly, there is no such contradiction between Cd and Cu. Thus, the applicability of mechanistic whole-plant models to ecotoxicological techniques is still up for debate, despite the fact that these models primarily centre on nutrient fluxes and shoot-root allocation, two crucial processes. The ecological importance of species-specific variations in nitrogen and carbon metabolism has been extensively proven, and the effects of root and shoot competition are acknowledged (e.g., De Ruiter et al., 1993, Bijlma and Lambers, 2000). However, the natural processes that influence the rhizosphere volume of soil in terms of heavy metal uptake, retention, and reallocation remain largely unknown. Although mycelium is thought to retain or perhaps immobilise pollutants, there is a lack of field empirical evidence and little experimental data. In addition, there are a number of issues that make comparing sites challenging. For example, surface water runoff and erosion significantly impact soil mycorrhizal propagule amounts, which in turn limits the likelihood of fungal colonisation and plant regeneration. However, there is mounting evidence that metal buildup in mycorrhizal fungus improves plants' ecotoxicological tolerance inside the rhizosphere. Entry et al. (1996), Delvaux et al. (2000), and Steiner et al. (2002) all found that vascular plants could accumulate radionuclides and then remove them with the help of these mycorrhizal symbionts. Fungal symbionts, including ectomycorrhizas and other external infections, are present in the roots of the majority of plant species. Although various types of mycorrhiza do exist in the Ericales plant-hosts, the most common kind of symbiosis is vesicular-arbuscular mycorrhiza, sometimes known as arbuscular mycorrhiza. Despite the accumulation of heavy metals in the extramatrical hyphae of macromycetes, the relevance of ectomycorrhizas as a potential limitation of heavy metal contamination in their plant hosts remains uncertain (Wilkins, 1991). And different ectomycorrhizal fungi have different heavy metal tolerance levels (Kahn et al., 2000). In fact, it appears that affected plants may be benefiting from the illness because of internal diseases of their roots. Since mycorrhizas are essential for root protection, their significance in plants growing on heavy metal polluted sites becomes more apparent (Galli et al., 1994). The fungus Hymenoscyphus ericae detoxifies and assimilates large quantities of harmful organic acids generated by microbial breakdown of fatty and phenolic residues, making ericoid mycorrhizal associations common in acidic, nutrient-poor soils (Leake et al., 1989). In a polluted mining site, ericoid mycorrhizas appear to provide their Calluna plant hosts adaptive resistance to AsO4 3 and constitutive resistance to Cu2+, but low pH and anaerobic conditions also aid in metal mobilisation (Sharples et al., 2001). The unique environmental monitoring and site remediation opportunities presented by Calluna heathlands in mycorrhizal symbiosis with H. ericae are truly remarkable. Nutrient absorption is obviously affected by both the kind of fungal infection and the shape of the root system. For example, plants with deep roots, like woody shrubs or trees, and shallow roots, like grass hummocks, would have different root systems. Marschner et al. (1996) and Entry et al. (1999) both agree that further field research are needed to fully understand the uptake and translocation of trace chemicals. Future dose assessment studies must account for this basic process if they want to understand how mycorrhizae affect root absorption and plant adsorption of trace chemicals.

Psychological indicators

Self-Rating Anxiety Scale and Self-Rating Depression Scale

To evaluate the participants' baseline mental health before the trial began, we used the Self-Rating Anxiety Scale (SAS) (Zung, 1971) and the Self-Rating Depression Scale (SDS) (Zung, 1965). According to Yan et al. (2023), Jigeer et al. (2022), and Sia et al. (2020), these measures are often used to assess the short- and long-term psychological well-being of individuals in relation to parks, gardens, and other natural environments. We used these measures in our study to account for participants' pre-experiment mental states and reduce their influence on the results. Both the anxiety and depression scales have 20 questions that describe common symptoms, such as nervousness, shaking, and experiencing sudden and unexplained dread and weariness, respectively. For the last week, participants used a 4-point scale that went from "a little of the time" to "most of the time" to indicate how often these symptoms occurred. Anxiety and depression symptoms are more severe in those with higher scores, respectively.

