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PLANTING DESIGN UTILIZING PHYTOREMEDIATION OF GARDEN-RANGELAND ECOTYPES IN URBAN GREEN SPACE (CASE STUDY OF THE NEW CITY OF PARDIS)

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ABSTRACT

Developing and expanding the cities and the increasing the industrial activities in and around cities have produced many environmental problems and issues and threatened human health. It is possible that environmental design science plays a particularly significant role in this field, primarily green space designing that it is possible to be examined in terms of various aspects. Accordingly, there are new ideas in this field, including the design of new cities with a phytoremediation approach. This research aims to examine and analyze the collected library and field documents in order to define accurately the principles of ecological design in new cities utilizing the refining qualities of plants in order to reform the environment and reduce the harmful environmental influences of pollutants. Accordingly, the urban, climatic features of Pardis are first examined and proper air-purifying plants were then investigated and introduced according to the pollution produced by the soil of the region through sewage inserting the canals and no suitable and sufficient green space in the city, which is one of the major environmental problems of this city and regarding the design principles in the surrounding green spaces and passages of the region.

INTRODUCTION

A new list of harmful environmental phenomena such as air pollution, water, soil, waste production, and other environmental pollutants have been provided due to the unnecessary development of industrial cities and developing human dependence on industrial products that have also increasingly diminished the wanted quality of life in the city [1]. It is required to include the current environmental approach into the plans and policies of the city administration in order to maintain current conditions despite instances of instability and threats such as using energy improperly, inappropriate use and consumption of basic resources, population growth, illogical models of production and consumption, increasing pollution, which regrettably, we observe them a lot in metropolitan regions [1]. Various methods are available in order to reduce soil and water pollution that the most well-known of them is to apply plants as phytoremediation of green plants and their relationship with soil microscopic organisms to reduce soil pollution in groundwater [2].

Phytoremediation has been defined as a refining technique including the adsorption, deformation, accumulation, or sublimation of pollutants using plants in order to remove water, soil, and air pollution [1]. Plants utilize various strategies in order to resist metal toxicity, including engineering mechanisms such as the treatment of industrial effluent and biological methods such as microbial Bioremediation. Of course, engineering methods are extremely difficult and pollute another portion of the environment and also these methods are not affordable [2]. It is possible to apply green spaces and landscaping utilizing plants considering its refining properties and decreasing pollutants and also creating visual quality to reduce the damaging effects of environmental pollution by observing scientific principles and rules [1].

There is no accurate and efficient research in Iran in terms of planting design in industrial and polluted environments based on using plants with environmental refinery power that is appropriate for each region. Notwithstanding, it has already been proven that many plants have refining properties. It can be efficient to isolate, remove, and inactive specific cell organs by releasing organic ligands in tolerance technology such as metal decomposition [3]. Phytoremediation is defined as the technique of refining, including the adsorption, deformation, accumulation or sublimation of pollutants with the help of plants to remove water, soil and air pollution. [4] Plants adopt different strategies to combat metal toxicity that aid in tolerance mechanisms such as metal decomposition, separation from specific cell organs, removal and inactivation by the release of organic ligands. [5]

There are several physical, chemical, and biological techniques that can be applied in order to remove metal-contaminated soil. [6] stated that Brassicaceae have the capacity to release more than 40 grams of selenium per hectare daily in the form of various gaseous compounds. Some aquatic plants such as Typha latifolia L. additionally have the capacity to evaporate selenium into the atmosphere [7, 8]. They explained that the species present various capacities in absorbing elements and the genus of Poaceae or Gramineae has the most distinguished plenty of species and the root has a more substantial percentage compared to the stem and leaves as an absorbing organ. Furthermore, zinc with

