Original Research Paper

Phytoremediation and Adsorption of Heavy Industry Emitted from Cement Industry through Plant Leaves, Case Study: Golestan Peivand Cement Factory

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Abstract: Cement factories are found to be one of the major causes of pollution. Cement mist and dusts depositions affect the photosynthesis, secretion and fertility of the plant. Increasing the concentration of airborne dust reduces photosynthetic potential in leaves, closes leaf stomatals and, in general, reduces the growth and fertility of plants. The purpose of this study is to determine the best tree species for absorbing contaminants from the cement plant. Data were analyzed using descriptive statistics and inferential statistics. To determine the normal distribution of metal content in oak, Paliurusspina-christi Phragmitesaustralis, Kolmogorov-Smirnov test was used and one-way analysis of variance was used to determine the difference. The results showed that F calculated for cadmium level ($F = 4.123$) with degrees of freedom df = 17 and df = 2 at 95% confidence level ($\alpha = 0.05$) is greater than F from critical table ($F = 3.59$), therefore difference between cadmium and oak and Paliurusspina-christi and Phragmitesaustralis plants is statistically significant, but the means of other metals in oak and Paliurusspina-christiandPhragmitesaustralisis statistically equal. Also, the amount of cadmium with oak tree was significantly different (P-value = 0.049). It was found that the cadmium content of the Paliurusspina-christi was higher than the oak tree, in other words Paliurusspina-christicadmium others get better.

Keywords: Air Pollution, Cement Industry, Paliurusspina-christi Golestan

Introduction

Air pollution is one of the most important environmental problems that have always been a serious threat to public health and health (Perez and Reyes, 2006). Industrialization, urbanization and continuous growth of the population have led to an increase in air pollution and the environment. Chronic exposure to air pollutants is a widespread global problem; (Daryanoosh *et al*., 2016).

The cement sector is one of the most important sectors producing pollutants in the environment, which has significant environmental effects on the ecosystem. The most important pollutants from the cement industry are the immediate and local effects of particles and carbon monoxide, each of which has a different effect on living organisms and the environment. Abbasi and Salari (2006) Air Pollution Caused by Outputs from the Manufacturing Industries Cement can be considered an important source of environmental pollution. Dust and gases from the cement industry today are of particular importance to manufacturers and pro-environmental organizations and residents around the factories. The presence of particles along with air pollutants such as nitrogen and carbon atoms in the smoke exhaust can have irreparable effects on humans and the environment around the above industries, such as plants (Singh and Rao, 1981). The particles released from the cement

industry, due to their size and composition with other air pollutants, have various and irreparable effects on plants. However, the existence of abundant mines, favorable energy reserves and the high demand for domestic and foreign markets has led to a dramatic increase in the growth rate of cement industry in recent years. Dust and gases from the cement industry have increased with increasing production and in addition to air pollution, soil contamination and subsequent damage to plant tissues (Environmental Protection Organization, 2003). Increasing the concentration of dust released from cement plants in the air will reduce the photosynthesis potential, close the stomata of the leaves and, in general, reduce the growth and fertility of the plants (Mosavi *et al.*, 2015). Cement dust particles often have a diameter of less than 10 microns and, given that the means diameter of the plant apertures is 30 microns (Majnounian, 1990), these particles easily permeate the middle tissue of the plant and since more than 80% These particles form calcium carbonate ($CaCo_3$), react with inter-tissue water and produce carbonic acid (Farmer, 1993). Iran is one of the few countries that are seriously looking for a widespread expansion of the cement industry, with cement production from 13 thousand tons in 1956 to 1963 million tons in 2007, the highest level of production in the Middle East (Sadeghiravesh and Khorasani, 2009). Studies in Iran have shown that there is a reverse correlation between vegetation density and vegetation density, with dust particles deposited out of factory chimneys. As far as the source of particles is farther away, the amount of deposition of particles decreases and vegetation density and diversity increase. In the vicinity of the plant, the amount of deposition of more particles and species diversity is reduced (Kakooei *et al.*, 2012).

The effect of dust particles on cement plants on communities and ecosystems.

