

# Literature Review of Documented Economical, Environmental, Lifestyle, Health and Social Benefits of Indoor Plants

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**Abstract**—The effect of urbanization has spread all over the place in the world and created numerous physiological, psychological in addition to environmental problems those are extending extensively day by day. There is a lot of infrastructure being developed due to the unexpected expansion of the urban sprawl, in consequence, green spaces are extensively damaged and reduced from the city gradually. Greening the great indoors with living plants is innovative technology in architecture can regain losses of a natural environment in dense urban areas which provides economical, environmental, lifestyle, health and social benefits as well as it is a sustainable solution to improve the environmental balance of cities to limit the major negative effects of urbanization. This study is being focused to a small document with reference to the benefits of indoor plants based on the existing scientific evidence. Studies also indicate that people have learned and innate responses to plants. We hope that the present and future community can be greatly benefited along with realized through this discussion and review that indoor plants have multi-sensory benefits which can enhance our life span. This research will be successful when citizens are able to understand the truth on the subject of the benefits of indoor plants nurturing inside the building or home.

**Index Terms**— Indoor Plants, Natural Environment, Nurturing Benefits, People-Plant Interaction, People Responses

## 1 INTRODUCTION

Urban sprawl is increasing rapidly around the world. Developing urbanization of the world has interrupted people in regularly communicating with the natural environment. Coincident with urbanization, there is many evidence of an increase in the worldwide prevalence of physiological and psychological disorders [51]. In the modern era of scientific enterprise, a large number of studies have demonstrated the importance of nature to human physical and mental health, distinguishing the numerous ways in which people depend on the natural environment. This paper aims to contribute some of the beneficial literature of indoor plants, and then examines some of the postulated reasons why humans respond positively to plants.

## 2 PURPOSE OF THE STUDY

With the increasingly rapid growth of modern cities, the environment of our city is greatly damaged, which is destroying the urban ecology. Now our big concern is: how can the indoor plant help to sustain this urban ecology? I propose that

‘greening the great indoors’ with living plants is an important element in enabling sustainable urban communities of the future, since such communities will increasingly depend on a healthy ‘indoor facility ecology’. So, to sustain our urban ecosystem, why should we culture the indoor plants in the internal spaces and what are the benefits of this? What are the effects of the indoor plants on the lives of the children and senior citizen’s of our community? The purpose of the research is to analyze the ‘**Literature Review of Documented Economical, Environmental, Lifestyle, Health and Social Benefits of Indoor Plants**’ and to teach communities on how to create holistic, positive and remedial green environments with indoor plants. This research studies will be very valuable to the world and our community; the future of healthier lifestyle environments, economical interior plantscapes and natural indoor green environment. It will inspire the community to create alternative holistic, green and healthier indoor environments in interior spaces.

### 3. BENEFITS OF INDOOR PLANTS

When we decorate interior spaces with indoor plants, we are not just adding greenery. These living plants interact with our body, mind and home in ways that enhance the quality of life.

#### 3.1 Economic Benefits

Indoor plants can help us economically in various ways. This section provides examples of the economical benefits of indoor plants.

##### 3.1.1 Increased business performance

The indoor plants produce a positive natural pleasing environment that accelerates the reception of customers into the store, increasing the appreciation of the quality of the products and services provided by the store. Indoor plants play an active role in enlarging a business through revival, increasing the number of additional customers, increasing sales, reduces shopping related stress and customers feel more relax, and improving the overall environment of the shop. As a result, customers are willing to travel, shopping and return more as a quality resource, increasing the total amount of shopping time and pay higher prices [9].

##### 3.1.2 Cooling indoor air and saving energy

Plants are a natural humidifier. The amount of water evaporate from any plants via the leaves will almost exactly equal the amount of water used for watering the plant which will increase humidity significantly in the building but this will depend on the size and number of the plant, present temperature and humidity of the room [15]. Also, his study demonstrated that the maximum cooling a plant could give is:  $0.5 \times \text{latent heat of water} = 0.5 \times 2270 \text{ kJ per day} = 13 \text{ watts}$  which suggested in using plants to improve the thermal conditions significantly. Lohr [35] clearly demonstrated that indoor plants significantly control relative humidity of the air inside the room which ranges is often 30% to 60% recommended for human health and comfort, especially when the building is being heated. Kokogiannakis *et al.* [32] explicates a methodology for representing indoor plants performance and indicates that if we irrigated plants regularly they will evaporate and transpire which could alter the humidity and temperature inside the buildings.

