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Application of polymerized graphene oxide for optimization of o-xylene removal from aqueous solutions through response surface methodology

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Expanded Abstract

1. Introduction

Following an accidental oil spill, the removal of surface oil is usually the important concern for decreasing energy loss and damage to the environment. O-xylene is one of the common compounds which exist in the effluent of oil and petroleum industries. Consequently, the removal of o-xylene from groundwater and surface waters is essential. One of main techniques that are useful for cleaning up the soluble oil is adsorption. Adsorption methods are simple and economical and the removal of toxic chemicals using porous adsorbents has aroused attention. Graphene as a new synthetic 2D allotrope of carbon has advantages as an adsorbent due to its flexible structure. Graphene has a very fine potential as adsorbent material due to its low cost and environmentally friendly product and by the fact that graphene can be reused without any significant change in its adsorption capacity.

2. Materials and Methods

2.1. Preparation of graphene oxide (GO)

GO was prepared from graphite powder by Hummers and Offeman method.

2.2. Polymerization of GO

2 g of GO powder were dissolved in 20 ml of dimethylformamide with stirring. Then, allylamine (10 ml) was added to the solution by continuous stirring at 160 rpm for 2 days. Later, the mixture was washed via dimethylformamide and filtered, the product was dried at room temperature.

The grafting of GO with allylamine (GO-AA) was transferred into the flask and was dissolved in 30 ml of methanol. Next, APS (0.75 g) and MVK (30 ml) were rapidly poured to the solution. The mixture was heated at 60°C in a nitrogen atmosphere for 5 h under stirring. The solution was washed with methanol and filtered. At the end, the product was dried at room temperature.

2.3. Modification of polymerized GO with methyl vinyl ketone (GO-MVK)

At first, GO-MVK was mixed with ethanol (150 ml) and aniline (50 ml) and added into the flask. The mixture was fitted under atmosphere of nitrogen at 40°C for 6 h, with agitation speed of 180 rpm. After filtering, the final product was washed with ethanol and further dried in vacuum oven at 40°C for 3 days.

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2.4. Batch adsorption experiments

For batch adsorption experiment, the desired dosage of graphene oxide grafted with poly methyl vinyl ketone and aniline (GO-MVK-ANI) was mixed with 50 ml of aqueous o-xylene solution (20 mg/l) in a 100 ml flask which was shaken using a rotary shaker at 150 rpm at 25±2ºC. Then, the solution was filtered with syringe filter. The concentration of o-xylene was quantified using GC-FID.

2.5. RSM design

RSM is the statistical and mathematical method for designing experiments, building models, and estimating the effects of several factors for desirable responses. This technique is suitable for optimizing the effective parameters with a minimum number of experiments. Herein, the effects of 3 variables in adsorption process including contact time, initial pH and adsorbent dose were investigated with a standard central composite design (CCD). The number of experiments is selected 20 basing on a 2^3 full factorial CCD for the 3 factors. Five levels of factors were investigated according to the obtained experimental data using MINITAB 16 which are presented in Table 1.

Table 1. Experimental range and levels of independent variables

Variable	Factor	Unit	Range and level				
			-α	-1	0	1	+α
Contact time	X_1	min	10.91	45	95	145	179.09
Initial pH	X_2	-	4.31	5	6	7	7.68
Adsorbent dose	X_3	g/L	0.05	0.8	1.9	3	3.75

Finally, the optimum value of parameters has been earned for the selected target (o-xylene removal efficiency) in optimization process of RSM program.