13.97% had the highest frequency of adsorption by studied species among the adsorbed elements. [9] stated that common water hyacinth/Eichhornia crassipes is an effective plant in order to remove rare metal elements from sewage streams. All these properties and explanations explain that common sunflower (Helianthus annus L.) and mustard (Brassica juncea) are the most effective plants introduced in order to be used in plant treatment techniques and removing heavy metals from aquatic environments [10]. Mustard roots have the capacity to absorb cadmium, chromium, copper, nickel, lead, and zinc, while common sunflower removes lead, uranium, cesium-137, and strontium-90 from hydroponic solutions. [11] It is possible to perform phytoremediation by planting special rangeland species in order to improve and reform the soil. Plants with high absorption capacity belonged frequently to the families Asteraceae, Fabaceae, Brassicaceae, Poaceae, and Amaranthaceae. Several rangeland species whose phytoremediation properties have been investigated include Milkvetch, Acantholimon, Festuca, Medicago sativa, White Clover, Alyssum, Parviflorum, Artemisia, Artemisia sieberi, Fumaria officinalis, and Ebenus stellata. Sunflower is used to remove heavy metals and absorbs most of the lead and cadmium through the roots of the plant. Sunflower has a higher plant extraction potential compared to many plants [12, 13].

The offered materials and current environmental problems explain that it is required to provide a solution based on ecological principles in order to remove and reduce damage in industrial and new cities and stop environmental problems in the future, consequently, this study aims to design planting using garden and rangeland plants with the property of phytoremediation in urban green space in Pardis.

RESEARCH METHODOLOGY

The research method in this study involves data collection and data analysis, which has been performed using library and field methods and in a descriptive form. Texts, papers, and Internet resources have been exactly analyzed in the first stage in order to formulate a well-defined definition of new cities, their principles, and landscape design. Reasoned sources such as maps, aerial photographs and upstream plans were then considered and the industries active in this city and the type of pollutants were also recognized in order to identify the components of the new Pardis city. Another group of information is available that is registered by referring to the relevant centers and receiving earlier registered information. It was then recommended to perform planting design by observing the criteria based on phytoremediation and introducing proper plants for this method.

Pardis is the center of Pardis County and is located in 17 km northeast of Tehran and there is no meteorological station in the new city of Pardis to examine the climate of the region, hence, we have used meteorological information of Abali and Dushan Tappeh synoptic stations. Abali synoptic station is located at 35° 45° ***north*** latitude and ***51° 53° east*** longitude and 2465 meters above sea level. The geographical position of Dushan Tappeh synoptic station is ***35° 42°*** north latitude and ***51° 20°*** east longitude at an altitude of 1209 meters above sea level.

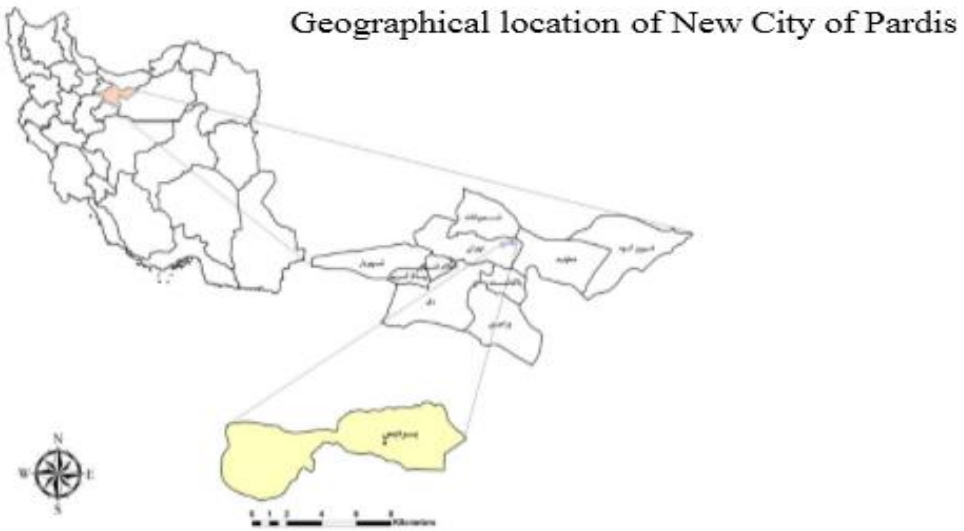

Figure 1- Map of the studied area [14]

Fundamentally, growth and development in plant populations depend on all environmental properties, particularly its climatic requirements. Consequently, atmospheric properties heavily influence the type of plant species that have the capacity to grow in any region. [15]. Figure 2 presents the average temperature, minimum and maximum temperature in various months of the year.