##### 3.1.3 Medicinal use

According to the World Health Organization, 80% populations of the world still rely on traditional medicines for their psychological and physical health requirements [49]. Certain indoor plants have been the source of modern medicines which are relatively safer and cheaper than synthetic or modern medicine [2].

#### 3.2 Environmental Benefits

For more than half of the world population in 2008 will live in an urban environment. The connectivity of people with the natural environment is reducing continuously to grow the

urbanization of the world but plants continue to provide environmental benefits at every spatial level in worldwide which is discussed in this section.

##### 3.2.1 Reduce carbon dioxide (CO<sub>2</sub>) concentration

Approximately 90% of people lives in indoor spaces and their health are affected by the concentration of CO<sub>2</sub> in these spaces. Indoor plants directly reduce the concentration of CO<sub>2</sub> to a certain extent during the day in the indoor environment, depending on the ambient light and temperature conditions [11]. Su and Lin [55] constructed an indoor 189 pots green-wall of Bird's-Nest Fern and his result of the experiment indicated that the density of CO<sub>2</sub> was reduced from 2000 to 600 ppm in 5.37 hours, temperature decreased to 2.5°C and relative humidity increased about 2~4% with plants with light at night which improve greater indoor air quality.

##### 3.2.2 Pollution improvement

Plants have been identified as "lungs of cities" [40] because they have the ability to reduce pollutants from the air. NASA studies have found that indoor air pollution averages two to five times higher than outdoors and foliage monoxide plants remove interior pollutants including carbon monoxide, nitrogen dioxide and toxic agents such as benzene, formaldehyde and trichloroethylene, and reduce airborne mould spores and bacteria by up to 60% from the indoor air [65]. A team of researchers found that ornamental indoor plants can effectively remove three common indoor pollutants of formaldehyde, nitrogen oxides (NO<sub>x</sub>) and sulfur oxides (SO<sub>x</sub>) [42]. A laboratory studies showed that potted indoor plants can reliably reduce CO<sub>2</sub> levels by about 10% in offices in the air conditioned building, and by about 25% in the naturally ventilated building [57]. Research by Lohr *et al.* [36] confirmed that it is possible to reduce the amount of particulate matter by up to 20% with the use of plants in the room which increases the quality of the indoor air.

##### 3.2.3 Improve indoor quality

Indoor plants serve as an important tool in improving air quality in indoors and mitigating potential health effects on human inhabitants. In developed countries peoples often spend over 90% of their time indoors [27]. The U.S. Environmental Protection Agency (EPA) reported detection of more than 900 VOCs in the air of public buildings [18]. Volatile organic compounds (VOCs) have a negative effect on indoor air quality [16] and can cause acute illnesses and chronic diseases [56]. Different indoor plant species commonly used for interior landscapes for their ability to remove VOCs such as benzene, toluene, aliphatic, octane, trichloroethylene, alpha-pinene [66] from indoor environment. One potted plant per 100 square feet of indoor space in an average home or office was sufficient to cleanse the air of pollutants [47].

#### 3.3 Lifestyle Benefits

The plant is a great thing for humans and our world's ecosystems. Keeping plants inside our house, place of work, learning

and hospital centers can greatly improve our lifestyle. There are many benefits mentioned in this section that we can enjoy if we keep plants in our indoor spaces.

### **3.3.1 At Workplace**

Indoor plants are an integrated part of the workplace and people-plant relationships at the workplace affect a large phenomenon, influencing the social climate, hierarchy, interaction among the workers and affecting many aspects of the working environment, the individual's well-being, and to some degree the workplace's competitiveness [59].

#### **3.3.1.1 Reduces feelings of stress and negativity**

Many experimental studies suggested that the effects of indoor plants are greater for those who have relatively high levels of stress and negativity [30]. A number of studies have examined the effects of indoor plants on positive significant results to the effectiveness and well-being of office workers and those results include psychophysiological stress responses, task performance [52] and emotional states [1]. People with plant interaction showed faster physiological and psychological stress reduction [12]; improved emotional and cognitive health [1]. Lee *et al.* [33] suggest that active interaction with indoor plants can reduce physiological and psychological stress compared with mental work, this is accomplished through suppression of sympathetic nervous system activity and diastolic blood pressure and promotion of comfortable, soothed, and natural feelings.

#### **3.3.1.2 Increased productivity**

Today people feel that adding plants to the inside places improves worker productivity and satisfaction "[10, 36, 52]." The use of indoor plants in a variety for interior plantscapes influence positive reaction time was 12% faster than in the absence of plants, which indicate that plants may have contributed to increased productivity [36]. Interaction with plants can change human attitudes, behaviors, and physiological responses; furthermore, it may decrease absenteeism, increase productivity and overall satisfaction and happiness in people's lives [23].