3. Results and Discussion

The synthesized product was characterized via fourier transform-infrared resonance (FTIR) spectroscopy, scanning electron microscopy (SEM), energy-dispersive X-ray (EDX) spectroscopy and Brunauer-Emmett-Teller (BET) analysis. The total pore volume and average pore diameter of the GO are enlarged by polymerization and modification. The effect of three different parameters including the contact time, initial pH and adsorbent dose on adsorption process of o-xylene using GO-MVK-ANI were investigated. The o-xylene adsorption behavior at different contact time was carried out (Fig. 1a). As can be seen, the maximum o-xylene removal was observed in the initial 10 min of adsorption process. Then, the adsorption capacity became constant, approximately. The effects of pH on adsorption capacity are shown in Figure 1b. There was no significant change in removal efficiency during the increasing of the pH range. According to Figure 1c, when adsorbent dose increased, the o-xylene removal efficiency improved. The reasons of this enhancement are that the surface area of the adsorbent, available adsorption sites and also active functional groups are improved with increasing of adsorbent dose. Basing on RSM results, the R^2-value is found very high for o-xylene removal (R^2= 99.27%) which is a good confirmation between the experimental and the predicted results. Finally, the optimization of adsorption process was applied for the removal of o-xylene. The experimental checking under optimum conditions (the contact time of 11 min, pH of 4.35 and adsorbent dose of 2.43 g/L) was obtained 74.5% for o-xylene removal efficiency which is close to the model result (75%).
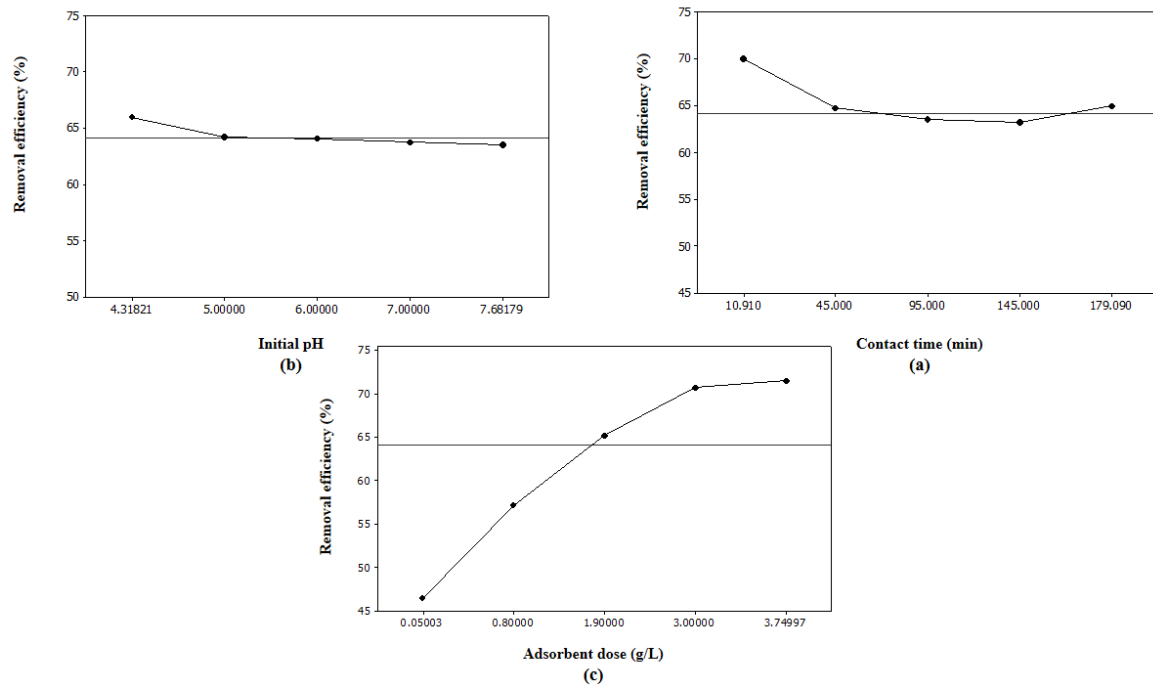
Fig. 1. Main effects of (a) contact time, (b) initial pH and (c) adsorbent dose on o-xylene removal efficiency using GO-MVK-ANI

4. Conclusions

The aim of this research was to investigate GO-MVK-ANI to adsorb o-xylene from aqueous solutions. The total pore volume and average pore diameter of GO were improved from 0.016 cm3/g, 4.853 nm to 0.022 cm3/g, 23.187 nm by polymerization and modification. Based on the results acquired, adsorption contact time was 11 min. It confirms that this adsorbent has high efficiency in the removal of o-xylene for conditions that need rapid treatment. Moreover, GO-MVK-ANI has high stability in the different ranges of solutions pH. According to the ANOVA results, the model presents high R^2-value of 99.27% for o-xylene removal and indicates that the accuracy of the polynomial model was successful. The o-xylene removal efficiency under experimental optimum conditions was obtained 74.5% which confirms close to the RSM results.

Keywords: adsorption, graphene oxide, o-xylene, polymerization, response surface methodology.

Evaluation of Performance of Interpolation Methods in Mapping of Heavy Metals in Soil (Case Study: Harris Town, North-Western Iran)

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Expanded Abstract

1. Introduction

It is inevitable to analyze the existing contaminant elements in soil as the most important source of nutrition for human. Heavy metals are considered and referred among these elements. The contaminated soils of urbanized regions are directly related to human, while these elements are absorbed by plants, through which they enter the human food cycle. The excessive increase of these elements results in the growing incidence of diseases such as cancer. Moreover, the irresolvability of these materials may have dangerous impacts on the human digestion as well as nervous systems. Contamination, due to heavy metals in soil, has even resulted in some animals' death.

There are various factors involved in soil contamination. One of main factors is the incorrect use and increasingly irregular exploitation of nature by human beings. In Iran, inappropriate economic exploitation of agricultural fields and aberrant use of chemicals have led to the higher concentration of heavy metals in soil, turning to a crucial problem in certain areas. The most significant cause of soil contamination is the wrong use of chemical fertilizers, resulting in the agglomeration of heavy metals in soil. Therefore, it is inevitable to identify the spatial distribution of these elements. The geo-statistical instruments have facilitated the quantification of soil spatial characteristics, whereby leading to the probability of spatial interpolation.

Objectives of the study are: (i) to prepare zoning maps of elements including Zinc, Copper, Iron, Manganese and Potassium using mathematics and geo-statistics methods as well as choosing the most optimum technique of spatial interpolation by comparing RMSE, MAE and MBE; (ii) to analyze the probable spatial correlation between the concentration of these elements in agricultural soils; (iii) to distinguish the regions affected by the excessive contamination higher than the threshold limit of general index and WHO standard and also Iran's Soil and Water Research Institute's standard.

2. Materials and Methods

2.1. Statistical analyses

In this research, first of all, 370 samples of soil were randomly selected from this region and the concentrations of abovementioned elements were measured. Then, the accuracy of the measured data was examined by applying 3 Sigma Validation Test. At the next stage, the spatial distribution of the elements of Zinc, Iron, Copper, Manganese, and Potassium was examined using mathematics and geo-statistics interpolation models. These methods which are based on the first principle of geography include certain mathematical methods such as the Inverse Distance Weighting, Local Polynomial, and Radial Basis Functions and geo-statistics methods such as Ordinary Kriging (OK), Simple Kriging (SK), and Universal Kriging (UK) with Circular, Globular, Gaussian, and Exponential Variogram Models.

