



Indoor plants-a novel approach to reduce the risk of atmospheric pollution

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Abstract

In the present mechanical world, one of the greatest desires of mankind is to be healthy and happy. Human being need oxygen to lead a healthy life. But the oxygen inhaled by mankind is highly polluted due to urbanization and industrialization. The atmosphere is completely surrounded by various pollutants emitted from vehicles and industries. The inanimate objects such as wood, household chemicals, plastic furniture and various other indoor products are also releasing harmful compounds and gases that reduces indoor air quality which ultimately affects physical and mental health of human beings. Naturally, plants give lifesaving gas (oxygen) to all the living organisms on earth. But due to population explosion, there is no enough space to grow plants in our house. An average person spends nearly 90 percent of their time inside, predominantly in houses, offices and schools. So, the poor quality of the indoor air causes some health issues. Usually, the indoor plant containers are made of different materials, but earthen and plastic pots are most widely used and these requires vast area as well as a greater number of pots. Hence, the present study is an attempt to design an indoor plant micro tower that occupies a small area and can grow more than 20 plants which reduces indoor pollutants and gives fresh air. The right choice of plants can be an excellent way of improving indoor air quality and general health. Plants such as Holy basil, First aid plant, Snake plant, Spider plant, Sword fern and Areca palm are selected and planted in the micro tower. These are the best oxygen producing plants which gives fresh oxygen and absorbs CO₂ and other pollutants from the indoor environment. Fresh oxygen also reduces mental stress and various respiratory problems and increases memory power. The present study showed the moderate rate of shoot growth (in Centimeter), well adaptability and survivability in all the plants except spider plant. Hence, the present work highlights the necessity of indoor plants in today's scenario and make people to realize and nurture the indoor plants to lead a healthy and happy life.

Keywords: atmospheric pollution, micro tower, indoor plants, oxygen producer

Introduction

Without air, there is no life. Oxygen is an essential molecule and vital for all living things to respire and for the function of cells. The earth's atmosphere contains oxygen because plants continuously produce through photosynthesis. This abundant supply of oxygen allows life forms to flourish. Therefore, oxygen had been thought to be an essential biomarker for life (Norio Narita, 2015) [20]. Oxygen is required for the cells in our body to breakdown complex food molecules into simpler substances. During this process, energy is released which is utilized for all the cellular and other functions of the body. Oxygen is one of the best oxidizers and needed to burn the fuel sugars and fatty acids in the cells to produce energy. Oxygen is brought into lungs via breathing, where it is transported by red blood cells to the entire body to be used to produce energy. The air that is inhaled is about 20% oxygen, and the air that is exhaled is about 15% oxygen, so about 5% of the volume of air is consumed in each breath and converted to carbon dioxide. Therefore, a human being uses about 550 liters of pure oxygen per day (Discovery Health).

Our atmosphere is highly polluted right now due to various human activities and we are breathing highly polluted air. Vehicles are the major pollution contributor, producing significant amounts of nitrogen oxides, carbon monoxide

and other pollutants. Some air pollutants are poisonous, inhaling them can increase the chance to cause health problems. Breathing polluted air can cause a higher risk of asthma and other respiratory problems. The pollutants may reach concentrations in the air that cause undesirable health, economic, or aesthetic effects. When carbon monoxide is breathed into the lungs, it binds with hemoglobin in red blood cells to make carboxyhemoglobin (COhb) which is then transported into the blood stream. An abundance of carbon monoxide in the blood stream starves the body of oxygen and in the worst cases, can cause death. People with heart or lung disease, older adults and children are at greater risk from air pollution (Yvette Brazier, 2017 Carbon monoxide (co), the silent killer, Medical News Today) [38]. On the other hand, indoor air pollution is the degradation of indoor air quality by harmful chemicals and other materials; it can be up to 10 times worse than outdoor air pollution. This is because contained areas enable potential pollutants to build up more than open spaces. (MEDLINE/PubMed (National Library of Medicine)). Materials including wood, household chemicals, and plastics used in furniture and various other indoor products can release harmful compounds and gases affecting indoor air quality (Silverhill Institute of Environmental Research and Conservation Canadian charitable foundation, 2013).