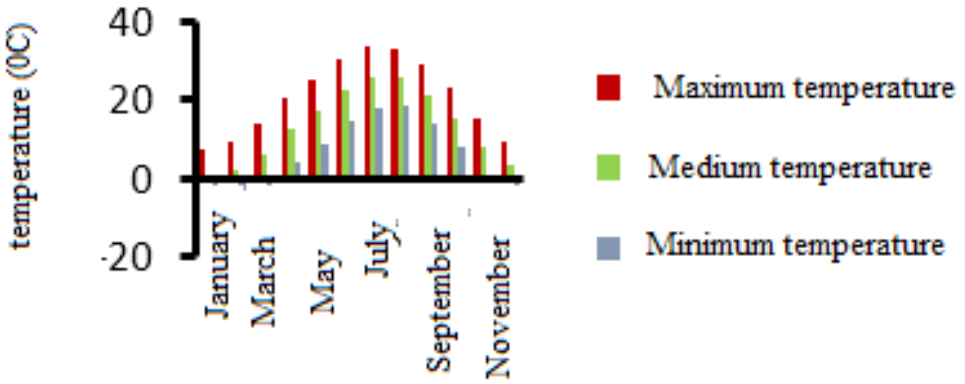

Figure 2 - Average, maximum, and minimum temperature parameters in selected stations [15]

The new city of Pardis has a semi-arid climate. Hence, it is located on the foothills overlooking south of Alborz, and air currents and climatic influences of central Iran will affect this region and consequently, will have the climatic components of this region of Iran [15]. As Figure 3 shows, March has the highest monthly precipitation and September has the lowest value. The average annual precipitation in the statistical period in selected stations is 404.65 mm

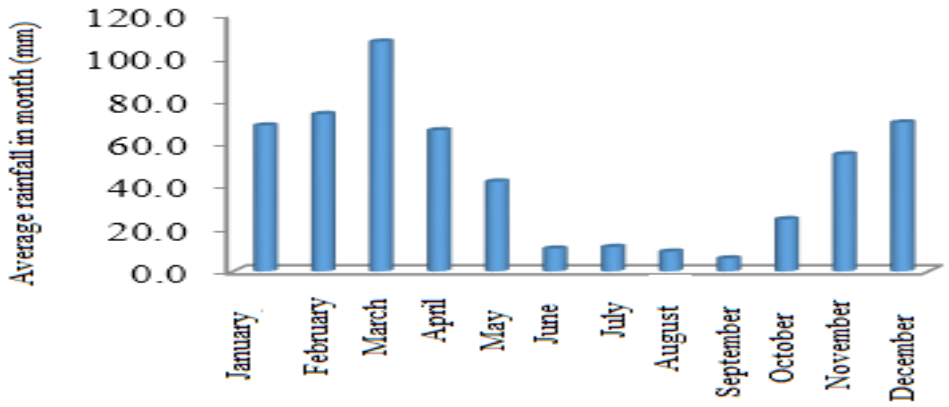

Figure 3 - Average monthly precipitation

Examining soil texture and structure, drainage, erosion, permeability, soil depth, examining the soil chemical analysis such as salinity, pH, minerals, organic, soil grade, and fertility. Exploring the map of soil units that have been developed by the consultant of the green space community plan of the new city of Pardis and coordinating the site area map with it determines that the natural border of the Pardis's large park site includes four distinct soil samples that that the consultant of the city's green space community plan compiles them in the form of four soil units and it is classified as follows [15].

- Soil unit No. 1 ..... The northernmost part of the site and inside the smaller part of the site (medium texture (Loam), quite shallow (10-25 cm) to shallow (25-50 cm))
- Soil unit No. 3 ..... The northernmost part of the large part of the site and the southern part of the smaller part of the site (medium to the heavy texture (Loam-clay Loam), really deep (more than 120 cm) with too high mixed lime)
- Soil unit No. 6 ..... On the northeast side of the larger part of the site (medium texture (Loam), deep (higher than 120 cm))
- Soil unit No. 10 ..... The southernmost part of the site and inside the larger part of the site (heavy texture (clay Loam), quite deep (higher than 120 cm))