#### **3.3.1.3 Reduces staff illness and sick-leave absences**

Researchers showed that the presence of indoor plants in the office settings may reduce the symptoms of physical discomfort and the sick building syndrome [19] those ultimately reduces the sick-leave absences [10]. If indoor plants have been set up in workplace, staff wellbeing is enhanced with sick-leave absences reduced by over 60% [20]. While statistically controlling of an indoor work environment with indoor plant by psychosocial and basic personal characteristics factors that plausibly reduce sick leave absence, excessive work stress and complaints, and thereby increase workers productivity [29]. When plants in office spaces are installed compared to traditional offices without plants then increases employee morale and proactive efficiency which reduces the leave absences [14].

#### **3.3.1.4 Increases job performance and satisfaction**

Plants are widely used for office settings, and they can play an important role to improve the indoor environmental quality, reduce psychophysiological stress, influences the effectiveness and well-being [10] which increases the work performance, satisfaction, productivity and the positive health effects of building users [7]. For decades, psychologists have realized that that indoor plants and window views of nature were positively connected with higher job performance and satisfaction but it is depend upon a number of factors at the workplace such as the physical surroundings, the indoor architectural environment, organizational structures, the culture at the workplace, the social climate, management style, characteristics of the work, and employees' psychological states, feeling of empowerment, and level of knowledge [17].

#### **3.3.1.5 Heightened concentration and attention**

An investigation demonstrated that the feeling of creativity at work may be related to vitality which outcomes from attention restoration and lower stressful arousal after nature exposure [5]. Researchers have found that interior plants can reduce eye irritation and work stress, and motivate employees who improve concentration and attention [58].

#### **3.3.1.6 Inspire creativity**

People habitually use ornamental indoor plants in the rooms to change the room environment. Nowadays, adding plants in workplaces has expanded extensively in the hope of increasing the atmosphere of the internal environment. The presence of the plants inspires creativity significantly, and creativity increases when people are in a positive mood, and mood help to perform and accomplish a creative task [52].

#### **3.3.1.7 Improve mental health**

We all want to live in a healthy and pleasurable environment and now interior plants may offer some psychological and restorative values such as reduced tension [61]. A number of studies represents that indoor plants were affecting many aspects of the working environment such as the physical surroundings, the social climate, image of the workplace; the individual's physiological and psychological benefits such as mood, general well-being, emotions, self confidence; and to some degree the workplace's competitiveness [59], all improve mental health. Our happiness was marginally positively related to the frequency of physical activity in nature and free time physical activity in natural surroundings is a potential strategy for enhancing employee vitality across time [31]. Vitality is an feelings of restoration or relaxation, emotion of aliveness, and activated positive affect [43] which increases positive reactions and thoughts, improves strength of mind and productivity [50], all relevant to employee mental well-being.

### **3.3.2 At Home**

Plants can play an important role in providing a higher quality

living environment and excellent way of improving indoor air quality and general health [48].

### 3.3.2.1 Feel overall wellbeing

Indoor plants around the home greatly improve the mood of occupants and reduce the stress depression which increases the positive energy levels and help occupants feel safe and relaxed. Mintz [41] said that the aesthetic quality of a room influences people's moods and greater feeling of well-being. It is possible to improve the aesthetic quality by arranging indoor plants in the room and feel more "relaxed" [4].

### 3.3.2.2 Breathing easier

Lack of negative ions in the air may reduce the respiratory effects of the person which decline the health of humans breathing it. At the same time, the air associated with negative ions can improve the health condition and provide a comfortable environment. Sinicina and Martinovs [54] concluded that the plants are able to stabilize the ion concentration and help to increase the concentration of negative ions and to decrease the concentration of positive ions.

### 3.3.2.3 Reductions in aggression and violence

Mental fatigue associated with aggression and violence in a variety of populations, and the presence of plants might have influenced recovery from mental fatigue [52]. It has become common to arrange plants in the hope that the arrangement would reflect an effective positive interruption which may provides enough involuntary attention, raising positive feelings, reducing anxiety-related thoughts and encouraging recovery from stress [62], all influences the aggression and violence.

### 3.3.2.4 Improves memory and mood

In recent years, the growing results of research on the effects of natural environment on humans have increased. There is good evidence in the natural environment or just looking at nature, it promotes recovery from stress, improves memory and mood [60]. Shibata and Suzuki [53] investigated that task performance and mood was highly influenced by the presence of the indoor plants in a room.