2.2. Kriging

Kriging is a method based on Weighted Moving Average. One of the features distinguishing it from other interpolation methods is that it is regarded as the Best Linear Unbiased Estimator. The first stage in statistical analyses is the computation and drawing of variogram. In fact, variogram represents the variability of samples

based on their distance. The next stage is the selection of the best theoretical model for fitting to experimental variogram. The modeled variogram shows the spatial self-correlation of data, and describes range, sill and nugget. The Kriging interpolator is divided into different methods. The models being tested in this research are Ordinary, Universal and Simple Kriging.

2.3. Inverse Distance Weighting

The Inverse Distance Weighting is a radix point method which acts based on the first principle of geography. In this interpolation method, the weighting parameter operates according to the criterion that an increase in the distance from the sampled points to the passive point leads a decrease in its effect in the expected value.

2.4. Local Polynomial Method

Polynomial interpolation is a method for finding a formula, the figure of which passes through the data. The Universal Polynomials identify the fitted surface to data by considering all existing data in the analysis, while local polynomials perform this action for a limited number of points within a considered oval. This method allocates the least proportional squares among the identified points in the oval shape area as the point weight. Thus, interpolation is performed based on the allocated weight of the relations of the first, second and/or third grades among the variables in the neighboring points of X, Y, and Z along with the minimization of estimated errors.

2.5. Radial Basis Functions

This method is a manner of artificial neural networks in which the predicted values are higher than the maximum observed and lower than the existing minimum observed. Indeed, the surface fitting by these functions acts like a plastic membrane so as to minimize the total surface curvature. The RBF performs interpolation based on five principal functions. The main core of these functions is the sum of squares values. In this method, a function is considered for each location, where the linear combination of these functions is used for predicting the amount of function in the passive location as the final function. In this study, functions including Spline Function, Quite Regular, Spline with tension, Multi-Quadric function, Reverse Multi-Quadric Function and Spline Function with thin surface were used.

2.6. Validation Criterion of Interpolation Methods

In this research, the observed data were divided in two groups of experimental and control, with the proportion of 80 to 20. At the beginning, by applying the experimental data, a surface was fitted for the data using each interpolation method. Jackknife Cross-Validation Method was used to determine errors vector. The basis of this method is that when fitting the surface, one of the data is omitted each time, fitting is performed by using other data and the data deviation from the predicted value is recorded. Then, the control data is inserted in the fitted model and the amount of data deviation from the fitted model is being reported.

In order to examine the accuracy and validation of each method in the zoning of the aforementioned heavy metals, Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Mean Basin Error (MBE) were applied. The closer the values of (RMSE), (MAE), and (MBE) to zero, the more efficient (effective) the performance of the fitted model.

3. Results and Discussion

All obtained numbers for the spatial correlation between the elements are of positive value, and this represents a direct relation in the reciprocal transformations of elements. Among the results obtained, the spatial correlation between two metals of Zinc and Copper is more intense, as with 46%, includes the most intense relation as compared to each pair of other elements. Meanwhile, the correlation between the two elements of Manganese and Potassium has the least value with 1%.

By using the QQ chart, it was found the data of Potassium, Zinc, Iron and Manganese having a relatively high skewedness and far from normal distribution. As it was previously indicated, variogram explains the relation between sample variability as well as their interaction. In order to choose the best model of experimental variogram, the proportion of nugget to sill was used, in which the least value represents the best model (Fig. 3). By using Arc GIS Software, the most optimum model for the preparation of zoning maps was examined. Among the various models, deviation vectors were drawn from the measured value for the fitted surface. These vectors were drawn for both sets of data. By comparing the measured data and the global index of soil contamination and WHO standard, it was found that the highest volume of elements of Iron, Copper, and Manganese is not

located in the permissible range, while the amount of this element is located in the impermissible range in the whole region under study (Figs. 4 to 8).

4. Conclusion

According to the experiments of the study, it was concluded that interpolation methods have totally accuracies close to each other in the interpolation of a surface. In selecting a nominated model for interpolation of points for potassium, the Inverse Distance Weighting (IDW), for Zinc and Manganese, the Kriging, and for Iron and Copper, the Radial Basis Function (RBF) were selected as the best method. This condition represents the relative priority of Radial Basis Function and Kriging models in contrast to Inverse Distance Weighting and Local Polynomial methods. Regarding the zoning maps for the elements, it was determined that Potassium is located in the contamination range based on WHO global standard. The cause of this pollution is the excessive usage of potassium-based chemical fertilizers. Other elements were placed at the secure range according to global standards. At the next stage, these elements were categorized for low-consumption elements by Iranian standards. In which the results showed that Copper is exposed to contamination in the abundant range in more regions, while Manganese is placed in the adequate range, and Zinc and Iron in the defect range.

Keywords: GIS, heavy metals, interpolation methods, kriging, soil pollution.

