

The Effect of Ornamental Plant Species in Reducing Pollution and Purifying the Air of Sports Facilities

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Ornamental plants are one of the cheapest and most natural elements for air purification and pollution reduction. The ability of this type of plant species to absorb pollutants and purify the air is undeniable. Today, due to industrialization and technological progress, air and environmental pollution has become an important concern in developing countries. The purpose of this research is the effect of ornamental plant species in reducing pollution and purifying the air of sports venues. Pollutants that affect the cleanliness of sports places include: Benzene, formaldehyde, carbon monoxide, trichloroethylene, ammonia, fume and xylene. Eight plant species include: English ivy (*Hedera helix*), Aloe vera, devil's ivy (*Epipremnum aureum*), dwarf date palm (*Phoenix roebelenii*), spider plant (*Chlorophytum comosum*), variegated snake plant (*Sansevieria trifasciata* 'Laurentii'), boston fern (*Nephrolepis exaltata* 'Bostoniensis') and bamboo palm (*Chamaedorea seifrizii*). In order to purify the air and reduce pollution, pollutants were investigated for air purification and reduction of pollutants in this research. According to the results of this research ($P < 0.05$), the necessary information to predict the correlation of air purification with different plant species statistically showed that, based on the model, eight studied plant species have a natural correlation with air purification and *Sansevieria trifasciata* has the greatest effect in reducing pollution and purifying the air of sports venues (Beta = 0.348, Value = 0.966). The results showed that in any part of the world, the studied plant species are among the most effective species in air purification, so they are suitable for streets, parks and sports places. It is suggested that by using the results of this research, the relevant officials and stakeholders should pay more attention and use the mentioned plants to improve the air quality of the city and sports facilities.

Abstract

Keywords: Ornamental plants, Sports, Sports complex, Weather.

INTRODUCTION

Creating an urban green space and using plants in the home and work environment is one of the simplest and most important measures to reduce air pollution, because today the role of plants and trees in cleaning the air is not hidden from anyone (Dabiri and Bashiribod, 2014). Urban forests are an essential part of urban ecosystems and provide a myriad of ecological services that contribute to enhancing human welfare, but at the same time, they are profoundly influenced by urbanization (Barona, 2015). Trees and shrubs are a valuable addition to most properties. Adequately planted, well-maintained trees add beauty, wind protection, shade, wildlife habitat, visual screening, and other benefits to the landscape (Kuhns and Rupp, 2000). Plants form the basis of all ecosystems and can partially alleviate the risk of pollution in green spaces (Lohe *et al.*, 2015). Biomonitor plants are active collectors that reflect the accumulated effect of environmental pollution and the accumulation of toxicants from atmospheric pollution deposition, binding, and solubility of metals on the leaf surface and soil pollution concentration and bioavailability of elements in soil (Petrova, 2011). Plants have the ability to absorb elements of heavy metals and can reduce pollution (Mohammad Khabbaz, 2014). An ornamental plant is a plant that is grown in a flower garden or as a house plant, in addition, some of them are also air purifiers and are effective in cleaning the air. They are usually planted for their flower display. In recent years flowers and ornamental plants industry in Iran has developed extensively (Mahmoodisafa *et al.*, 2016).

The rapid growth of industry and urbanization has produced dust, particulates, and million tons of pollutants that threaten the environment and human health (Hakimzadeh Ardekani *et al.*, 2014). Contrary to the common ideas of most people, the dangers caused by pollutants in closed places are more than in open environments. Based on the research and studies of the American Environmental Protection Agency and its scientific advisory board in recent years on the impact of air pollution on humans, it indicates the fact that the amount of air pollution in indoor places can be 2 to 5 times higher. This has made the risk of indoor pollution one of the five main threats to human health (Pluschke, 2012). The Situation is significantly worsening in densely populated cities, which are highly influenced by anthropogenic activities. Artificially built environments are replacing natural vegetation cover leading to poorer self-monitoring and regulation of urban ecosystems, thereby contributing to poor air quality in cities (Hakimzadeh, 2014). These closed places also include spaces such as sports facilities. In the definition of sports facilities, they say: Spaces that are created by fences and in order to create a place for sports and sports activities. Green spaces change the environment by controlling climate, controlling pollution and increasing air quality, protecting against ultraviolet radiation, wind, reducing pollution, and protecting water and soil quality, and this can also indicate the environmental values of green spaces for sports facilities (Sajjadi, 2017). It is recommended to grow plants that have the capacity to absorb air pollution inside sports facilities (Immig and Rish, 1997).