### 3.3.2.5 Positive emotions

Plants have been important to changes in human emotions and promotes human senses and mind; for improving mental cognition and performance "[52, 53]." There are several investigations showed that a floral display had positive effects on human emotions, such as composition and confidence [1].

### 3.3.2.6 Flowers generate happiness

Natural aesthetic beauty is soothing for humans, and to keep flowers around and inside the room environments is a great way lowering stress and anxiety levels. Those who keep flowers in their homes feel happier and more relaxed. As a result they are less likely to suffer from stress-related depression,

due to positive energy emerging from the environment [13].

### 3.3.2.7 Cognitive benefits

Bratman *et al.* [8] review the effects of such nature experience on human cognitive function and mental health; and they found that nature experience would decrease anxiety, rumination, and negative effect; and would increase positive effect, increase verbal and visual working memory capacity, and improve performance on the executive component of an attention test.

### 3.3.2.8 Effects on children

Taylor *et al.* [58] is one of the earliest studies to explore the potential for contact with nature to have a positive effect in reducing the impact of attention deficit disorder in children. Studies reported that even a view of nature-green plants and vistas-helps reduce stress among highly stressed children; increases children's ability to focus and enhances cognitive abilities [64]. The authors review evidence the health benefits of various forms of contact with nature, including viewing nature, being in nature, contact with plants improve a full range of physical, mental, and social health benefits of children [39].

### 3.3.3 At Learning Centre

If the reading environment is not comfortable, then students may have a lot of risk of increasing mental fatigue which can cause distraction and reduced performance, negative emotions such as irritability and tension [63]. Ornamental indoor plants are helpful in creating a positive learning environment which reducing student tendency towards confusion and mental exhaustion, helping them to be able to focus and concentrate on school work, influencing students' learning and academic performance, changing students' behavior and health [21]. Han [25] investigated that the effects of limitedly visible leafy indoor plants on the psychology, physiology and behavior of student and found that the students had immediately and significantly stronger feelings of preference, comfort, friendliness, fewer hours of sick leave and punishment records due to misbehavior when indoor plants were present compared to without indoor plants. Fjeld *et al.* [19] declared that the health and discomfort symptoms of students were found to be 21% to 25% lower when plants and full-spectrum lighting was present compared to without plants.

### 3.3.4 At Hospital

Surgical patients in hospital rooms with plants and flowers had significantly fewer intakes of postoperative analgesics, more positive physiological responses that stimulate lower systolic blood pressure and heart rate, lower ratings of pain, anxiety, and fatigue, and more positive feelings and higher satisfaction about their rooms compared to without plants which helps to patients faster recovering from abdominal surgery [46]. Professor Roger Ulrich from Texas A&M University focused on the effects of plants in hospitals and found that plants reduce dependency on serious postoperative drugs,



improve the effect of relaxation, create a positive and holistic environment, reduce stress, decrease the heart rate, reduce blood pressure, and improve the patient satisfaction and recovery time which reduce hospital length of stay and result in fewer medications for patients [61].

### 3.4 Health Benefits

Fjeld *et al.* [19] has been found that if the plants are kept in the office then cough and fatigue were reduced by 37% and 30%, respectively, dry or hoarse throat and dry or flushed facial skin each decreased about 23%; and a significant reduction was obtained in neuropsychological symptoms (fatigue, hoarseness, feeling heavy-headed, headache, dizziness, and concentration problems) and in mucous membrane symptoms (itching or irritation of the eyes; irritated, running, or stuffy nose; dry or hoarse throat; cough; and nausea), while skin symptoms (dry or flushed facial skin; scaling or itching scalp or ears; and hands with dry, itching, or red skin) also seemed to be unaffected by the plant intervention.

### 3.5 Social Benefits

Ornamental plants can affect the compassion level that people feel towards others. Studies have shown that people who spend more time around plants are much more likely to try and help others, and often have more advanced social relationships. Those who take care of nature know how to care for others and they can easily reaching the hearts of their peers and forming shared bonds resulting increases compassion for each other as it increases the human compassion for the environment which improves social relationships between people and increases their concern and empathy toward others [3].

## 4 WHY WE RESPONDED WITH PLANTS

Research has shown that people when viewing trees typically give high aesthetic preference ratings compared to inanimate objects and feel more positive emotions [37]. The savanna hypothesis proposed by Orians "[44, 45]" might help explain why these responses to nature are so universal. This hypothesis has predicted human aesthetic responses to trees with spreading forms based on hypothetical innate knowledge of the shapes of trees that would have been associated with productive human habitats.