Non-carcinogenic quantitative risk assessment of heavy metals in 8 fish species of Iranian international wetlands by EPA/WHO instructions

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Extended Abstract

1. Introduction

In aquatic ecosystems, wetlands and rivers have a great ecological importance. Heavy metals from geological and anthropogenic sources are increasingly being released into natural waters. Contamination of aquatic ecosystems with heavy metals has seriously increased worldwide attention, and a lot of studies have been published on the heavy metals in the aquatic environment. Under certain environmental conditions, heavy metals may accumulate to toxic concentrations and cause ecological damage. Mercury is a special concern in marine ecosystems, where methylation occurs during the process of biotransformation and accumulates in biota. Mercury is a toxin to the central nervous system and it can readily cross the placental barrier. Lead is attracting wide attention of environmentalists as one of the most toxic heavy metals. The sources of lead release into the environment by waste streams are battery manufacturing, acid metal plating and finishing, ammunition, tetraethyl lead manufacturing, ceramic and glass industries printing, painting, dying, and other industries. Lead has been well recognized for its negative effect on the environment where it accumulates readily in living systems. Lead poisoning in human causes severe damage to the kidney, nervous system, reproductive system, liver and brain.

The aim of this study is determination of mercury concentration in the muscle, intestine, gonad and kidney of *Rutilus rutilus, Hemiculter Leucisculus* (Anzali wetland), and *Alosa Caspia Caspia* (Caspian Sea), and mercury and lead concentrations in the muscle of *Ctenopharyngodon idella, Cyprinus carpio, Hypophthalmichthys molitrix, Hypophthalmichthys nobilis, Schizocypris altidorsalis,* and *Schizothorax zardunyi* (Hamun wetland). The results of this study were compared with global standards. As well as in this multispecies monitoring, health risk assessment of consumers by EPA/WHO instructions has been done. The main objective was to evaluate the potential health risks associated with heavy metals via consumption of fish from the wetlands using the Average Daily Dose for Intake Process (ADD_{pot}) and Hazard Quotient (HQ) from heavy metals.

2. Materials and Methods

2.1. Case study

The Caspian Sea (Fig. 1), which is located in the northern I.R. Iran, is the largest lake in the world and is connected to the distant Baltic through canals and the River Volga. It is unique closed water basin playing the important role in the establishment of the climate. The Anzali Wetland (193 km^2; Fig. 1), located in the southern coast of the Caspian Sea, is internationally known as an important wetland for migratory birds, and was registered as a Ramsar site in June 1975 in according to the Ramsar Convention. Hamun wetland, the largest freshwater expanse of the Iranian plateau, is listed in the Convention on Wetlands, Ramsar.

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2.2. Sampling

The fish species including *Rutilus rutilus, Hemiculter Leucisculus* (from Anzali wetland), and *Alosa Caspia Caspia* (from Caspian Sea), *Ctenopharyngodon idella, Cyprinus carpio, Hypophthalmichthys molitrix, Hypophthalmichthys nobilis, Schizocypris altidorsalis,* and *Schizothorax zardunyi* (Hamun wetland) randomly were collected.

Fish samples (20 samples from each species) were transferred to the laboratory and stored in refrigerator. Afterwards, the tissues were separated and dried.

2.3. Mercury and lead analysis

The dried samples were ground and changed into a homogenous powder and then the mercury concentration rate has been determined by advanced mercury analyzer, model 254. Lead concentration rate has been determined by Atomic Absorption Spectroscopy (AAS), Perkin Elmer 4100.

2.4. Health risk assessment by EPA/WHO method

2.4.1. Hazard identification

Hazard identification involves gathering and evaluating toxicity data on the types of health injury or disease that may be produced by a chemical and the conditions of exposure under which injury or disease is produced. The subset of chemicals selected for the study is termed "chemicals of potential concern". Data from acute, subchronic, and chronic dose-response studies are used.

2.4.2. Dose-response assessment

The dose-response assessment involves describing the quantitative relationship between the amount of exposure to a chemical and the extent of toxic injury or disease. The US EPA established the Reference Dose (RfD) as below:

$$RfD = \frac{NOAEL \text{ or } LOAEL}{UF \times MF}$$

NOAEL: No Observed Adverse Effect Level
LOAEL: Low Observed Adverse Effect Level
UF: Uncertainly Factor
MF: Modifying Factor

2.4.3. Exposure assessment

A generalized dose-response relationship is applied to specific conditions for some population. The sources of an environmental hazard, concentration levels at that point, pathways, and any sensitivities are characterizes. Exposure assessment involves describing the nature and size of various populations exposed to a chemical agent, and the magnitude and duration of their exposures. The exposure pathway of heavy metals to human through ingestion of contaminated food has been studied by many researchers. Average Daily Dose for Intake Process ADD_{pot} is calculated as:

$$ADD_{pot} = \frac{(C \times IR \times ED)}{BW \times AT}$$

C: Concentration of toxic material
IR: Ingestion Rate
ED: Exposure Duration
BW: Body Weight
AT: Averaging Time

2.4.4. Risk characterization/ risk calculation

The Average Daily Dose for Intake Process (ADD_{pot}) (total intake) is compared to the RfD. If $ADD_{pot} <$ RfD, then no problem. Hazard Quotient (HQ) is calculated as:

$$HQ = \frac{ADD_{opt}}{RfD}$$

3. Results and Discussion

The concentrations of Hg in tissues of *Rutilus rutilus, Hemiculter Leucisculus*, and *Alosa Caspia Caspia* were measured (Table 1). There was no significant difference between the independent variables of gender, age and weight of the dependent variable. It is the amount of mercury in the tissues of the *Rutilus rutilus*. But between

the length and the amount of mercury in the kidney of *Rutilus rutilus*, there was significant difference at 95% (p=0.015; Figs. 2 and 3).