Trees and green spaces in sports facilities should be designed and built in such a way that the sports center officials can monitor and control the users and athletes and coordinate with the relevant institutions regarding the provision of green space maintenance costs. The studied plant species are introduced in this section:

Hedera helix: This ornamental plant is a flowering, twisting and climbing plant that has an effect on air purification. If it is close to a tree, wall or rock it will climb it, otherwise it will crawl on the ground. This plant has green and heart-shaped leaves and has many medicinal uses, including the treatment of acute respiratory tract inflammation caused by cough, and more than 3 medicinal products are made from this plant in Iran (Hamedani, 2022).

Aloe vera: This plant has long been cultivated as an ornamental plant and a medicinal plant, and it can be kept as a plant in an apartment or in a pot. This ornamental plant is a plant without a stem or with a very short stem and grows 60 to 100 cm. Its leaf is thick and fleshy spear with white jagged edges and the color of the leaf is green to gray. Its flowers grow in summer and are sometimes up to 90 cm long, and it absorbs air pollutants. Different species of this plant are resistant to heat, drought and even salinity, and according to the climatic conditions of Iran, our country has a high capacity to produce this valuable plant (Najafi *et al.*, 2016).

Epipremnum aureum: This ornamental plant is one of the most suitable and popular indoor plants and it is kept and propagated in warm greenhouses. Its decorative value is due to its bright yellow and creamy white mixed colors and it is considered a climbing plant, because after the stems rise and the leaves grow, a path can be determined for it, and it has the ability to follow the desired path. You can grow without soil and only by staying in water and turn the desired place into a beautiful and pleasant place. In addition to beautifying the surrounding environment, this plant also helps purify the air and plays a significant role in oxygen production and air purification, and is very efficient in removing indoor pollutants such as formaldehyde (Amirimehr, 2020).

Phoenix roebelenii: This ornamental plant is an air purifying plant. It is simple and easy maintenance has made it a very suitable choice for the interior of homes and organizations. These ferns are native to tropical regions and some others are native to temperate regions. This ornamental plant is an evergreen plant and is used both in pots and hanging. This plant needs 1000 lux of light, temperature of 25 degrees Celsius, medium to high irrigation, air humidity of 70%-90% and alkaline soil, and it continues to grow in less light conditions (Tajik *et al.*, 2022).

Chlorophytum comosum: This plant is mainly cultivated as an ornamental plant and is considered one of the most popular houseplants that grows in the warm regions of America, Africa and Europe. The ability of this plant to reduce air pollution makes it one of the best air purifying plants. In addition, the plant takes root, leaves and flowers quickly, and the use of nitrate increases the yield and quality of these plants (Osku *et al.*, 2022).

Sansevieria trifasciata: This plant is one of the native plants of Africa, Madagascar and South Asia and is actually a very diverse group of plants. This group has more than 70 species, different colors and sizes. Unlike many other ornamental plants, this hardy plant is long-lived. These plants have short-legged and long-legged cultivars and tolerate low water and low light conditions well, and excessive watering should be avoided. One of the characteristics of this plant is the absorption of air formaldehyde, hence it helps to purify the air (Tajik *et al.*, 2022).

Nephrolepis: This plant is one of the valuable plants that has been known for centuries as an ornamental plant that purifies the air. These plants do not like the cold, so to keep these plants in the climate of temperate regions, they are placed outside in the shade of the sun in the summer and brought indoors in the winter. In northern Iran, this plant and some other palms are planted in outdoor gardens (Tajik *et al.*, 2022).

Chamaedorea seifrizii: This plant is native to parts of Africa and grows in dense rows with reed stalks and can reach a height of 40 meters. This plant is one of the shade-loving and ornamental plants and can continue to live in low light conditions (Eslamian *et al.*, 2009).