The quality of the indoor environment has become a major health consideration, since people spend 80–90 % of their time indoors. The plants can reduce indoor air pollutants by 75 % in different conditions. An evaluation of these studies done throughout the world clearly indicates that potted plants can provide an efficient, self-regulating, low-cost, sustainable, bioremediation system for indoor air pollution, which can effectively compliment engineering measures to reduce indoor air pollution, and hence improve human wellbeing and productivity (Pipal, 2012)^[25].

Indoor pollution also plays a big role in the overall status of polluted air. Cleaner, better quality air can improve energy at work and home activities because polluted air saps our overall energy level by making our lungs and the rest of our body, work harder, thus reducing our efficiency. Breathing cleaner air can allow our organs to work better, usually leading in oxygen absorption by our brain, making us mentally keen and more energetic (Gaurav Arora, 2018). Today, there are numerous scientific studies documenting the relationships between people and plants, both indoors and outdoors (Lohr, 2000; Pearson-Mims and Lohr, 2000; Relf and Lohr, 2003)^[14, 23, 26]. The range of benefits that has been documented is broad: air quality is improved (Wood *et al.*, 2002)^[37], stress is lowered (Dijkstra *et al.*, 2008), recovery from illness is faster (Ulrich, 1984)^[33], mental fatigue is reduced (Tennessen and Cimprich, 1995)^[31], and productivity is higher (Lohr *et al.*, 1996).

Plants are essential for our survival. They provide food, fiber, building material, fuel, and pharmaceuticals. Plants also produce intangible benefits for people, such as improving our health, reducing stress, providing fresh oxygen etc. These benefits occur with plants outdoors and indoors. People have been bringing plants into their homes for thousands of years. Indoors plants have many benefits. Physically, they contribute to cleaner, healthier air for us to breathe, thus improving our well-being and comfort. They make our surroundings more pleasant, and they make us feel calmer. Interior plants have been associated with reduced stress, increased pain tolerance, and improved productivity in people (Virginia Lohr, 2010)^[35].

Indoor plants- an urge tool to get pure oxygen

Indoor air quality and pollutants are too recognized as a potential source of health risk. Moreover, women and children are the main victims of this exposure due to their spending more time in an indoor rather than outdoor environment. Common indoor air pollutants are released from dust mites, molds, fungi, bacteria and pests. Several products such as furniture, rug and oven cleaners, paints and lacquers, paint strippers, pesticides, mosquito repellents, dry-cleaning fluids, building materials and home furnishings also release indoor air pollutants. World Health Organization (WHO) has estimated that, 1.5 million premature deaths per year are directly attributed to indoor air pollution from the use of solid fuels. Indian cooking needs long hours, using lots of oils and ghee as frying media, producing oil vapours which are inhaled, impacting the health of women.

Total suspended particulate matter, high level of toxic pollutants, smoke density and oil vapours increase the risk

of respiratory infection, lung cancer, cataracts, cardiovascular and other diseases (Chauhan and Chetan, 2013).

There is an urgent need to create awareness among people about the issue and the serious threat it poses to their health and well-being. Education should help people in finding different ways of reducing the indoor air pollutants at home and working place for cleaner indoor air. Plants produce oxygen and absorb carbon dioxide during photosynthesis and maintain the atmosphere. Oxygen is essential for cellular respiration for all aerobic organisms. Plants help in maintaining oxygen balance, the most important gas that enable us to breathe. Indoor plants have the ability to remove harmful pollutants from the air by absorbing pollutants through their leaves and roots and purifies the air as well as produce pure oxygen to breathe.

Benefits of indoor plants:

- Reduces carbon dioxide level in the room and gives pure oxygen
- Increases humidity
- Reduces the level of certain pollutants
- Keeps air temperatures down
- Provides cleaner air
- Lowers the risk of illness
- Enhances concentration and memory
- Cleaner air enables clearer thinking
- Office plants promotes occupant health and wellbeing
- Promotes healing in hospitals (oxygen therapy).