It is possible to define the water resources related to the new city of Pardis in two general classes of surface water resources and groundwater resources:
1) Surface water resources: They include the Anjirak water river and the channels that flow from the snowy heights of the northern part of the city, and it eventually flows into the Jajrood River after crossing through the southern plains of the Tehran-Amol superhighway.
2) Groundwater resources: They include wells, passages, and springs that are largely located accompanying the river and waterway of the new city of Pardis. [15]

RESULTS AND DISCUSSION

It is true that there are Khojir National Parks and Sorkheh Hesar Park near the new city, but Pardis is suffering from a severe shortage of green space and the maximum per capita green space will touch 5.5 square meters if the recommended projects are thoroughly completed. Khorramdasht industrial town that is located on the south side of Pardis city, and the increasing population of the city and urban and industrial sewerage, will provide air and

water pollution. Citizens living in Pardis explain the current identity of Pardis in such a way that is known for the clean air and the beauty of the urban landscape, which, if environmental pollutants are ignored, the proposed identities will degenerate in the next few years [16]. It appears that the Pardis has not been a proper place to construct the city in terms of land use planning. Pardis is a city with the character of clean air and a quiet and nonviolent city that if the environmental indices are not observed in the future, we will experience a polluted city with an increasing number of people and an increase in the transfer of motor vehicles. The cement factory, alcohol factory, Khorramdasht town industries, and the transportation of motor vehicles are the main reasons for air pollution in the region. Furthermore, most industries in the region and Pardis have no effluent treatment system, which if the treatment plant is not established, the water environment of the river will be endangered to pollution and destruction by increasing population and wastewater entering the canals of the Jajrood River [16].

The general public know about the performance and the role of green space and trees in reducing pollution in cities, a tree produces an average of 2 kg of oxygen every year. The amount of oxygen released by leafy trees per hectare is between 2500 to 3000 kg and is able to meet the requirements of 10 people. Additionally, a tree evaporates 250-400 liters of water in a year by evaporating and transpiration, and this amount is different in various plants so that the leafy trees including aciculiform increase the air humidity. Accordingly, it is possible that green space design with a phytoremediation approach plays a significant role in reducing pollution in this area. Fundamental studies in the field of physical, geology, and soil science fields, hydrology, and types of pollutants were collected utilizing field visit reports and maps related to each mentioned case [17].
We extracted the following items in achieving transparent and sustainable principles to plan and design cities [1]:

- The outdoor space of the sites is required to be environmentally friendly and on the other hand, the created green space is required to have a network structure.
- A systematic view should be available in the green landscape design of these sites.
- The proposed landscape is required to have the power of restoration and reconstruction and use a minimum degree of resources.
- It is required that developed landscapes be able to solve various pollutants from industrial activities or make them useful.

It is required to define physical plans in ecological design in order to realize the objectives of the project in order to accomplish the predetermined objectives by executing the project properly. These plans are discovered after the initial recognition of the wanted site and determining the opinions and constraints of the site.

It is required to consider the following cases in planning plants for green space and phytoremediation [1]:

- Applying diverse plant species and resistance to environmental conditions in the area in wide streets to produce visual corridors.
- Reducing the costs to maintain green space applying resistant species and...
- Applying deciduous plants around industrial units has provided shade in the summer and has provided the possibility of direct use of solar energy in winter, which this plan is useful in reducing fuel consumption and pollution caused by it.
- Consuming rainwater and recycled water in a maximum way in order to reduce the efficiency of natural water resources.
- Creating an artificial swamp on the site to help to prevent the deterioration of surface water and collect water waste and create a proper visual landscape in the middle of the city.

- A place to spend leisure and rest time.
- Employing plant species classified in Table 1 in the planting design of the city because of heavy metals in the effluent of the units [12].

Numerous plants have been employed in studies conducted on plant accumulation, but a smaller group of these plants have been more considered due to their wide distribution, easy accessibility, easy growth, and high basic knowledge about these plants [18].