A review of research literature shows: Akhavan Markazi *et al.* (2021) showed in a research entitled "Comparison of plant remediation power of two ornamental plants pothos and snake plant when faced with indoor air pollution" that indoor air pollution is one of the most important environmental issues in the world and every The two species used in the research are capable of plant remediation of closed environments, and this ability was observed in pothos more than snake plant due to its higher adaptability to the conditions. Also, when exposed to

benzene, the most stress and tissue damage were caused to the plants and the least when treated with acetone. Cai and Li (2019) showed that in a detailed survey to determine the levels and sources of heavy metal pollution in street dust in Shijiazhuang, China, the mixed group of traffic and industry accounted for the largest amount of heavy metals in dust in the city and natural solutions to remove pollution should be identified. Salimi and Sahraei (2016) showed that efforts should be made to purify the air inside the building, because the quality of the air inside the building in conditions of dust and lack of proper ventilation can increase the pollution inside the building, and in this case there will be no way to purify the air and remove pollutants, inside of the building. Mohammad Khabbaz (2014) showed in a research entitled “The role of plants in reducing air pollution” that many plants have the ability to absorb elements of heavy metals and can clean the air and reduce pollution. Fatehifar *et al.* (2012) showed in a research investigated indoor air pollution and ways to reduce it and identified the type of activity in closed environments, especially the type of fuel consumed in heating systems, ventilation of places and their design. He declared the type of activity effective on the amount of pollutants and the reduction of air quality in closed environments. Wolverton *et al.* (1995) showed that leaves, roots, soil and microorganisms associated with plants are a means of reducing air pollution and stated that plant roots and microorganisms associated with them destroy a variety of viruses, bacteria and disease chemicals and they clean the air.

It is obvious that with the large increase of pollutants in urban life and the need to use safe and secure sports places in Rasht city, the need for the presence of plant species in these places is essential for air purification. Therefore, the current study was conducted with the aim of the effect of ornamental plant species in reducing pollution and purifying the air of sports facilities in Rasht city in 2023.

The city of Rasht, capital of Guilan Province in northern part of Iran, is located in a temperate humid region in the foothills of Northern Alborz range in seaward plains (Lat. 37° 16' N., Long. 49° 36' E., Alt. 7 m.) to the South of the Caspian Sea. Its precipitation rate is over 1300 mm, the number of rainy days is 135, and the average relative humidity is 82.6 %. The maximum temperature occurring in July-August is 31.6 °C and the minimum occurring in December-January is 3.5 °C (Meteorological statistics of Rasht based on the data of Meteorological Organization of Guilan Province for 2010–2015). The city of Rasht has a population of 640,000 located in the center of Guilan Province. It has 58 parks and its per capita green space is about 2.6 m² (Annuals Statistics, 2017). This research was conducted from June 2023 to September 2023 in the 6000 person Shohada sports complex in Rasht and Sampling was done purposefully. The location of the study area is shown in Fig. 1.

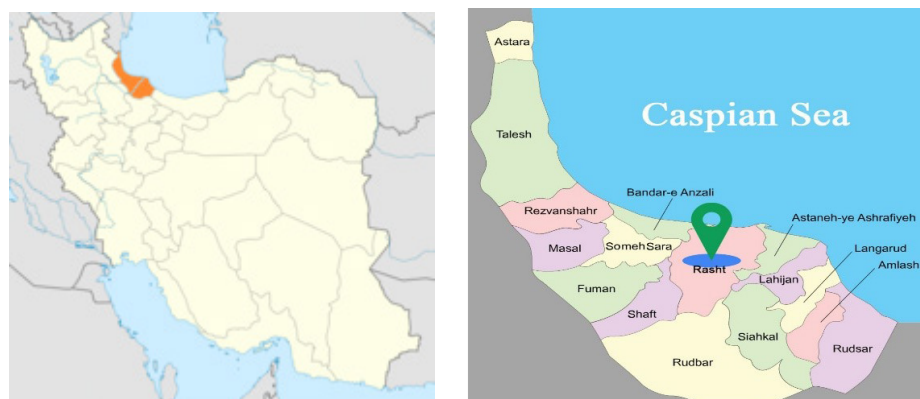


Fig. 1. The location of the study area (Annuals Statistics, 2017).

Sampling and analysis

The samples were taken from the sports facilities of Rasht city. The number of Eight plant species in sports facilities was investigated to reduce pollution and purify the air. In this research, library resources and mass communication tools have been used to collect data. The internal reliability of the data was determined using Cronbach's alpha test. The value of Cronbach's alpha coefficient was 78%, so we can rely on the reliability of the data. For the statistical tests of the research, first, the Kolmogorov-Smirnov test was used for the normality of the data, and the distribution of the data was reported to be normal. Linear regression has been used to examine the contribution of the power of predicting the changes of the dependent variable through the independent variable. Linear regression has been used to determine the effect of the independent variables of plant species on the dependent variable of air purification. The data normality analysis showed that the data distribution was normal. The studied plant species are shown in Fig. 2.