Positive and Negative Affect Scale

Using the Positive and Negative Affect Scale (Watson et al., 1988), we were able to record more thorough emotional responses to our natural surroundings. An affect's valence (from nice to bad) and arousal (from active to deactivated) are two dimensions that Russell (1980) mapped out in his circumplex model. As an example, "excited" is a highly arousing emotion with a positive valence, whereas "sad" is a lowly arousing emotion with a negative valence. Since physiological arousal does not provide much information on the emotional tone of a feeling, we used the PANAS to gauge the emotional intensity. In order to measure the instantaneous affective reaction to different natural surroundings, this scale is utilised in a large number of investigations. According to a meta-analysis conducted by Gaekwad et al. (2022), PANAS is mainly used in research that evaluate the psychological advantages of being in nature. Animal variety in urban forests is associated with increased positive affect and decreased negative affect, according to research by Nghiem et al. (2021). Participants were immersed in virtual reality settings exhibiting diverse plant components, and Huang et al. (2019) used PANAS to analyse emotional reactions. Ten items on PANAS measure positive affect (such as interested, enthusiastic, inspired, or active), while ten items on PANAS measure negative affect (such as upset, terrified, worried, or irritated). Using a scale from 1 to 5, respondents expressed their fleeting emotions by choosing one of five possible answers. A higher score indicates a more intense level of the corresponding impact, whether positive or negative.

Perceived Restorativeness Scale

According to research based on the Attention Restoration Theory (ART), mental exhaustion can occur after engaging in focused attention for an extended period of time (Kaplan and Kaplan, 1989). In contrast, weary minds may recharge in natural settings, which can offer soothing experiences. The four basic features of a restorative environment are as follows: "being away," meaning to be detached or removed from one's usual surroundings; "fascination," meaning to be captivated by or interested in the environment; "extent," meaning to be fully immersed in a different or broader context, either physically or perceptually; and "compatibility," meaning to be in harmony with one's own needs and actions (Kaplan and Kaplan, 1989).

The Perceived Restorativeness Scale (PRS) was created by Hartig et al. (1997) and is based on Attention Restoration Theory (ART). It is a four-dimensional measure of how people perceive the restorative benefits of natural surroundings. The restorativeness of greenspace qualities has been measured using this scale in many research (Akpinar, 2021, Subiza-Perez and Vozmediano, 2020, Yakinlar and Akpinar, 2022). Nghiem et al. (2021) also found that a person's sense of emotional well-being is mediated by how restorative they feel the urban forest to be. We calculated the restoration potential for each situation using the PRS. The PRS is comprised of 26 items in total, with 6 of those components having inverted scoring. We used a seven-point Likert scale to rate each item. The repair potential was higher for scores that were higher.

Stress task

In order to ensure that the mathematically demanding assignment was appropriate for bachelor students at The purpose of adjusting the difficulty level and time limitation was to make participants feel stressed out without letting them give up entirely. Three addition and subtraction equations involving two numbers were presented in each question, with a time constraint of five seconds for each problem. The assignment immediately moved on to the next question when the timer ran out. The question page's top bar now shows the right pace of questions in real-time, adding pressure. Individuals were informed that there will be an extra performance award for going above and above the proper rate of earlier participants. We settled on an 80%

simulated accuracy rate. At least five minutes of stress stimulation time was required, although test takers varied by around a minute in response time owing to differences in typing speed.

Statistic analysis

Figure 2(a) and (b) portray the changes in SCL and nSCR during the experiment, which included three stages: baseline, stress-arousal, and virtual reality immersion. We used the Kruskal-Wallis H test for non-continuous variables and one-way ANOVA tests for continuous ones. We evaluated three separate groups at baseline, post-stressor, and for changes from baseline to post-stressor to make sure there weren't any differences between the groups. Additionally, we checked for differences in the individual response to stress stimuli, meaning differences before and after stress stimulation. The baseline was set at the value at three minutes in, and the post-stressor measurement was taken at the value at four minutes. This study's statistical analyses were conducted using IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA).