Material and Methods

The present study is an attempt to design an indoor plants micro tower to get pure oxygen. Oxygen producing plants such as *Dypsis lutescens* L., *Aloe vera* (L.) Burm.f., *Ocimum sanctum* L., *Sansevieria trifasciata* Prain., *Chlorophytum comosum* (Thunb.) Jacques. *Nephrolepis exaltata* Schott. were selected and planted in the micro tower. Plant survival and growth was regularly monitored and the rate of shoot growth was recorded.

Soil type

Soil mixture consists of clay, sandy and silt soil to hold water, perlite to give aeration, vermiculite to hold nutrients. These were uniformly mixed for good root growth and used in the micro tower after sterilization.

Sterilization of Soil

Sterilization reduces the number of microorganisms and weeds present in the soil. The soil particles were mixed thoroughly and then the mixture was moisturized and placed in an oven and allowed to heat at 180°C for 1 hour and cooled before use.

Containers

Indoor plant containers are made of many materials, but clay and plastic materials are most widely used. These requires a greater number of pots as well as large area. Hence, the present study focused on the construction of indoor plants micro tower to grow more number of plants within a small area.



Fig 1: Micro tower

Structural Design of the Micro tower

The Micro tower is made up of zinc material and powder coated with violet colour. It consists of central supporting rod with five trays in different diameters and arranged in an acropetal manner. The diameter of each tray is measured as 620 mm (first tray), 510 mm (second tray), 378 mm (third tray) and 260 mm (fourth tray) respectively. The diameter of fifth top most tray is 142 mm and followed by 210 mm in height. The height of the remaining trays is 75 mm per each and the overall height of the micro tower is up to 1140 mm. Each tray of the micro tower is divided into four compartments except the top most tray. Totally, 17 compartments are situated in the entire micro tower which occupies only a small part of a room (24.409 inches). Excess water is collected from all the trays towards the first tray through the holes present at the base of each tray and finally drained off through the pipe fitted at the base of the micro tower (Fig -1).

The best six oxygen producing indoor plants were selected and planted in the micro tower. Areca palm was planted at the top most fifth tray, Snake plants (fourth tray), First aid plants (third tray), Holy basil (second tray) and Spider plant, Sword Fern were planted at the first tray respectively (Fig -2).

Cleaning and Trimming

To maintain certain size, the shoots were removed when the plants grow rapidly and were cleaned with a moist cotton.

Growth parameters

The percentage of plant survivability and growth rate of shoots were measured and recorded.



Fig 2: Micro tower with indoor plants

Oxygen Producing Plants used for the Study

Oxygen producing plants such as *Dypsis lutescens* L., *Aloe vera* (L.) Burm.f., *Ocimum tenuiflorum* L., *Sansevieria trifasciata* Prain., *Chlorophytum comosum* (Thunb.) Jacques., *Nephrolepis exaltata* Schott. were used for the present study.

Dypsis lutescens (H.wendl.) Beentje & Dransf.

Common Name: Areca Palm

Botanical Name: *Dypsis lutescens* (H.wendl.) Beentje & Dransf.

Family Name: Arecaceae

Plant Description

Areca palm is also called yellow butterfly palm and golden cane palm is one of the easiest palm trees to grow indoors.



Fig 3: *Dypsis lutescens* (H.wendl.) Beentje & Dransf.

The foliage is evergreen, of fine texture and yellow-green in colour. Pinnate, 6 to 8 pale green leaves per stem, 80 to 100 leaflets, to 8 feet long (2.4m) yellow if grown with enough light, 2 feet long. Yellow male and female flowers on the same inflorescence (Asha Jyothi, 2018)^[2] (Fig -3).