The color is another changeable that is associated with the strength of people's responses to nature. Leaf color and size were examined as potential visual cues for food selection [38]. In a study with humans, physiological responses to tree canopies of various hues and intensities were measured. It showed that, while all tree colors were calming, healthy green trees were more calming than other canopy colors, including less bright green, orange, and yellow [28].

The world's human population is becoming concentrated into cities, giving rise to concerns that it is becoming increasingly isolated from nature. Urban public green spaces form the arena of many people's daily contact with nature and such contact has measurable physical and psychological benefits; and this benefits increase with the species richness of urban

green spaces. These results indicate that successful management of urban green spaces should emphasize biological complexity to enhance human well-being in addition to biodiversity conservation [22].

Ballig and Falk [6] examined human visual preferences and showed photos of different biomes to children and adults. In their study, elementary school children showed a significant preference for savanna over all other biomes, and mid adolescence and through adulthood, more familiar natural environments were equally preferred to savanna; and the authors have suggested that this innate preference is the ecological behavior of human's (genotype and phenotype). Han convinced with the research and he says based on his study that a non habitat-specific approach to environmental responses holds more promise than a habitat-specific approach [24].

## 5 DATA COLLECTION, ANALYSIS AND FINDINGS

Research studies data will be compiled through online search of ResearchGate, Pubmed, Google Scholar Article; Web of Science, Journal Articles. Inclusion criteria for Literature Review and Articles will be included; Case studies done with Plants Articles from all countries will be accepted. Different article, books and abstract are using for data collecting and analyzing. The possible findings of the research are to improve quality of life and longevity of individuals' through nursing of indoor plants.

## 6 CONCLUSIONS

The importance of plants is not limited to their role in meeting our physical, environmental and economic needs. Plants contribute positively to our mental health, improve our physical health, and make our communities safer. An understanding of why people respond to plants is beginning to be examined in this study. Overall, this literature review has documented a broad range of the benefits of interacting with indoor plants. This discussion has been shown that interactions with indoor plants can deliver a range of economical, environmental, life-style, physical and social benefits that are significantly beneficial for human well-being those are not well known or understood within the general population. Understanding the benefits of interacting with plants is also important from a sustainability perspective.

## REFERENCES

- [1] M. Adachi, C.L.E. Rode, and A.D. Kendle, "Effects of floral and foliage displays on human emotions," *HortTechnology*, vol. 10, no. 1, pp. 59-63, 2000.
- [2] H. Ammara, R. Salma, D. Farah, and M. Shahid, "Antimicrobial activity of some plant extracts having hepatoprotective effects," *Journal of Medicinal Plant Research*, vol. 3, no. 1, pp. 20-23, 2009.
- [3] M. Andrews and B. Gatersleben, "Variations in perceptions of danger, fear and preferences in a simulated natural environment," *Journal of Environmental Psychology*, vol. 30, pp. 473-481, 2010.
- [4] H. Asaumi, H. Nishina, H. Nakamura, Y. Masui, and Y. Hashimoto, "Effect of ornamental foliage plants on visual fatigue