Mean concentrations of Hg in muscle of *Ctenopharyngodon idella, Cyprinus carpio, Hypophthalmichthys molitrix, Hypophthalmichthys nobilis, Schizocypris altidorsalis*, and *Schizothorax zardunyi* were 0.14, 0.28, 0.15, 0.15, 0.34 and 0.36 mg/kg, respectively (Table 1). The results of laboratory analysis showed that there are significant difference between the concentration of mercury in the muscle between species (p<0.001).

Mean concentrations of Pb in muscle of *Ctenopharyngodon idella, Cyprinus carpio, Hypophthalmichthys molitrix, Schizocypris altidorsalis,* and *Schizothorax zardunyi* were 0.32, 0.39, 0.35, 0.72 and 0.81 mg/kg, respectively (Table 1). There was no significant difference between lead concentrations of these species (p>0.05).

Table 1 shows ADD_{pot} and HQ of heavy metals in muscles of fish samples from the wetlands. Among the fish species examined in this study, *Hemiculter Leucisculus* with a HQ value of 0.009 has the lowest potential health risk to mercury and *Schizothorax zardunyi* with a HQ value of 1.2 has the highest potential health risk to mercury. The HQ through the consumption of *Schizocypris altidorsalis* and *Schizothorax zardunyi* was higher than 1 (for mercury), indicating that there is potential health risk associated with the consumption of these fish from the hamun wetland. The results for lead concentration indicate that there is no HQ value > 1, indicating that humans would not experience any significant health risk if they only consume metals from these species of fish from the hamun wetland. The concentrations of mercury in all species were below the limits for fish proposed by United Nations Food and Agriculture Organization (FAO), World Health Organization (WHO), US Food and Drug Administration (FDA) and US Environmental Protection Agency (EPA), and European Union (EU) (Table 2). Lead concentrations in *Ctenopharyngodon idella, Cyprinus carpio, Hypophthalmichthys molitrix* were under the scope proposed by FAO, WHO, FDA, Turkish Acceptable Limits (TAL), United Kingdom Ministry of Agriculture Fisheries and Food (UK MAFF) and National Health and Medical Research Council (NHMRS), but lead concentration in *Schizocypris altidorsalis,* and *Schizothorax zardunyi* were higher than WHO and TAL (Table 2).

It should be noted that maximum consumption of 0.020 kg/day of *Schizocypris altidorsalis* and 0.019 kg/day of *Schizothorax zardunyi*, there is no potential health risk (CR_{lim}).

4. Conclusion

The results of the present study aimed to provide data from Caspian Sea, Anzali wetland, and Hamun wetland as indicators of natural and anthropogenic impacts on aquatic ecosystem as well as to evaluate the human hazard index associated with fish consumption. The human health hazard Quotient (index) showed that the cumulative risk greatly increases with increasing fish consumption rate, thus yielding an alarming concern for consumer health.

Keywords: Anzali wetland, Caspian Sea, Hamun wetland, heavy metals, risk assessment..

Investigating the effect of industrialization on environment quality in Iran emphasizing the moderating role of social capital (Kalman filter approach)

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Expanded Abstract

1. Introduction

One of the main concerns of industrialization is the corresponding environmental effects. Industrialization has affected the entire environment with its severe downside problems. The formation of massive pollution made by industries is the result of the constant need and greed of the human being. These industries, including transportation and manufacturing, are exhausting the earth's resources and are causing tremendous stress on the environment and the ecological system. Water, soil and air pollution are defined as the negative results of industrial development and industrialization. Global warming and greenhouse effects are the result, which is a massive impact of industrialization on the environment. The degradation of the entire environment and ecological system is inclined to become permanent and tends to cause several negative effects on the economy, by causing human losses, ill health of the employee's at large costs to governments, manufacturing and society. Therefore, it is very important to find necessary solutions to control such effects to facilitate the conditions for achieving sustainable industrial growth. This requires to identify the exact effects of industrialization on environment and the factors and solution which can mitigate this kind of bad effects of industrialization. According to the literature, there are a wide variety of variables that can help policymakers to control the side effects of industrialization. Social capital is one of these factors. This paper is to investigate the contribution of social capital in moderating the environmental effects of industrialization.

2. Materials and Methods

Data for variables in the estimated econometric models of this paper are per capita carbon dioxide emission (as environment quality index), per capita income, per capita industrial value added (as industrialization index), energy use intensity, urban population, human capital and social capital- being gathered from Iran central bank data center during the period 1967-2015. Augmented dickey fuller test is used to investigate the stationary of variables included in the econometrics models of the study. In order to analysis the moderating role of social capital as well as human capital in the reaction of environment quality to industrialization in Iran, two steps were taken as follows: at the first step, the effect of industrialization on environment quality was estimated using Kalman filtering approach during the period 1967-2015. At the second step, the moderating role of social capital is tested using Johnson co-integration approach. Sohwarz and Quinn criteria were used to determine the optimal lag numbers in vector autoregressive model. The number of co-integration vectors was determined using maximum eigenvalue and trace tests. Vector error correction model is used to test and analyze the partial short-run adjustments.