Effect on Human Health

Persons exposed to cement particles are at risk of developing pulmonary, respiratory and digestive diseases (Adak and Purohit, 2007). Also, those exposed to cement particles released from their workplace are at risk of increased liver abnormalities, pulmonary disorders and cancer. Reducing the antioxidant capacity of blood plasma is a possible cause of the mechanism of the disease (Aydin *et al.*, 2010).

Effect on Plants

Dust deposits physically affect plants either directly or indirectly and can degrade plant resources. The plant stomata are blocked by the deposition of cement particles on the surface of the leaves and thus the mechanism of air exchange and the use of sunlight (the process of photosynthesis) is disrupted (Migahid and El-Darier, 1995). Particles released from cement factories are often taken to the areas around the factory through wind and settling in the factory. Such deposits of fine particulate matter and other pollutants interfere with the metabolic activities of the plants and cause serious damage to the growth and plant quality and the closure of the leaf aperture, early fall and eventually plant crop decline (Singh and Rao, 1981).

Impact on Surface and Ground Waters

When particles of cement come into contact with water, hydroxide is formed which eliminates the natural water play and covers a thin layer of cement covering the surface of the springs and lakes. Water hardness, which is subsequently responsible for respiratory and intestinal diseases in the area, is affected by the excess salt of AL, Mg, K, Na, Ca, such as hydroxides, sulfates and silicates (Mishra, 1991).

Considering the above mentioned issues, which indicates the increasing development of the cement industry in the country and since these industries are potentially polluting the environment, it is necessary to identify the identified effects and appropriate strategies for controlling and decreasing it. The purpose of this study was to investigate the effect of cement dust on leaf of tree species around Golestan cement plant. Therefore, the Neka Cement Plant, with its production of over 3 million tons of Portland cement per year, is considered as the largest cement producer in the country, located near the three villages and forests, to determine the absorption of pollutants from the industry's dust.

Studies on contamination of cement industry in Iran and in the world.

Bertoldi *et al.* (2012) explored the impact of the cement industry on the health of the population of plants near the cement factory in two cities of Italy and found that this industry has very harmful effects on the health and life of the plant population near the plant. Princewill and Adanma, 2011) studied the concentration of pollutants such as manganese, chromium, cadmium, zinc and iron in woody species Azadiracthaindica, MangiferaindicaAndropogongayanus, Uvareachamaeand Gmelinaarborea around the cement plant in Nigeria. There was a positive and significant correlation between heavy metals in soil and plant growth and the concentration of Cadmium element was higher than standard. Amal and Migahid (2011) in the western part of Egypt on wild spinach desert species and stated that annual species are very sensitive to pollution of cement plants and have less growth than plants in less polluted areas and the amount of chromium has been less pronounced in the one-year-old species. Nanos and llias (2007) in a region called Vlús, the Greek center,

cement dust on the parameters of the physiology of olive leaves and stated that cement mist changes the leaf physiology, which is the result of a change in plant fertility (Figs. 1 and 2). The research hypothesis can be considered a scientific guess or pre-judgment, which is tested by gathering the facts that leads to acceptance or rejection of that hypothesis. In other words, the hypothesis is considered as the proposed solution by the researcher for the research problem or the result of the research. For this research, a hypothesis is considered. Thus, the absorption of metal elements in tree species is more than shrub species. One of the objectives of this research is to determine the best tree species to absorb pollutants released from the cement plant.

Materials and Methods

Geographic and Human Features of the Studied Area

Golestan province with 2.2 million hectares of land, consisting of a total area of Golestan province, is about 1126000 hectares and a forested area is about 430000 hectares and totally accounts for about 70% of the province's natural resources.