- caused by visual display terminal operation," *Journal of Shita*, vol. 7, pp. 138-143, 1995.
- [5] R.A. Atchley, D.L. Strayer, and P. Atchley, "Creativity in the Wild: Improving Creative Reasoning through Immersion in Natural Settings," *PLoS ONE*, vol. 7, no. 12, e51474, 2012.
- [6] J.D. Balling and J.H. Falk, "Development of visual preference for natural environments," *Environ. Behavior*, vol. 14, pp. 5-28, 1982.
- [7] P.M. Bluysen, C. Roda, C. Mandin, S. Fossati, P. Carrer, Y. de-Kluzenaar, V.G. Mihucz, F.E. de-Oliveira, and J. Bartzis, "Self-reported health and comfort in 'modern' office buildings: first results from the European OFFICAIR study," *Indoor Air*, vol. 26, pp. 298-317, 2016.
- [8] G.N. Bratman, G.C. Daily, B.J. Levy, and J.J. Gross, "The benefits of nature experience: Improved affect and cognition," *Landscape and Urban Planning*, vol. 138, pp. 41-50, 2015.
- [9] C. Brethour, G. Watson, B. Sparling, D. Bucknell, and T. Moore, "Literature review of documented health and environmental benefits derived from ornamental horticulture products," *Agriculture and Agri-Food Canada Markets and Trade*, Ottawa, ON, 2007.
- [10] T. Bringslimark, T. Hartig, and G.G. Patil, "Psychological benefits of indoor plants in workplaces: Putting experimental results into context," *HortScience*, vol. 42, no. 3, pp. 581-587, 2007.
- [11] M. Cetin and H. Sevik, "Measuring the Impact of Selected Plants on Indoor CO2 Concentrations," *Pol. J. Environ. Stud.* vol. 25, no. 3, pp. 973-979, 2016.
- [12] C.Y. Chang and P.K. Chen, "Human response to window views and indoor plants in the workplace," *HortScience*, vol. 40, pp. 1354-1359, 2005.
- [13] C.C. Collins and A.M. O'Callaghan, "The impact of horticultural responsibility on health indicators and quality of life in assisted living," *HortTechnology*, vol. 18, pp. 611-618, 2008.
- [14] E. Conklin, "Interior plantings bring nature indoors," *AmerNurseryman*, vol. 139, p. 10, 1974.
- [15] D. Coley, "The Effect of Indoor Plants on the Indoor Environment of St. Lloyes Residence. University of Exeter, Centre for Energy and the Environment," Internal Document 775, 2011, available at [http://ecodesign.s3.amazonaws.com/extracare4exeter\\_ecc\\_d4fc\\_appendix3\\_15e87cf549b3fbd8.pdf](http://ecodesign.s3.amazonaws.com/extracare4exeter_ecc_d4fc_appendix3_15e87cf549b3fbd8.pdf).
- [16] A. Darlington, M. Chan, D. Malloch, C. Pilger, and M.A. Dixon, "The biofiltration of indoor air: Implications for air quality," *Indoor Air*, vol. 10, pp. 39-46, 2000.
- [17] A. Dravigne, T.M. Waliczek, R.D. Lineberger, and J.M. Zajicek, "The effect of live plants and window views of green spaces on employee perceptions of job satisfaction," *HortScience*, vol. 43, pp. 183-187, 2008.
- [18] EPA, "Report to Congress on indoor air quality," *Assessment and control of indoor air pollution*. EPA/400/1-89/001C, vol. II, p. 250, 1989.
- [19] T. Fjeld, B. Veiersted, L. Sandvik, G. Riise, and F. Levy, "The effect of indoor foliage plants on health and discomfort symptoms among office workers," *Indoor Built Environ.* Vol. 7, pp. 204-209, 1998.
- [20] T. Fjeld, "The effects of plants and artificial daylight on the well-being and health of office workers, school children and health-care personnel," *Proceedings of International Plants for People Symposium*, Floriade, Amsterdam, NL, 2002.