Benefits

Major indoor air pollutants removed by areca palm are acetone, xylene, and toluene from the indoor air. A major source of acetone indoor is from petroleum and diesel product, nail polish, paints, detergents, adhesives and cleaners etc. Xylene is also one of the major indoor air pollutants mainly accumulates because of poor ventilation, paints and wooden furniture. Toluene causes central nervous system disorders and also affects the pregnant women and thus causes developmental disorders in newborns and fetus (ATSDR, 2000)^[1].

Aloe vera (L.) Burm.f.

Common Name: First aid plant

Botanical Name: *Aloe vera* (L.) Burm.f.

Family: Asphodelaceae

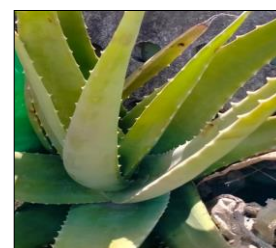


Fig 4: *Aloe vera* (L.) Burm.f.

Plant Description

Aloe vera is a stem less or very short stemmed plant growing to 60- 100 cm tall, spreading by offsets. The leaves are thick and fleshy, green to grey-green, with some varieties showing white flecks on their upper and lower stem surfaces. The margin of the leaf is serrated and has small white teeth. The flowers are produced in summer on a spike up to 90 cm (35in) tall, each flower being pendulous, with a yellow tubular corolla 2-3 cm (0.8-1.2in) long (Gong *et al.*, 2002)^[7] (Fig -4).

Benefits

The plants improving the air quality and emits oxygen at night and increases the longevity of life.

Sansevieria trifasciata Prain.

Common Name: Snake Plant

Botanical Name: *Sansevieria trifasciata* Prain.

Family Name : Asparagaceae

Plant Description

It is an evergreen perennial plant forming dense stands, spreading by way of its creeping rhizome, which is sometimes above ground, sometimes underground. Its stiff leaves grow vertically from a basal rosette. Mature leaves are dark green with light grey-green cross-banding and usually range from 70-90 cm (28-35in) long and 5-6cm (2.0-2.4) wide, though it can reach heights above 2m (6ft) in optimal conditions.



Fig 5: *Sansevieria trifasciata* Prain.

The plant exchanges oxygen and carbon dioxide using the crassulacean acid metabolism process, which is only present in a small number of plant species. The microscopic pores on the plant's leaves, called the stomata are used to exchange gases and only opened at night to prevent water from escaping via evaporation in the hot sun. As a result, stored oxygen is released at the opening of the stomata at night, unlike most plants which continuously exchange gases during the day (Fig -5).

Benefits

The snake plant cleans air better than most other indoor plants as it has the ability to absorb excessive amount of carbon monoxide. Additionally, it emits oxygen and filters other toxins from the air such as benzene, xylene, trichloroethylene and formaldehyde. When placed in office and home space, snake plants can assist in increasing productivity, decreasing stress, fostering happy vibes and

enriching overall well-being and health (Harrison and Lorraine, 2012)^[8].

Ocimum tenuiflorum L.

Common Name : Holy Basil

Botanical Name: *Ocimum tenuiflorum* L.

Family : Lamiaceae



Fig 6: *Ocimum tenuiflorum* L.

Tulsi is known as “The Incomparable One,” “Mother Medicine of Nature” and “The Queen of Herbs,” and is revered as an “elixir of life” that is without equal for both its medicinal and spiritual properties (Singh *et al.*, 2010)^[29].

Plant Description

Holy basil is an erect, many-branched subshrub, 30–60 cm (12–24 in) tall with hairy stems. Leaves are green or purple; they are simple, petiole, with an ovate blade up to 5 cm (2 in) long, which usually has a slightly toothed margin; they are strongly scented and have a decussate phyllotaxy. The purplish flowers are placed in close whorls on elongated racemes (Warrier, 1995)^[36].

Benefits

“Tulsi gives out oxygen for 20 hours and ozone for an hour per day along with the formation of nascent oxygen which absorbs harmful gases like carbon monoxide, carbon dioxide, etc. (Fig -6).