Preliminary SAS and SDS scores did not show any significant differences, indicating that all groups started off with the same mental state. Table 1 shows that there were no statistically significant changes in SCL, nSCR, or the positive and negative impacts measured across the three situations (baseline, post-stressor, and difference following stimulus). This proved that the random assignment worked as intended. As a result, the ensuing variations in the scenarios may be explained by the immersive nature of VR. After that, we used the paired t-test or the Wilcoxon signed-rank test to see if there was a significant difference between pre- and post-stress, so we could verify that the stress induction had worked.

Table 1. Comparative analysis of baseline and post-stressor and their variations across three scenarios.

Variable	Empty Cell	Empty Cell	**Urban park**	**Peri-urban park**	**Nature conservation area**	***F***	χ^2	***p***
Gender	Male		16	11	12			
	Female		14	19	18			
Age		M	23.700	22.070	21.870			
		SD	3.621	2.545	3.246			
SAS		M	40.375	41.250	39.750		1.368	0.505
		SD	9.865	8.233	9.724			
SDS		M	43.083	45.917	45.000		0.745	0.689
		SD	9.370	8.497	10.453			
SCL	Baseline	M	1.780	2.0600	2.230	0.421		0.658
		SD	0.941	1.459	2.875			

Variable	Empty Cell	Empty Cell	**Urban park**	**Peri-urban park**	**Nature conservation area**	***F***	χ^2	***p***
	Post-stressor	M	6.030	7.330	7.840	1.601		0.208
		SD	3.418	4.108	4.552			
	Difference	M	4.250	5.275	5.609	1.012		0.368
		SD	3.198	4.210	4.084			
nSCR	Baseline	M	18.470	18.370	21.300	0.721		0.489
		SD	10.533	10.331	11.332			
	Post-stressor	M	23.030	23.270	23.300	0.033		0.968
		SD	4.247	4.705	4.236			
	Difference	M	4.567	4.900	2.000	0.631		0.534
		SD	10.884	10.196	11.686			
PA	Baseline	M	31.000	30.0700	29.100		1.158	0.561
		SD	7.259	5.953	7.1500			
	Post-stressor	M	30.530	29.430	29.830		0.482	0.786
		SD	5.788	6.312	8.457			
	Difference	M	−0.467	−0.6333	0.733		1.303	0.521
		SD	6.1405	4.789	6.220			
NA	Baseline	M	17.630	17.200	16.430		1.695	0.428
		SD	5.359	7.194	5.569			
	Post-stressor	M	19.930	20.770	18.500		1.646	0.439
		SD	6.005	7.509	7.0750			
	Difference	M	2.300	3.567	2.0670		0.910	0.634
		SD	4.565	6.252	5.723			

Note: F: statistical value for one-way ANOVA; χ^2: statistical value for the Kruskal-Wallis test. P: p-value; M: Mean; SD: Standard Deviation.

Copyright@ijarets.org

Conclusion

Air pollution, habitat loss, soil contamination, and climate change are some of the environmental stresses that urban ecosystems are facing more and more. These factors have a major influence on plant variety. According to this research, these stresses cause shifts in species composition, which benefits invasive and stress-tolerant plants at the expense of native plant populations. The results highlight the need for more research into the link between urban environmental factors and biodiversity if we are to create long-term conservation plans. Incorporating green infrastructure, pollution control measures, and habitat restoration initiatives into urban development can help prevent the loss of biodiversity. Anthropogenic disturbances can disrupt ecological equilibrium, but urban resilience can be enhanced by preserving natural vegetation, encouraging adaptable plant species, and limiting human disturbances. To further our understanding of urban vegetation's adaptation mechanisms and to inform policy choices, long-term monitoring and multidisciplinary study are essential. Cities may increase ecosystem services, environmental quality, and the sustainability of urban green areas by using biodiversity-friendly urban design methods. The efficacy of conservation initiatives in fostering plant variety in fast developing urban environments should be evaluated in future research, and species-specific reactions to urban stresses should be investigated.

References

[1] Aarssen, L.W., 2001. On correlations and causations between productivity and species richness in vegetation: predictions from habitat attributes. Basic Appl. Ecol. 2, 105–114.

[2] Acocks, J.P.H, 1988. Veld Types of South Africa, 3rd edn. Memoirs van die botaniese opname van SuidAfrika 57, pp. 1–146.