3. Results and Discussion

Augmented dickey fuller test shows that the order of integration of all variables is one and so these variables are not stationary series at level. This result leads the research team to use co-integration test to analysis the relationship between variables. Estimation of the environment quality function, by Kalman filter approach estimation, shows that per capita carbon dioxide emission (environment quality index) is positively influenced by first power of per capita income, per capita industrial value added (industrialization index), energy use intensity and urban population. This finding is in line with the theoretical expectation and many other empirical researches in this field. The coefficient of the first power of per capita income in estimated model is 0.1659 and

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indicates that if the first power of per capita income increases one unit, per capita carbon dioxide emission increase 0.1659 unit. The coefficient of the energy use intensity in estimated model is 0.0005 and indicates that if energy use intensity increases one unit, per capita carbon dioxide emission increases 0.0005 unit. The coefficient of the urban population in estimated model is 0.0027 and indicates that if urban population increases one unit, per capita carbon dioxide emission increases 0.0027 unit. The coefficient of per capita industrial value added (industrialization index) in estimated model is 0.8176 and indicates that if industrialization index increases one unit, per capita carbon dioxide emission increases 0.8176 unit. There is a positive and statistically significant relationship between per capita industrial value added and per capita carbon dioxide emission. Estimation of industrialization coefficient in environment quality function using Kalman filtering reveals that this coefficient has experienced an increasing trend during the period 1982-2015. This finding shows that the degree of industrialization side effects on environmental quality has been intensified during the period. Co- integration test based on eigenvalue and trace statistics in this paper confirm the presence of almost one co-integration vectors between the model variables. According to the estimated coefficients of restricted vectors, there is a long term negative relationship between social capital and the coefficient of industrialization in environment quality function. The coefficient of social capital in restricted vector is estimated around -12.1956. This shows that, in long term, as social capital improves or increases around one unit, the coefficient of industrialization in environment quality function decreases and mitigates around 12.19 units. According to the estimated vector error correction model, social capital and human capital does not significantly affect the degree of industrialization effects on environment quality.

4. Conclusion

Based on the negative and significant coefficient of social capital in environment quality function estimated in this paper, it is inferred that the fraying trend of social capital has intensified the negative environmental side effects of industrialization in Iran during last decades. At the same time, improving the people's awareness of environmental supportive activities has mitigated the harmful effects of industrialization.

Estimating the preservation value of environmental resources of Abar area of Shahrood by using individual's willingness to pay

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Expanded Abstract

1. Introduction

Valuation of non-market functions and services of the natural resources and the environment is important due to some reasons including understanding the environmental and ecological benefits by humans, feedback of the importance of environmental issues to the planners, creating the relation among economic policies and incomes from natural resources, measuring the role and importance of the environmental resources in improving the welfare of society and sustainable development, adjusting and reforming the national accounts such as gross national product (GNP), and preventing the uncontrolled destruction and exploitation of natural resources. The maximum willingness to pay (MWTP) by the users for non-market goods such as improving the quality of the environment, wildlife, and forests represents the economic value of the resources (Kealy & Turner, 1993). In recent years, economists and policy makers have used CVM to estimate this value and the other economic values.

The Contingent Valuation Method (CVM) is applied as a standard and flexible tool to measure the use and non-use values of the environment for which there is no market (Amigues et al., 2002). This method was firstly introduced by Ciriacy and Wantrup in 1947 and also it was for the first time used by Davis in 1963. This method specifies the individual's willingness to pay (WTP) in the form of hypothetical tools (Han & Lee, 2002). The evaluator in this method refers to the people in order to determine the economic value of the goods and environmental services of the environment such as wetlands and then measures their preferences based on the offered prices. That's why CVM is often called as the preferred method, too (Venkatachalam, 2003).

The objective of this research is evaluation WTP of the individuals who were categorized into two different groups of consequentialists and deontologists to estimate the conservation value of the Abar watershed of Shahrood that located in the Semnan Province. Also, it was determined the factors affecting on the WTP to estimate the conservation value of the study area.

2. Matherials and Methods

Contingent Valuation Method (CVM) was used in this research to determine the conservation value. The WTP is determined under the certain hypothetical market scenarios. Dichotomous Choice (DC) methods are more consistent than the other methods of extracting the WTP due to motivating the respondents (Lee & Han, 2002). In this research Double –bounded Dichotomous Choice (Hanemann, 1994; Carson, 1985) questionnaire was designed to do the interview and to extract the respondents WTP to determine the conservation value of the region in order to make aware the respondents completely from the condition of hypothetical market. The questions of questionnaire were about the socio-economic characteristics affecting individual preference (such as the age, gender, education, the number of family members and so on) and the WTP for each member of the family. Finally, the individual WTP was questioned using a Double –bounded Dichotomous Choice. The simple random sampling method was used as for sampling in population

To determine the offered prices in the Double –bounded Dichotomous Choice Method, 35 open-end questionnaires were completed and the respondents were asked about the maximum WTP. Finally, the offered prices were calculated. The WTP amount (middle, minimum and maximum) was obtained through asking the

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basic questions. In accordance with the statistical procedures, 20,000, 10,000, 20,000 Rials have been stated respectively as the middle, minimum and maximum offered prices to protect the Abar watershed of Shahrood. The Logit model parameters were estimated using maximum likelihood by Shazam software.

3. Results and Discussion

The results have been presented 60% of the respondents were male and 80% of the respondents were married. The average age of the respondents was 37.4 years. The average of the variable of cost was 16.44 billion Rials per month. The average household size of the visitors of the region was 3.7 persons. Almost 1% of the respondents were members of the environmental organizations. The average number of the times that the region was visited was estimated to be 3.4. 18 % of the respondents declared their willingness to participate in the conservation of the region. Based on the results, most of the respondents stated that they are willing to pay to protect the vegetation cover in the region due to the regulatory functions of vegetation cover including climate regulation, carbon dioxide absorption, reducing soil erosion and so on. According to the results, the questions of the WTP are asked in this way that the middle option is firstly asked. If the respondents give a negative answer to the question, then the lowest offered price will be asked of the respondents and if the respondents give a positive answer, then the highest offered prices will be asked. Based on result, 63 individuals of the respondents (18%) are willing to pay for the conservation of Abar watershed.