Stabilized Vegetation

It has been proven that metal-tolerant native grasses have been successfully established in metal ores in the UK and have a proper growth during 9 years. [19] Brassica June Indian mustard has comparatively high biomass. This plant grows fast and has the ability to absorb and accumulate metals and radionuclides. Sunflower has also the capacity to accumulate metals and has the same biomass as Brassica June Indian mustard. [20] The study conducted on modeling the pollution estimating in the United States showed that urban trees have eliminated massive amounts of air pollution and improved urban air quality.

Row	The title of plant	The Persian name	The Latin name	Absorbent organ	Absorbed contaminants
1	Plants with ornamental form	False cypress	Chamaecyparis sp.	-	Smoke and soot, nitrite
2	Ornamental herbaceous plants and flowers	Viola douglasii	Viola calaminaria	-	Lead, zinc
3		Akhtar	Canna generalis	-	Lead
4		Ornamental Cabbage	Brassica juncea	-	Lead
5		Sunflower	Helianthus Annus L.	-	Radioactive, metals, strontium-90, cesium-137
6		Sweet scented geranium	Pelargonium SP.	-	Metals, hydrocarbons, nickel, cadmium and lead
7		Alyssum	Alyssum lebiacum	-	nickel
8		Dichondra grass	Cynodon dactylon	-	cadmium
9		Crowngrass	Paspalun vaginatum	-	cadmium
10		Catchflies	Silene vulgaris	-	Copper, cadmium and zinc
11		Festuca	Festuca arundinaceae	-	Petroleum hydrocarbons
12	Flower	Lilac	Syringa vulgarism	-	-
13	Shrubs	Oleander	Nerium oleander	-	Lead
14		Kornos	Cornus alba	Root,Stems leaves	Cu, Zn, Pb, Cd
15		common juniper	Juniperus communis	Root,Stems leaves	Cr, Mn, Ni, Cu
16		Euonymus japonicus	Eunymus alatus	-	Ozone

Table 1- Proposed species that are proper for the climate and absorbers of

Control of pollution from PM10, NO2, SO2, CO, O3, in an average of 711,000 tons yearly has been estimated in cities, and a study conducted in Boston also showed that trees planted on city streets and parks are different in terms of resilience to urban environmental stress. Applying plants to dismiss phytoremediation is an interesting and efficient way in order to improve urban air quality, therefore, it is possible that tree planting management based on shading, selection, and type of plant species to be a sustainable strategy in order to improve urban air and be near the urban standards [21]. Consequently, it is better to utilize plants in shrub planting compositions that can absorb these pollutants. Nevertheless, we can apply plants that occupy more space per unit area in order to increase the refining process or combine them with plants with green surfaces, which is based on size, color, adaptability, etc. [1]. Phytoremediation stops the destruction of natural landscapes and increases the activity and diversity of soil microorganisms and increases the health of ecosystems. [22] Most of the polluted sites have herbaceous and resistant plant species and it is a safe method of biological treatment to perform refining by them and other non-edible species, particularly ornamental species due to not joining the food chain network [23]

It is important and required here to create an interconnected network in planting plant species, provide continuity in maintenance facilities, and also observe connected visual lines. According to the phytoremediation approach in the ecological design of the site, it is highly significant to select plants suited to the type of pollutants and also the refining properties of the plant and apply the principles of landscape design in this field [1]. Coordinating the properties of soil units indicates that as we move from the south of the site to the north of the site, soil pH, flow rate, land slope and gravel amount will be increased and soil depth and its ability will be decreased to develop green space, which it is required to pay high attention to the selection of plant species for planting in this space because of high cost and time-consuming process of soil remediation to eradicate these problems, otherwise we will encounter many problems that will impose a high cost on the project during operation [15]. Finally, according to the topography of the park border and the quality of its soil and estimating environmental, implementation, and economic considerations, the best way to reduce implementation costs and eventually utilizing and creating a more sustainable space is to sample and determine the soil components of the important parts of the green space before implementing the green space of the project and after the implementation of the architectural plan so that the costs to provide the most sustainable design can be reduced by combining the soil reformation strategy and selecting the suitable species with the environmental constraints of this field [15].