[3] Adams, J.H., Constable, J.V.H., Guenther, A.B., Zimmermann, P., 2001. An estimate of natural volatile organic compounds emissions from vegetation since the last glacial maximum. Chemosphere – Glob. Change Sci. 3, 73–91.

[4] Anderson, L.J., Maherali, H., Johnson, H.B., Polley, H.W., Jackson, R.B., 2001. Gas exchange and photosynthetic acclimation over subambient to elevated CO2 in a C3–C4 grassland. Glob. Change Biol. 7, 693–707.

[5] Bijlma, R.J., Lambers, H., 2000. A dynamic whole-plant model of integrated metabolism of nitrogen and carbon. 2. Balanced growth driven by C fluxes and regulated by signals from C and N substrate. Plant Soil 220, 71–87.

[6] Ellenberg, H., Weber, W., Düll, R., Wirth, V., Werner, W., Paulißen, D., 1992. Zeigerwerte von Pflanzen in Mitteleuropa, 2nd edn. Scripta Geobotanica 18. Goltze, Göttingen

[7] Aronson, M. F., La Sorte, F. A., Nilon, C. H., Katti, M., Goddard, M. A., Lepczyk, C. A., ... & Winter, M. (2014). A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers. *Proceedings of the Royal Society B: Biological Sciences, 281*(1780), 20133330. https://doi.org/10.1098/rspb.2013.3330

[8] Chen, Y., Wang, J., Lin, M., & Liu, Y. (2015). Effects of heavy metal contamination on soil microbial diversity and ecosystem function. *Environmental Pollution, 206,* 40–48. https://doi.org/10.1016/j.envpol.2015.06.009

[9] Francis, R. A., & Chadwick, M. A. (2013). Urban ecosystems: Understanding the human environment. *Routledge*.

[10] Kabisch, N., Qureshi, S., & Haase, D. (2016). Urban nature: Human–nature interactions in urban green spaces—A systematic review of contemporary issues and prospects for future research. *Environmental Science & Policy, 62*, 49–59. https://doi.org/10.1016/j.envsci.2016.01.013

[11] Kendal, D., Williams, N. S., & Williams, K. J. (2017). Drivers of diversity and tree cover in gardens, parks and streetscapes in an Australian city. *Urban Forestry & Urban Greening, 27*, 154–162. https://doi.org/10.1016/j.ufug.2017.07.009

[12] Kularatne, R. K. A., & De Silva, K. H. S. S. (2013). Air pollution and its impact on the vegetation of Colombo city, Sri Lanka. *Environmental Monitoring and Assessment, 185*, 4023–4034. https://doi.org/10.1007/s10661-012-2843-4

[13] McKinney, M. L. (2006). Urbanization as a major cause of biotic homogenization. *Biological Conservation, 127*(3), 247–260. https://doi.org/10.1016/j.biocon.2005.09.005

[14] Peters, K., Elands, B. H. M., & Buijs, A. E. (2020). Urban green space and the quest for nature: The influence of naturalness and place identity on well-being. *Landscape and Urban Planning, 195*, 103731. https://doi.org/10.1016/j.landurbplan.2019.103731

[15] Shochat, E., Warren, P. S., Faeth, S. H., McIntyre, N. E., & Hope, D. (2010). From patterns to emerging processes in mechanistic urban ecology. *Trends in Ecology & Evolution, 25*(4), 195–204. https://doi.org/10.1016/j.tree.2009.10.013

[16] Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kazmierczak, A., Niemelä, J., & James, P. (2007). Promoting ecosystem and human health in urban areas using green infrastructure: A literature review. *Landscape and Urban Planning, 81*(3), 167–178. https://doi.org/10.1016/j.landurbplan.2007.02.001

[17] Williams, N. S., Lundholm, J., & MacIvor, J. S. (2019). Do green roofs help urban biodiversity conservation? *Journal of Applied Ecology, 56*(8), 1783–1791. https://doi.org/10.1111/1365-2664.13420

[18] Zhao, C., Chen, Y., & Sun, B. (2021). The role of mycorrhizal fungi in plant adaptation to urban environmental stressors. *Journal of Environmental Management, 298*, 113470. https://doi.org/10.1016/j.jenvman.2021.113470