Based on the logit model results, the coefficient of the variables of age and income are significant at the level of 1% and the variables of the financial affordability, gender, married, cost, visit number and bid are significant at the level of 5% and effect on the willingness to pay. Based on the theory, the sign of the estimated coefficient of the bid is negative which indicates that if the offered price for protecting the area increases the probability of the acceptance for paying a given amount will decrease. LR test statistic was used in the Logit model to assess the significance of the whole model and goodness of fit. The amount of this statistic was 62.68. Being significant of this statistic indicates that the estimated model is significant in general. The results reveal that almost 91% of the respondents were correctly allocated to predicted WTP either 'yes' or 'no' in the model, indicating a relatively good fit to the data. Based on the results of the study, mean of willingness to pay for preserving was estimated about 10574 Rials and preservation value of family was about 126889 Rial in year. Also, annually preservation value of watershed was about 27353.6 million Rial in year.

Based on the results, the expected value of the WTP for the individuals was obtained 10574 RLs/month (126889 RLs/year). Molaei et al. (2010) in their study about the conservation value of Arasbaran forestes estimated the WTP per household per year to be 112,520 RLs (2.813 US$). The difference of two studies is related to the time of the study. Amirnejad (2007) also estimated the monthly average of the WTP for per family for the conservation value of Golestan national park to be 14,400 RLs (0.36 US$). Daneshvar et al. (2007) studied the Existence Value of the countryside village of Zoshk in Khorasan (Western north of Iran) and found that the monthly average of the WTP for the Existence Value of the region is 11,300 RLs (0.28 US$). Nakhaee et al. (2010) estimated the average of the WTP to be 12646 RLs (0.316 US$) per month for per household for the conservation value of the Protected Forest Park of Nour. Fatahi and Fathizadeh (2011) were estimated the average WTP of people to protect the Gomishan wetland in Golestan province to be 72,850 RLs and the conservation value for each family (with 5.4 members) was estimated to be 393390 RLs/year (9.83 US$/year).

Carrying out this study in the current situation is an important step to protect the protected areas and the natural resources and to move towards the sustainable development. The economic, political, and social planners and decision-makers always emphasize on the cost-benefit analysis in their decisions. Such analyses are based on the quantity and the monetary units. Therefore, the economic valuation of the protected areas is important and as long as the fans of the nature and its conservation cannot determine the value of the services based on the monetary units, the important services and functions of the protected areas and natural resources which are largely out of the market will be ignored. In terms of the management, results of this research are very hopeful especially because the results indicate that the natural resources and specially the Abar watershed are important for people. The results can justify planners, authorities, and policy makers to protect the quantity and quality of the natural resources and to prevent of putting aside the natural resources and the environment due to the lack of supporting by the governments.

4. Conclusion

The estimated economic conservation value does not represent the value of the entire ecosystem of the region. In the other words, the ecosystem of the study area has many other values that can be demonstrated. Some of them consist of the biological control of pests, pollination, water and soil conservation, medicinal plants and byproducts, capture and storage of carbon dioxide and producing the oxygen, biological diversity, preventing soil erosion, combating with the air pollution, reducing the noise, adjusting and softening the climate, creating

green space and landscape and natural scenery, increasing the groundwater resources and flowingly the springs and rivers, and so on that their values should be estimated.

Estimation the Shadow Price of Pollution in Iran's Wheat Production and Distribution Chain

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Expended Abstract

1. Introduction

The use of energy input in addition to physical inputs causes pollution and greenhouse gas emissions such as carbon dioxide. Therefore, the energy consumption in the process of production of agricultural products will be accompanied by the release of carbon dioxide. Energy consumption at all stages of the supply chain of a product is most important and its use is associated with externalities. These effects can also occur in the product distribution. Internalizing these external effects involves estimating the environmental damages caused by economic activities, so product prices are more transparent and can also cover social preferences after internalization. On the other hand, the lack of equality between supply and demand of food products in each region and the distance between production areas and consumption areas, trade, and its distribution become inevitable among different regions. Road transport causes side effects. Greenhouse gas emissions are one of its varieties.

Wheat as the main product in the Iranians food basket devoted 51.2% of the acreage to crops. This acreage in the 2013-2014 crop years produced 10.58 million tons. Although that energy consumption in the transport sector in the period 2000 to 2014 has increased by 1.86 times, carbon dioxide emissions has been at a rate of 2.04 times. Accordingly, emissions increased according to per unit fuel consumption. As a result, taking environmental control policies in this sector become inevitable. The calculation of environmental impacts arising as a result of wheat movement can play an important role in managing green supply chain.

2. Materials and Methods

The aim of this study was to estimate the value of the shade of environmental emissions in the production and distribution chain of the wheat in Iran. So, the amount of energy consumed in the production of wheat and distribution in the country is estimated for the years 2000 to 2014. Then, using a distance function based approach to estimate carbon dioxide emissions shadow price of wheat has been manufacturing and distribution sectors. A unique feature of this study was to evaluate and compare the importance of each part of the supply chain on environmental emissions.