Although, the soil of this area has a high ability to create runoff in the natural state and this increases the possibility of erosion and flooding, but after the implementation of the project, most of the project will be allocated to green space, and measures will be taken to increase the permeability of the soil and also the plant species will be dehydrated In the implementation of vegetation, which these actions highly reduce the potentiality of runoff, and they are required only be performed in areas with very steep slopes or measures such as

the implementation of absorption wells is required to be taken at surfaces that are not penetrable. [15]

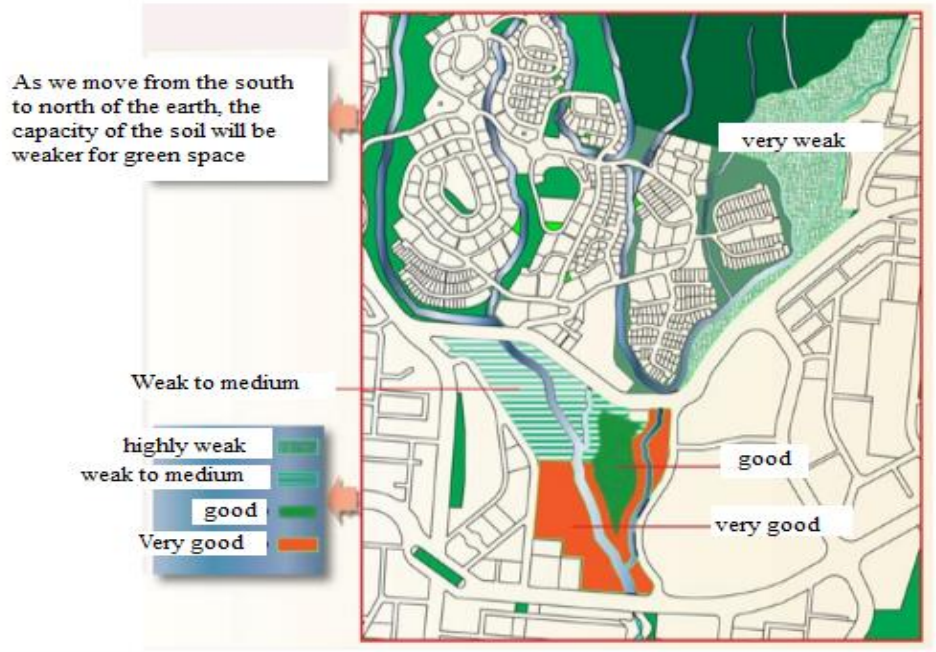

Figure 4- Soil capability for green space [15]

FINAL CONCLUSION

Pardis, as a dynamic and active system, requires a constant flow of matter and energy, and if the energy and materials do not enter and exit the city according to a suitable and sustainable environmental management model, the city system will be disrupted and mismanaged and it will cause environmental, social, economic and political problems at the regional and national levels in the long term. Consequently, it will be highly useful and valuable to recognize environmental problems, particularly for new and emerging cities in order to solve current problems and compensate for previous damage and protect the environment. [16] Currently, heavy metal pollution in soils is one of the most significant environmental concerns and health issues due to the potential risk of food chain pollution and other health risks. In this situation, it is possible that phytoremediation techniques seem like a significant tool to solve this problem. Hyperaccumulators can be utilized effectively to extract and collect large concentrations of harmful metals and other inorganic and soil contaminants. Furthermore, it is an interesting and useful method to use plants in order to remove pesticides and to improve urban air quality, accordingly, it is possible that managing tree planting based on shading, selection, and type of suitable plant species be a sustainable strategy in order to improve urban air and reaching to urban standards [21], accordingly, it is better to use plants that have the power to purify pollutants, also plants can be used to absorb pollutants that occupy more space per unit area and produce more biomass and have the ability to be combined with other green plants.

REFERENCES

Farzamfar N, Taghavi Lu, Kafi M, Khorasani N. A.Ecological design with emphasis on phytoremediation in order to perform sustainable development. (Case study: Parand Industrial Town). *Journal of Sustainability, Development, and Environment*.2004; 2:13-30.

Zangiabadi S. Phytoremediation Technology in removing Soil Pollution, First National Conference on Phytoremediation, International Center for Advanced Science and Technology and Environmental Sciences; 2011, Kerman.

Kamri A, Farshadfar M. 2012. New phytoremediation technology to generate a sustainable environment. *Journal of Biosafety*.2012; 5: 107-121.