Fig. 2. Plant species studied (Research findings, 2023).

RESULTS AND DISCUSSION

Green spaces and ornamental plant species have a leading role in human life. In this regard, it is necessary to use ornamental plant species to purify the air and reduce pollution. This research was done with the aim of The Effect of Ornamental Plant Species in Reducing Pollution and Purifying the Air of Sports Facilities.

Table 1, shows the studied plant species that are effective in air purification and pollution reduction. These pollutants are: Benzene, formaldehyde, CO, TCE, NH₃, fume and xylene.

The preliminary analysis of the research shows that the assumptions of normality, homogeneity and correlation have not been rejected in it. Then the relationship between plant species variable and air purification variable was investigated. Table 2, shows the positive and normal correlation between research variables.

Table 1. Effective plant species in reducing pollution and purifying the air of sports facilities.

Plant species	Benzene	Formaldehyde	CO	TCE	NH3	Fume	Xylene
<i>Hedera helix</i>	*	*		*		*	
<i>Aloe vera</i>	*	*					
<i>Epipremnum aureum</i>		*	*			*	
<i>Phoenix roebelenii</i>					*	*	
<i>Chlorophytum comosum</i>	*	*	*				*
<i>Sansevieria trifasciata</i>	*	*	*	*		*	
<i>Nephrolepis</i>		*	*				*
<i>Chamaedorea seifrizii</i>	*	*		*	*		

It shows the effectiveness of plant species in reducing pollutants and significant at $P < 0.05$.

Table 2. Correlation coefficient of research variables.

Pearson,s R	Value	Approx. Sig.
	0.425	0.05
N = 8		

Table 3, the summary of the regression model of the independent variable of plant species and the dependent variable of air purification is presented as shown below ($R^2 = 0.0093$, $P < 0.05$) explains the total amount of changes in the dependent variable of air purification by the independent variable of plant species.

Table 3. Summary of the regression model of the variables.

Model	R	R Square	MSE
	0.425	0.0180	0.56766

Table 4, ANOVA, which is used to compare the mean of two or more groups, the linear regression model significantly predicted the research variables. The value of 0.966 shows the statistical normality of the model and the regression value, which has value. The significance level ($P < 0.05$) shows that, in general, the regression model used in the research has predicted the significant value of the main research variable.

Table 4. ANOVA.

ANOVA	SS	df	F	Value
	0.622	7	1.032	0.966

Significant at $P < 0.05$.

The necessary information to predict the correlation of air purification with different plant species is provided in table 5. Statistically, based on the model, the eight studied plant species have a natural correlation with air purification and reducing the pollution of sports spaces and have a value (Beta = 0.348, Value = 0.966).

Table 5. Predict the correlation of air purification with various plant species.

Model	Unstandardized coefficients		Standardized coefficients		t	Value
	B	Std. Error	Beta			
	0.285	0.188	0.348		0.882	0.966

Significant at $P < 0.05$.

In addition to directly purifying the air from pollutants, plants also have an indirect effect in purifying the air from harmful factors for living organisms. There are various plant species that can clean and purify the air inside sports facilities by absorbing pollution and producing oxygen, and remove a significant amount of environmental pollution. The studied plant species *Hedera helix*, *Aloe vera*, *Epipremnum aureum*, *Phoenix roebelenii*, *Chlorophytum comosum*, *Sansevieria trifasciata*, *Nephrolepis* and *Chamaedorea seifrizii* showed that they play an important role in reducing pollution and purifying the air of sports venues. For example, the "*Sansevieria trifasciata*" has a high ability to eliminate most toxins and produces oxygen even at night.