Galicash is one of the cities of Golestan province in northern Iran. The city of Galicash was founded in 2010. The center of the city is its Galicash city. The Golestan Cement Cement Factory is located 6 km from Galikesh city, located in Golestan province and is located at the foot of the Nile Mountain of the AlborznMountain.
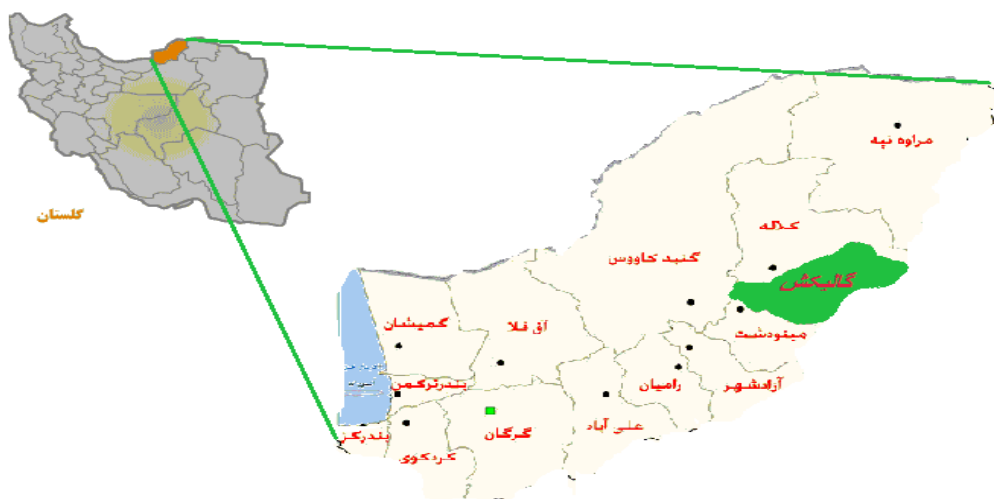

Fig. 1: Geographical location of the studied area

Fig. 2: Cement and mine extraction raw materials

Research Method

Determine Sampling Stations

To do this, seven stations were selected; the first station in the factory and six stations outside the area around the factory were selected. The stations were selected in such a way that there are three species of vegetation studied, including Paliurusspina-christi, oak and Phragmitesaustralis. Each station had three replications and for each sample of Paliurusspina-christi leaf, oak and Phragmitesaustralis, 21 samples were collected from all over the region.

How to do Sampling

Sampling was carried out at the specified points in July. At first, after examining the area and identifying species, among the species in the factory, three species were distributed at almost all levels of the factory and the surrounding area. Species were Quercus, Paliurusspina and Phragmitesaustralis. The sampling time has been in the period of growth and before the leaf fall, when it has the highest accumulation of contamination. Then she began to prepare leaf samples from the three species mentioned from the factory. Sampling was performed on sunny days (at least 10 days intervals from the last rainfall). The leaves were collected from the outer surface of the canopy from a height of 1 to 2 m from the surface of the earth and those facing the factory. To ensure that the leaves are homogeneous, leaflets with a length of 10.5 cm were collected. At each station, 1 sample tree was sampled. In the selection of stations, the dominant region of the region was of great importance, as it was sampled which was dominant in the direction of the wind and was located behind the factory. The leaves were then placed in plastic protective containers with minimal handling on the plastic and placed on each plastic bag, specifying the specimen type and the station number and repeat. A total of 21 leaf samples were taken (Fig. 3).

Sample Preparation

In the next step, the leaves dried out in open air and covered in a covered area and lasted for one to two weeks. After removing the samples from the plastic bags, place them on plain paper and exposed to air and then, after drying, the crushing machine is used for crushing the samples. Then they were transferred to the lab and in the laboratory section the digestion was carried out and samples were read by the ICP concentrations of the elements.

Concentration Measurement of Heavy Metals

Sample Digestion Method (AQU Regia Method)

In this method, digestion of chloride and nitric acid was used. First, pour 5 g of the sample into the test tube, then add 5 cm HCl of acid and 2 cc of acid nicotine and place it in the binomial for 1.5 to 2 h. After cooling with distilled water, the volume was 20 cc and then the solution was straightened. In the next step, using the ICP device, the concentration of heavy metals was measured (Moopam, 1999).

Sem Electron Microscope Test

Leaf specimens were subjected to electroscopic microscopic observations for dust morphology studies. In this regard, the Scanning Electron Microscopy (SEM) XL30 model manufactured by the Phillips Corporation of the Netherlands, which was located at TarbiatModarres University, as well as the golden laminating machine used to laminate the samples used in this study, was manufactured by Bal- Tec is from Switzerland.

Information Analysis Method

The data were normalized using Kolmogorov-Smirnov test and homogeneity of variances with Levene's test. In the case of data normalization and homogeneity of data variance, one-way ANOVA was used to compare the parameters. Tukey-HSD tests were used to compare the meanss. Pearson test was used to obtain correlation. All statistical tests were performed using SPSS v.11.5 software.