Ministry of environment and forest, New Delhi and forest tech committee also read a paper at the international conference on occupational respiratory disease at Kyoto in 1997 where cyclo oxygenase an enzyme only found in Tulsi was labelled for the first time. This enzyme regulates the mechanism of oxygen evolution (Staples *et al.*, 1999)^[30].

Tulsi has been shown to protect against the toxic effects of industrial chemicals such as butylparaben (Shah and Verma, 2012)^[27], carbon tetrachloride (Enayatallah *et al.*, 2004)^[6], copper sulfate (Shyamala and Devaki, 1996)^[28] and ethanol (Bawankule *et al.*, 2008)^[3] and common pesticides such as rogor (Verma *et al.*, 2007)^[34], chlorpyrifos (Khanna *et al.*, 2011)^[12], endosulfan (Bharath *et al.*, 2011)^[4] and lindane (Mediratta *et al.*, 2008)^[18]. Tulsi has also been shown to protect against the toxic effects of many pharmaceuticals' drugs including acetaminophen (Makwana and Rathore, 2011)^[17], meloxicam (Mahaprabhu *et al.*, 2011)^[16], paracetamol (Lahon and Das, 2011)^[13], haloperidol (Pemminati *et al.*, 2007)^[24] and anti-tubercular drugs (Ubaid *et al.*, 2003)^[32].

***Chlorophytum comosum* (Thunb.) Jacques.**

Common Name: Spider Plant

Botanical Name: *Chlorophytum comosum* (Thunb.) Jacques.

Family Name: Asparagaceae

**Fig 7:** *Chlorophytum comosum* (Thunb.) jacques.**Plant Description**

Chlorophytum comosum grows to about 60 cm & 24 in. height. It has fleshy tuberous roots, about 5-10cm in long. Flowers are produced in a long-branched inflorescence, which can reach a length of up to 75cm and eventually bends downwards. Flowers initially occur in clusters of 1-6 at intervals along the stem (scape) of the inflorescence. Each cluster is at the base of a bract, which ranges from 2-8cm in length becoming smaller towards the end of the inflorescence (Howell *et al.*, 1958)^[9] (Fig-7).

Benefits

Spider plant is also an excellent choice for interior design of both home and professional spaces. Additionally, over decorative it also has functional value, because it cleans the indoor air from dangerous toxic substances such as formaldehyde and xylene.

***Nephrolepis exaltata* Schott.**

Common Name: Sword Fern or Boston Fern

Botanical Name: *Nephrolepis exaltata* Schott.

Family Name : Nephrolepidaceae

**Fig 8:** *Nephrolepis exaltata* Schott.**Plant Description**

The fronds of *Nephrolepis exaltata* are 50-250 centimeters (20- 98) in long and 6-15 centimeters (2.4-5.9) in broad, with alternate pinnate. The pinnae are generally deltoid. The pinnate vein pattern is also visible on these highly compound leaves. The edges appear slightly serrate. The plant can grow both terrestrially and as an epiphyte, linear to lanceolate and glandular (Fig -8).

Benefits

The Boston Ferns are suitable for indoor use as a houseplant. It's also one of the top-rated plants for removing air pollutants from the air and because of its almost insatiable appetite for water it pumps out large amount of water vapor into the nearby air thereby increasing humidity (Maarten *et al.*, 2011)^[15].

There are already reports available on indoor plants which increases oxygen level in the room (Orwell, 2004 and National Aeronautics and Space Administration, 1989)^[21,19].

Results and Discussion

Air pollution is a major global environmental issue in today's scenario which includes both outdoor and indoor environment. Among these, indoor air pollution is highly dangerous than the outdoor pollution. WHO states that, 3.8 million premature deaths occur annually due to indoor air pollution and it also cause stroke, ischaemic heart diseases, chronic obstructive pulmonary diseases and lung cancer.