The results showed, *Hedera helix* is an ornamental and evergreen plant that is highly adaptable to environmental conditions and can grow and clean the air in high and low temperatures and low and high light. This plant has the ability to absorb pollutants such as: Benzene, formaldehyde, TCE and fume. The results of these researches are in line with Hamedani (2022), Sajjadi (2017), Lohe *et al.* (2015) and Mahmoodisafa *et al.* (2016). *Aloe vera* is an ornamental plant with many properties, one of its most famous benefits is absorbing pollutants such as formaldehyde and benzene and purifying the air. The research results about this plant are in line with these researches of Najafi *et al.* (2016), Lohe *et al.* (2015), Mohammad Khabbaz (2014), Immig and Rish (1997) and Wolverton *et al.* (1995). *Epipremnum aureum* is one of the popular ornamental and apartment plants that is very easy to maintain at home. This plant is a resistant plant that has a great ability to absorb environmental pollution. This plant can be easily fume, formaldehyde and CO to absorb and purify the air and has many uses in sports facilities. The results of the research are in line with researches Akhavan Markazi (2021), Amirimehr (2020), Sajjadi (2017) and Dabiri and Bashiribod (2014). *Phoenix roebelenii* is a valuable ornamental plant that has been used as an agricultural plant for centuries, and the ability of this plant to purify the air and reduce pollution is undeniable. This plant can absorb NH₃ and fume and clean the ambient air from pollutants. The results of these researches are in line with researches Tajik *et al.* (2022), Lohe *et al.* (2015), Dabiri and Bashiribod (2014), and Mohammad Khabbaz (2014).

Chlorophytum comosum is one of the most resistant and cheapest ornamental plants. This air purifying plant absorbs and removes many abnormal elements of the environment such as xylene, formaldehyde, benzene and CO. In addition to being considered a greenhouse plant, this plant is also compatible with open and closed environments such as sports facilities. The research results about this plant are in line with these researches of Osku *et al.* (2022), Sajjadi (2017), Mohammad Khabbaz (2014) and Wolverton *et al.* (1995). *Sansevieria trifasciata* is a beautiful and luxurious plant, with high resistance and evergreen, which is very easy to maintain and grow this ornamental plant. This plant has many fans due to its ability to absorb toxins such as CO, benzene, TCE, fume and formaldehyde and can be used in all open and closed spaces such as apartments, offices and sports facilities. The results of these researches are in line with researches Tajik *et al.* (2022), Akhavan Markazi (2021), Dabiri and Bashiribod (2014), Mohammad Khabbaz (2014) and Immig and Rish (1997). *Nephrolepis* is an air purifying plant and can absorb pollutants such as formaldehyde, xylene and CO, the simple and easy maintenance of this plant has made it a very suitable option for reducing indoor pollution and can be used in it is used in outdoor and other indoor places. The results of the research are in line with researches Tajik *et al.* (2022), Amirimehr (2020), Sajjadi (2017) and Lohe *et al.* (2015). *Chamaedorea seifrizii* is one of the other ornamental plants that has the ability to absorb toxins such as formaldehyde, benzene, TCE and NH₃ and has an effect on air purification and reducing pollution in buildings and sports facilities. The research results about this plant are in line with

these researches of Sajjadi (2017), Mahmoodisafa *et al.* (2016), Eslamian *et al.* (2009) and Wolverton *et al.* (1995).

The results obtained from that research provided useful information about the air purification of sports facilities through the studied ornamental plant species. The research results indicate a significant and important effect of ornamental plant species on reducing air pollution. These plants can be used as the most natural elements in air purification and reducing pollution in sports facilities. But currently, due to the small number and many limitations in related studies, it is recommended to conduct more research in this field. These findings are consistent with the results obtained from research on the relationship between plant components and pollution reduction.

CONCLUSION

Today, air pollution is one of the important challenges we are facing and its negative effects affect the quality of life and human health. In particular, we are always looking for ways to reduce air pollution. Plants are one of the best options for air purification and pollution reduction. Eight ornamental plant species: English ivy (*Hedera helix*), *Aloe vera*, devil's ivy (*Epipremnum aureum*), dwarf date palm (*Phoenix roebelenii*), spider plant (*Chlorophytum comosum*), variegated snake plant (*Sansevieria trifasciata* 'Laurentii'), boston fern (*Nephrolepis exaltata* 'Bostoniensis') and bamboo palm (*Chamaedorea seifrizii*) are given which are effective in purifying the air and reducing pollution. These pollutants are: Benzene, formaldehyde, CO, TCE, NH₃, fume and xylene. According to the results of this research, statistically, the correlation of air purification with the use of ornamental plant species showed that, based on the model, the eight studied ornamental plant species have created a natural correlation in air purification and reducing the pollution of sports facilities (Beta = 0.348, value = 0.966) and the results of this research confirm the significance of using ornamental plant species in air purification and reducing pollution in sports facilities.

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