Fig. 3: An overview of the chemical digestion of the samples

Results

Data were analyzed using descriptive statistics and inferential statistics. Descriptive statistics including tables for comparing the means amount of silver, arsenic, cadmium, cobalt, chromium, cesium, bismuth and barium in oak. Paliurusspina-christi and Phragmitesaustralis, according to PPM. In the inferential statistics for determining the normal distribution of silver, arsenic, cadmium, cobalt, chromium, cesium, bismuth and barium in terms of PPM, in oak plants, Paliurusspina-christi, Kolmogorov-Smirnov test and to determine the difference in silver content, Arsenic, cadmium, cobalt, chromium, cesium, bismuth and barium, according to PPM, one-way ANOVA has been used.

As it is seen, the calculated Z value for all of these metals in oak and Paliurusspina-christiplants is less than 1.96 and their level is less than 0.225 for two-domain tests. There is also a small distance between the mean and the middle, so we conclude that the distribution of these metals in the oak tree and Paliurusspina-christiplants is normal and parametric tests can be used. To study the hypothesis of this study, the amount of silver, arsenic, cadmium, cobalt, chromium, cesium, bismuth and barium in the PPM scale was measured in oak and Paliurusspina-christi. One-way analysis of variance was used to determine the difference between these metals in oak and Paliurusspina-christi.

From the values of "Table 2", since only F is calculated for cadmium content ($F = 123/4$) with degrees of freedom df = 17 and df = 2 at 95% confidence level ($\alpha = 0.05$) from F criticality table 59/3F =), so we conclude that the difference between cadmium levels of oak and Paliurusspina-christi plants is statistically significant, but the means of other metals in the oak tree and Paliurusspina-christi plants is statistically equal to Is. Tukey's post hoc test was used to determine the means cadmium content in which oak and Paliurusspina-christi plants were more than others.

In Tukey's table "Table 4", the significance difference of each of the meanss with other meanss in the column houses is the difference between the mean with the * and in the columns of the P-value with a significant level less than 0.05. From the values recorded in Table 4, only Paliurusspina-christi seedlings with oak tree have a significant difference (P-value = 0.049) and it is evident from the mean of "Table 3" mean that the cadmium content of the Paliurusspina-christi It is more of an oak tree, in other words Paliurusspina-christi absorbs cadmium from other people better (Table 1).

Table 1: Means and Middle and Z-score Kolmogorov Smirnov and Significance Levels for Oak Tree and Paliurusspina-christi

	Variable	Number	Means	Median	Z kolmogorov smirnov	Significance level
Oak	Silver	8	23.25	22.5	0.994	0.965
	Arsenic	8	17.00	18.0	0.571	0.900
	Cadmium	8	14.00	15.0	0.723	0.672
	Cobalt	8	23.75	22.5	0.791	0.559
	Chrome	8	21.25	21.0	0.458	0.985
	Cesium	8	19.88	22.0	0.666	0.760
	Bismuth	8	17.13	16.5	0.515	0.953
	Barium	8	15.63	12.5	0.792	0.558
Paliurusspina-christi	silver	8	26.75	25.0	0.494	0.966
	Arsenic	8	18.25	20.0	0.756	0.618
	Cadmium	8	20.88	20.0	0.542	0.931
	Cobalt	8	26.00	27.5	0.684	0.738
	Chrome	8	18.13	20.0	0.803	0.540
	Cesium	8	23.50	23.5	0.417	0.995
	Bismuth	8	15.88	15.0	0.758	0.613
	Barium	8	12.50	15.0	0.863	0.446
Phragmitesaustralis	silver	4	19.25	20.0	0.698	0.714
	Arsenic	4	17.25	17.5	0.349	1.000
	Cadmium	4	21.25	22.5	0.384	0.999
	Cobalt	4	22.00	22.5	0.601	0.863
	Chrome	4	17.50	15.0	0.883	0.417
	Cesium	4	21.75	22.0	0.538	0.935
	Bismuth	4	17.50	17.5	0.614	0.846
	Barium	4	14.50	15.0	0.620	0.837

Table 2: The results of one-way ANOVA test for the means amount of metal elements of silver, arsenic, cadmium, cobalt chromium, cesium, bismuth and barium in the oak tree and Paliurusspina-christi