- [21] B.J. Fraser, "Classroom and school climate," *Handbook of Research on Science Teaching and Learning*, D. Gabel, ed., Macmillan, New York, pp. 493-541, 1994.
- [22] R.A. Fuller, K.N. Irvine, P. Devine-Wright, P.H. Warren, and K.J. Gaston, "Psychological benefits of greenspace increase with biodiversity," *Biol. Letters*, vol. 3, pp. 390-394, 2007.
- [23] T. Gray and C. Birrell, "Are biophilic-designed site office buildings linked to health benefits and high performing occupants?" *IJERPH*, vol. 11, pp. 12204-12222, 2014.
- [24] K.T. Han, "Responses to Six Major Terrestrial Biomes in Terms of Scenic Beauty, Preference, and Restorativeness," *Environment and Behavior*, vol. 39, no. 4, pp. 529-556, 2007.
- [25] K.T. Han, "Influence of limitedly visible leafy indoor plants on the psychology, behavior, and health of students at a junior high school in Taiwan," *Environ Beha.* vol. 41, pp. 658-692, 2009.
- [26] T.R. Herzog, A.M. Black, K.A. Fountaine, and D.J. Knotts, "Reflection and attentional recovery as distinctive benefits of restorative environments," *Journal of Environmental Psychology*, vol. 17, pp. 165-170, 1997.
- [27] P.L. Jenkins, T.J. Phillips, E.J. Mulberg, and S.P. Hui, "Activity patterns of Californians-Use of and proximity to indoor pollutant sources," *Atmos. Environ.* vol. 26, pp. 2141-2148, 1992.
- [28] A.J. Kaufman and V.I. Lohr, "Does it matter what color tree you plant?" *Acta Hort.* vol. 790, pp. 179-184, 2008.
- [29] R.A. Karasek and T. Theorell, "Healthy work: Stress, productivity, and the reconstruction of working life," *Basic Books*, New York, 1990.
- [30] E. Kim and R.H. Mattson, "Stress recovery effects of viewing red-flowering geraniums," *J. Ther. Hort.* vol. 13, pp. 4-12, 2002.
- [31] K. Korpela, D.B. Jessica, S. Marjaana, P. Tytti, and K. Ulla, "Nature at home and at work: Naturally good? Links between window views, indoor plants, outdoor activities and employee well-being over one year," *Landscape and Urban Planning*, vol. 160, pp. 38-47, 2017.
- [32] G. Kokogiannakis and P. Cooper, "Evaluating the environmental performance of indoor plants in buildings," *Proceedings of BS2015: 14th International Conference of International Building Performance Simulation Association*, V.R. Khare & G. Chaudhary, eds., pp. 712-719, 2015.
- [33] M. Lee, J. Lee, B. Park, and Y. Miyazaki, "Interaction with indoor plants may reduce psychological and physiological stress by suppressing autonomic nervous system activity in young adults: a randomized crossover study," *Journal of Physiological Anthropology*, vol. 34, pp. 21, 2015.
- [34] M. Liu, E. Kim, and R.H. Mattson, "Physiological and emotional influences of cut flowers arrangement and lavender fragrance on university students," *J. Ther. Hort.* vol. 14, pp. 18-27, 2003.
- [35] V.I. Lohr, "The contribution of interior plants to relative humidity in an office," *The Role of Horticulture in Human Well-being and Social Development*, D. Relf, ed., Timber Press, Portland, OR, pp. 117-119, 1992.
- [36] V.L. Lohr, C.H. Pearson-Mims, and G.K. Goodwin, "Interior Plants May Improve Worker Productivity and Reduce Stress in a Windowless Environment," *Journal of Environmental Horticulture*, vol. 14, no. 2, pp. 97-100, 1996.