Amoei A, Mahvi A, Nadafi K, Fahimi H, Mesdaqinia A, Naseri S. Examining optimal operating conditions in phytoremediation of solid polluted by lead and cadmium by native plants of Iran. *Scientific Journal of Kurdistan University of Medical Sciences*.2012; 4: 93-102.

Choppala G, Saifullah, Bolan N, Bibi S, Iqbal M, Rengel Z, Kunhikrishnan A, Ok YS. Cellular mechanisms in higher plants governing tolerance to cadmium toxicity. *Crit. Rev. Plant Sci*.2014; 33: 374-391.

Sarwar N, Imran M, Shaheen MR, Ishaque W, Kamran MA, Matloob A, Rehim A, Hussain S. Phytoremediation strategies for soils contaminated with heavy metals: Modifications and future perspectives. *Contents lists available at ScienceDirect Chemosphere*. 2017; 171: 710-721.

Pilon-Smits E. Phytoremediation. *Annual Review of Plant Biology*.2005; 56: 15–39.

Tamratash R, Tatian M. R, Bakhshandeh Larimi S, Shokrian F. A review of aquatic plant species absorbing heavy elements in aquatic ecosystems of northern Iran. Wetland ecobiology.2009; (2). Pp. 81-90.

Zou Z, Qiu R , Zhang W, Dong H , Zhao Z , Zhang T , Wei X Xinde. The study of operating variables in soil washing with EDTA. *Environmental Pollution Journal*.2009; 1: 229-236.

Ghosh M, Singh S.P. A review on phytoremediation of heavy metals and utilization of its by-products. *Applied Ecology and Environmental Research*.2005; 3: 1–18.

Dushenkov S, Kapulnik Y. Phytofilitration of metals. In: Raskin, I., Ensley, B.D. (Eds.), *Phytoremediation of toxic metals - Using plants to clean-up the environment*.2000; 89– 106.

Karimi A, Hessit b, aShahbazi S. Applying refining plants in Desert Rehabilitation, First National Desert Conference.2012

Mehrabi G, Musanejad A, Musanejad M. Applying plants to eliminate soil pollution, the first national conference on phytoremediation, Kerman, International Center for Advanced Science and Technology and Environmental Sciences.2011

Ziari K, Asadi S, Rabbani T, Molaei Qolichi M. *Journal of Human Geography Research*.2013; 45: 1-28.

Architectural Exploration Consulting Engineers, 2005. Large Park of Pardis.

Moharram Nejad N, Malundi M. Examining the environmental problems of the new city of Pardis and presenting management solutions. *Journal of Environmental Science and Technology*.2007; 9: 121-127.

Bahreyni H. City, Urban Planning and Environment, *Journal of Environmental Studies*.1997; 20: 76-84

Mohammadzadeh A, Rahimi Moghaddam S, Chaychi MR, Heidarzadeh Y. Phytoremediation ability of nickel-contaminated soil using Sunflower (Helianthus annuus L.) and Sorghum (Sorghum bicolor L.) , *electronic journal of soil management and sustainable production*. 2006; 6: 131-142.

Hinchman R R, Negri C, Gatliff E G. Using green plants to clean up contaminated soil, groundwater and wastewater. *Agronne National Laboratory and Applied Natural Scinces, Inc*.2002

Davies F T, Puryear J D, Newton RJ, Egilla, J N, Saraiva Grossi J A. Mycorrhizal fungi increase chromium uptake by sunflower plants: Influence on tissue mineral concentratinon, grogth and gas exchange. *Journal of Plant Nutrition*. 2002; 25: 2389–2407.

Ferast m. The fig tree temples are suitable to control noise and air pollution. The second specialized conference on environmental engineering.2008.

Mohebbi A, Haroutionian S, Moezi A. Examining lead uptake by maize, alfalfa, and sunflower. Fourth Specialized Conference on Environmental Engineering, Faculty of Environment, University of Tehran, November .2010.

Taghizadeh M, Kafi M. Introducing phytoremediation technology and green space plant purifiers. Set of the Papers of Third National Conference on Green Space and Urban Landscape. Special issue of the monthly supplement, No. 27.1999.