		SS	df	MS	F	Significance level
Silver	Intergroup	154.8000	2	77.400	0.65	0.535
	Within group	2025.7500	17	119.162		
Arsenic	Within group	6.7000	2	3.350	0.124	0.884
	Within group	458.2500	17	26.956		
Cadmium	Within group	235.5750	2	117.778	4.123	0.035
	Within group	485.6250	17	28.566		
Cobalt	Within group	46.7000	2	23.350	0.808	0.462
	Within group	491.5000	17	28.912		
Chrome	Within group	54,375.0000	2	27.188	1.225	0.318
	Within group	377.3750	17	22.199		
Cesium	Within group	52.5750	2	26.288	0.724	0.499
	Within group	617.6250	17	36.331		
Bismuth	Within group	9.4500	2	4.725	0.336	0.719
	Within group	238.7500	17	14.044		
Barium	Within group	27.6750	2	13.383	0.389	0.684
	Within group	6.4.875	17	35.581		

Table 3: Number, means and deviation of cadmium content of oak and Paliurusspina-christi plants

	Number	Means	sd
Oak	8	14.000	3.30
Paliurusspina-christi	8	20.875	5.22
Phragmitesaustralis	4	21.250	8.54

Table 4: The results of Tukey's post hoc test to determine the significant difference of cadmium in samples

Component	Componentj	Mean difference (i-j)	P-value
Oak	Paliurusspina-christi	-6.875*	0.049
	Phragmitesaustralis	-7.25	0.097
Paliurusspina-christi	Oak	6.875*	0.049
	Phragmitesaustralis	-0.375	0.993
Phragmitesaustralis	Oak	7.25	0.097
	Paliurusspina-christi	0.375	0.993

*__Note:__ The means cadmium content of the plant is higher than the others, but because the number and standard deviation of Phragmitesaustralis samples are very different, there is no significant difference in Tukey's test

Discussion

Many studies have been done on the role of cement plants on the environment and the development of air pollution and, consequently, its destructive effects on plants (Salama *et al.*, 2011). The pollutants emitted from cement plants are often transmitted through the wind to the farther distances, depending on the severity of the wind at various distances from the plant on the soil, vegetation or residential areas of the area. Of course, the diffusion of these particles from the plant also depends on the size of the particles (Mandal and Voutchkov, 2011). As it was observed in the results, the cement plant is responsible for higher metals such as silver, arsenic, cadmium, cobalt and ... in cyanides. The presence of metals in dusty cement plants plays an important role in reducing the metabolic processes of plants. In addition, contamination from the cement plant contains amounts of toxic compounds such as fluoride, sulfuric acid, hydrochloric acid, lead, zinc, copper, manganese (Andrej, 1987). It is said that the canopy of trees is much

better than other plant species that has the capability to absorb and absorb particles in the air, due to the fact that they have a more violent and rough surface in these plants (Manning and Feder, 1982). Increasing the concentrations of airborne dust reduces the photosynthesis capability in leaves, closes the leaf stomata and, in general, reduces the growth and fertility of the plants. Sadeghiravesh and Khorasani (2009) also found that there is a reverse correlation between diversity and density of vegetation with deposition of dust from dust from the cement plant. As the particle diffusion source fades away, the amount of deposition of particles decreases and the density and diversity of the coating increase.

Conclusion

Research on the effects of cement plant pollutants on vegetation around the cement plant has been shown to degrade plant life. As it was observed, the dust deposited on the leaves of three species of oak and Paliurusspina-

christi and Phragmitesaustralis contained significant concentrations of such as silver, barium, bismuth, cesium, chromium, cobalt, cadmium and arsenic. The concentration of these elements in both species was reduced by distance from the factory. This means that the highest concentration of these elements was observed near the factory. The introduction of these compounds not only disrupts the metabolic activities of plants, but also can be the source of many dangerous diseases such as cancer for humans. Therefore, it is essential that factories located near residential centers should use appropriate filters to prevent the development of diseases such as cancer, respiratory problems and the disturbance of metabolic processes of plants and air pollution and the environment.

Acknowledgement

Author's Contributions

All authors equally contributed in this study.

Ethics

In this article, all ethical principles related to scientific-research articles such as validity and authenticity, originality, data collection in a standard manner, integrity, the accuracy of research and etc were observed.

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