- [37] V.I. Lohr and C.H. Pears on-Mims, "Responses to scenes with spreading, rounded and conical tree forms," *Environ. Behavior*, vol. 38, pp. 667-688, 2006.
- [38] P.W. Lucas, B.W. Darvell, P.K.D. Lee, T.D.B. Yuen, and M.F. Choog, "Colour cues for leaf food selection by long-tailed macaques (*Macaca fascicularis*) with a new suggestion for the evolution of trichromatic colour vision," *Folia Primatol.*, vol. 69, pp. 139-152, 1998.
- [39] C. Maller, M. Townsend, L. St.Ledger, C. Henderson-Wilson, A. Pryor, L. Prosser, *et al.*, "Healthy parks healthy people: The health benefits of contact with nature in a park context: a review of current literature (2nd ed.)," *Social and Mental Health Priority Area, Occasional Paper Series*, Melbourne, Australia: Faculty of Health and Behavioural Sciences, 2008.
- [40] E.G. McPherson, "Trees with Benefits," *American Nurseryman*, vol. 1, pp. 34-40, April 2005.
- [41] N. Mintz, "Bitekisinrigaku no ningenkankyō eno ouyou [An application of aesthetic psychology to human environment]," *Kankyo Shinri Towa Nani Ka*, D. Canter & M. Inui, eds., Tokyo, Shokokush, pp. 13-50, 1972.
- [42] E.-S. Mohamed, K. Eid, F. Eijiro, M. Eman, and A.E-F Yehia, "Correlation between some components of interior plants and their efficiency to reduce Formaldehyde, Nitrogen and Sulfur Oxides from indoor air," *International Research Journal of Plant Science*, vol. 3, no. 10, pp. 222-229, 2012.
- [43] G.A. Nix, R.M. Ryan, J.B. Manly, and E.L. Deci, "Revitalization through self-regulation: The effects of autonomous and controlled motivation on happiness and vitality," *Journal of Experimental Social Psychology*, vol. 35, pp. 266-284, 1999.
- [44] G.H. Orians, "Habitat selection," *The Evolution of Human Social Behavior*, J.S. Lockard, ed., Elsevier, Amsterdam, pp. 49-66, 1980.
- [45] G.H. Orians, "An ecological and evolutionary approach to landscape aesthetics," *Landscape Meanings and Values*, E.C. Penning-Roswell and D. Lowenthal, eds., Allen and Unwin, London, pp. 3-22, 1986.
- [46] S.-H. Park and R.H. Mattson, "Effects of Flowering and Foliage Plants in Hospital Rooms on Patients Recovering from Abdominal Surgery," *HortTechnology*, vol. 18, no. 4, pp. 1-6, 2008.
- [47] A.W. Prescod, "Growing Indoor Plants As Air Purifiers," *Pappus*, vol. 9, no. 4, pp. 13-20, 1990.
- [48] J. Qin, S. Chanjuan, Z. Xin, L. Hanbing, and Z. Lian, "The effect of indoor plants on human comfort," *Indoor and Built Environment*, vol. 23, no. 5, 709-723, 2013.
- [49] Rabe, V. Stoden, and B. Antory, "Isolation purification and identification of curcuminoids from turmeric (*Curcuma longa*) by column chromatography," *J. Exp. Sci.* vol. 2, p. 2125, 2000.
- [50] R.M. Ryan and E.L. Deci, "From ego-depletion to vitality: Theory and findings concerning the facilitation of energy available to the self," *Social and Personality Psychology Compass*, vol. 2, pp. 702-717, 2008.
- [51] M. Skar and E. Krogh, "Changes in children's nature-based experiences near home: From spontaneous play to adult-controlled, planned and organized activities," *Children's Geographies*, vol. 7, no. 3, pp. 339-354, 2009.
- [52] S. Shibata and N. Suzuki, "Effects of indoor foliage plants on subjects' recovery from mental fatigue," *N. Amer. J. Psychol.* vol. 3, pp. 385-396, 2001.
- [53] S. Shibata and N. Suzuki, "Effects of an indoor plant on creative task performance and mood," *Scandinavian Journal of Psychology*, vol. 45, pp. 373-381, 2004.
- [54] N. Siņicina and A. Martinovs, "Changes in air ions concentration depending on indoor plants activity," *Agronomy Research*, Tartu, Estonia: Estonian University of Life Sciences, vol. 14, no. 1, pp. 236-243, 2016.
- [55] Y.-M. Su and C.-H. Lin, "CO<sub>2</sub> Purify Effect on Improvement of Indoor Air Quality (IAQ) through Indoor Vertical Greening," *Proceedings of the World Congress on Engineering*, London, U.K. WCE, vol. II, 2013.
- [56] H.H. Suh, T. Bahadori, J. Vallarino, and J.D. Spengler, "Criteria air pollutants and toxic air pollutants," *Environ. Health Perspect.* vol. 108, pp. 625-633, 2000.
- [57] J. Tarran, F. Torpy, and M.D. Burchett, "Use of living pot-plants to cleanse indoor air," Research Review, 6th International Conference on *Indoor Air Quality, Ventilation & Energy Conservation, Sustainable Built Environment*, Sendai, Japan, pp. 249-256, 2007.
- [58] A.F. Taylor, F.E. Kuo, and W.C. Sullivan, "Coping with ADD: The surprising connection to green play settings," *Environ. Behav.* vol. 33, pp. 54-77, 2001.
- [59] J.D. Thomsen, K.H. Hans, and M. Renate, "People-plant Relationships in an Office Workplace: Perceived Benefits for the Workplace and Employees," *HortScience*, vol. 46, no. 5, pp. 744-752, 2011.
- [60] R.S. Ulrich, "View through a window may influence recovery from surgery," *Science*, vol. 224, pp. 420-421, 1984.
- [61] R.S. Ulrich, R.F. Simons, B.D. Losito, E. Fiorito, M.A. Miles, and M. Zelson, "Stress recovery during exposure to natural and urban environment," *J. Environ. Psychol.* vol. 11, pp. 201-230, 1991.
- [62] R.S. Ulrich, "How design impacts wellness," *Healthc. Forum J.* vol. 35, pp. 20-25, 1992.
- [63] J.S. Warm and W.N. Dember, "Awake at the switch," *Psychology Today*, vol. 20, pp. 46-53, 1986.
- [64] N.M. Wells and G.W. Evans, "Nearby Nature: A Buffer of Life Stress Among Rural Children," *Environment and Behavior*, vol. 35, no.3, pp. 311-330, 2003.
- [65] B.C. Wolverson, A. Johnson, and K. Bounds, "Interior landscape plants for indoor air pollution abatement," Final report NASA (NASA-TM-101766, NAS 1.15:101766), *Mississippi: National Aeronautics and Space Administration*, pp. 1-22, 1989.
- [66] D.S. Yang, V.P. Svoboda, S. Ki-Cheol, and J.K. Stanley, "Screening Indoor Plants for Volatile Organic Pollutant Removal Efficiency," *HortScience*, vol. 44, no. 5, pp. 1377-1381, 2009.