As people spend most of their time indoor, a new indoor plant micro tower is designed which is not exist so far and the vertical structure of the micro tower occupies only a small area on the floor. Best oxygen producing plants were selected and planted in the micro tower and watered regularly. Within 3 days, these plants were adopted well in the micro tower. After 10 days of planting, the height of the plants was increased. The micro tower is placed at the centre of the room which gives pure oxygen and beauty as well.

Survival of plants and growth parameter such as shoot length (in centimeter) was recorded. At 30th day, percentage of survivability was calculated. After survivability test, the dried spider plant (1) and holy basil (2) plants were removed from the micro tower. The remaining plants were watered regularly. At 1st, 30th and 60th day, shoot length was measured and recorded. All the plants showed increased rate of growth but the growth rate was very low in spider plant (Fig-9).

The shoot length was measured from 1st day after planting the indoor plants on the micro tower. The shoot length was measured at 30th and 60th day. In Areca palm, the shoot length on the initial day was 32.3cm. An increased rate of shoot growth was observed from 30th (32.8cm) and 60th (34.4cm) day. The shoot length on the 1st day, 30th and 60th day of Snake plant was 33.7cm, 34.5cm and 39.6cm; 12.5cm, 13.1cm and 15.9cm in First aid plant; 6.3cm, 9.7cm and 13.3cm in Holy basil; 5.8cm, 5.9cm and 6.0cm in Spider plant; 7.0cm, 8.5cm and 10.8cm in Sword Fern respectively.

The height of the shoot of Areca palm from the initial day up to 60th day was 2.1cm; Snake plant was 5.9cm; First aid plant was 3.4cm; Holy basil plant was 7cm; Spider plant was 0.2cm and Sword Fern was 3.8cm respectively (Fig-10). Among the six plants, holy basil and snake plant showed highest growth rate than the other plants studied. Previous reports are also support the importance of oxygen producing plants at indoor environment (Zhang and Wang, 2010)^[39]. Oxygen producing plants in the micro tower showed well adaptability, survivability and feasible rate of shoot growth. According to the present study, the newly designed micro tower would be a best way to reduce the risk of indoor pollution since it occupies only a small area and can grow large number of plants.

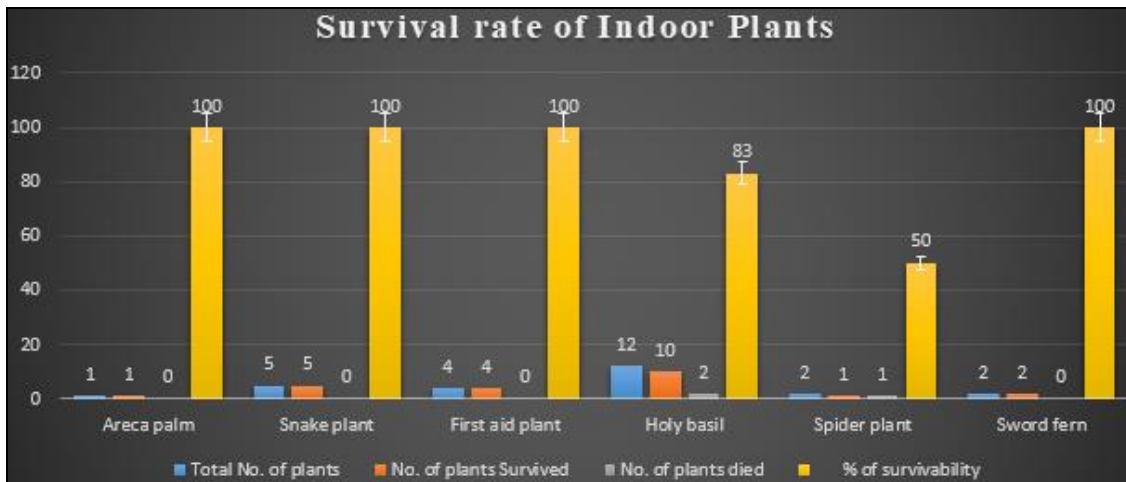


Fig 9: Survival rate of Indoor Plants

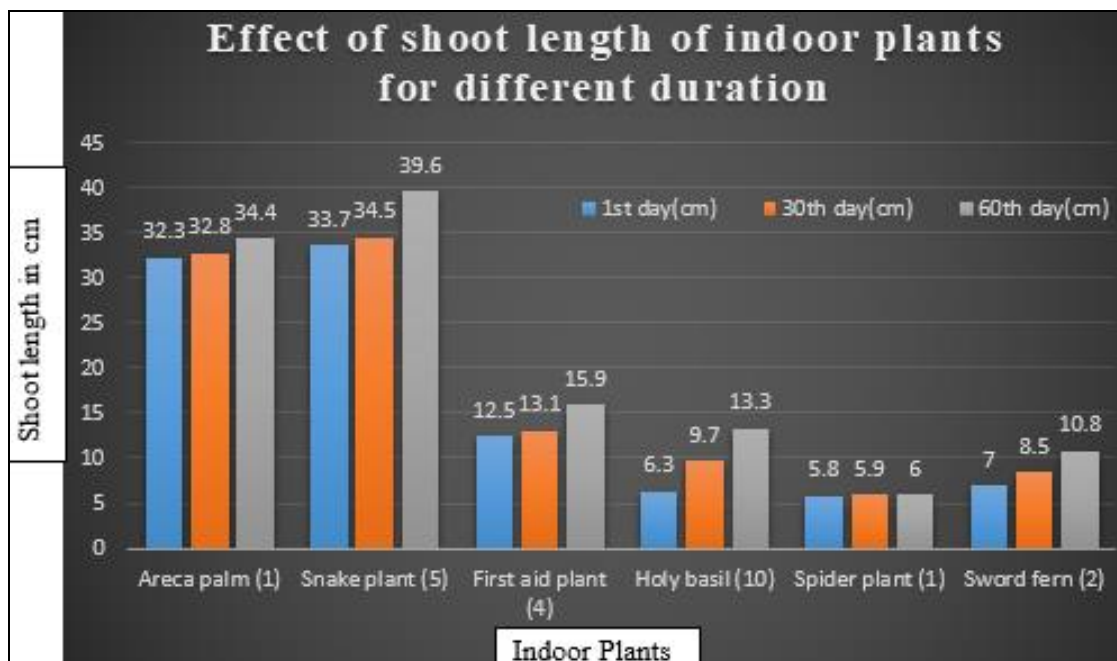


Fig 10: Effect of shoot length of indoor plants for different duration

Conclusion

Our environment is highly polluted right now due to smoke released from vehicles, factories etc. On the other hand, cultivable areas and plant population are being affected very terribly due to population explosion and urbanization. These two major issues lead to atmospheric pollution and the pollutants remains in the environment itself and cause various health issues. The pollutants in the outdoor can also enter indoor environments through natural ventilation and the pollutants in the indoor becomes more harmful. There is growing evidence that, global climate change also affects the indoor air quality and the pollutant exposure level of occupants. Indoor pollution can be even more deadly because it affects people in places where they spend 80% or more of their time each day. In fact, at home and work place, indoor air pollution levels are typically 2-5 times higher than outdoor pollution levels and can quickly become 100 times worse than outdoor air pollution. These pollutants can be reduced by plants because plants release oxygen and absorb CO₂ during photosynthesis. Indoor plants offer a valuable tool to reduce the risk of atmospheric pollutants. In Urban areas, there is not enough

space to grow plants indoors since there is very small area to live in which very difficult to grow plants. Thus, the present study is an attempt to grow more number of oxygen producing plants at indoor environment in a small area using a newly designed micro tower to get pure oxygen and to lead a healthy life.

This study will provide a basic knowledge on micro tower, significance of indoor plants to get pure oxygen and also offer evidence for extensive growth of life saving plants in various places such as houses, schools, colleges and workplaces. Hence, we conclude that, the newly designed indoor plant micro tower would be a great milestone for human society as it offers improved psychological well-being and physical health of human beings.

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