3. Result

Shadow price of emissions should be achieved in order to internalize the externalities. One way to obtain this shade value is to estimate the distance at which communication between desirable and undesirable outputs is determined. According to what was presented in the research method, the carbon dioxide emission in the production process is less than the distribution process. According to research findings, 1.4 tons of carbon dioxide emissions occur for per hectare wheat production in the country, but in exchange for the distribution of this amount of wheat the emissions will reach to 2.03 tons. Total emissions in total production and distribution will be equal to 3.43 tons per hectare. These results can show the more importance of the distribution sector in the environmental damages.

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According to the calculations of the current research, the ratio of CO_2 shadow price in production sector is 1.4% of the cost of production per hectare at average, but this number reaches 15.3% in the process of distribution indicating a much higher importance of the distribution process in CO_2 emissions. The control policies in the distribution process of products will be more efficient and more effective in the distribution process. On average in the years 2000 to 2014, it had a value of 852,400 Rials. This value in the production sector was equivalent to 76,300 Rials. Hence, the importance of distribution segment in carbon dioxide emissions is 11.2 times the production of wheat. The shadow value in the distribution sector of the real prices was higher than the value of shadow prices in the production sector. The shadow price of CO_2 emission in production and distribution sectors has been ascending, but since 2010 and the release of energy prices, has been an incremental process. Another interesting point is that this increasing process is also shown once again on the implementation of the second phase of the release of energy prices.

As it is known, the production and distribution of wheat is accompanied by social losses imposed on the community. These environmental damages are not included in the economic calculations. The total amount of damages is 16.7% of the wheat production cost. The consideration of this damages can change the comparative advantage of wheat production in Iran.

4. Conclusion

Green supply chain management requires that environmental impacts be taken into account in the production, distribution and consumption of goods. The first step is to calculate the quantity amount of environmental impacts in the supply chain. The carbon dioxide emission, as a result of energy consumption, is one of the major released pollutions in the environment. On the other hand, wheat as a strategic commodity plays a major role in Iran's food security. Therefore, the purpose of this study is to estimate the shadow price of carbon dioxide emissions in Iran's wheat production and distribution sector by using the Input Distance Function. The shadow value of the CO_2 emission can be considered a green tax. The results of the research showed that the shadow price of CO_2 emissions in the production sector is much lower than in the distribution sector. Also, the ratio of income to the cost of wheat production in Iran during the study period was 1.55. If the amount of environmental damage is taken into account during this period, this will be reduced to 1.33. Therefore, environmental considerations must be taken into account in the production and distribution of wheat.

Keywords: input distance function, pollution shadow price, production and distribution chain, wheat.

Investigation of factors affecting on land use change in Khorasan Razavi

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Expanded Abstract

1. Introduction

The soil is the bedrock of all human productive activities and the foundations of many of the great and ancient civilizations that have maintained soil conservation. Population growth and shortage of new land for agriculture, large areas of forests have become degraded and transformed into agricultural land and, consequently, agricultural land has become industrial and urban. The major impact of land use change on the physical and social environment is an incentive for research in relation to the reasons for land use change and its effects. Modeling and analyzing these factors can help to plan and plan agricultural land. One of the issues have faced many problems in developing countries over the last few decades is that the growing urbanization and urbanization have led to the emergence of huge immigration trends in urban areas around the world. Immigration to cities in these countries has caused such problems as incompatibility in utilization, urban environs, and the lack of urban services to immigrants, the creation of marginalization, the destruction of agricultural lands around urban development, and the modification of its use to industrial and urban uses. In Iran, as in other developing countries, this trend has existed.

On the other hand, the lack of serious attention to rural areas and agriculture, as well as the reduction of the share of villages and rural areas in the strategies of economic development and industrial development has caused the productive forces of these points to be able to provide livelihoods and to cities and areas around cities. Investigating the changes in land cover and land use from distant lands on the surface of the earth, which is usually made in two ways the first type is the changes that are made by natural factors such as erosion and flood occurrence, and the second type is the changes that occur by humans. Recently, in most parts of the world, human activities have been one of the main factors influencing land use change.

2. Materials and Methods

The data required for this study was completed by collecting 70 questionnaires in 2017. In the two-stage Hackman model, factors that can affect farmers' decision to change land management practices in agriculture, in the form of independent variables in the probit pattern and the factors that can affect the amount of change in use, in the set of independent variables in the linear regression model.

The second pattern is added by adding a new variable called MRI (IMR), which is constructed using the parameters, met the first pattern. The set of independent variables will be linked to the first stage. The dependent variable in the probity pattern consists of a binary variable with values 1 and 0. Accordingly, the dependent variable is the vector of the values 0 and 1 in which the number 1 is the decision to carry out the activity and 0 means the decision does not perform that activity. This variable is based on the dependent variable in the Tobit model. Hence, for Yi whose value is greater than 0, the number 1 is set to 0, and for Yi whose value is 0, it remains 0. In this way, the independent variable of the probit pattern is constructed for all observations.

In the above models, β coefficients of pattern parameters, IMR Reverse Mills Ratio, V and Ei are error sentences. In the first step, the Hackman method, the probit pattern is estimated using the maximum exponential method.

In the second step, the Hackman method, the linear regression model is estimated for observations whose Yi is greater than 0. At this stage, the inverse of the Mills ratio is added to the set of independent variables in the regression model. The coefficient of this variable expresses the error caused by the sample selection. If the

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coefficient of this variable is statistically larger than 0, deleting the zero views from the set of views will cause the skew of the estimated parameters of the template and if the coefficient of this variable is not meaningful, deleting zero observations, although not leading to the error of the estimated parameters, but it will lead to the loss of performance of the estimator. The presence of the inverse of the Mills ratio in the linear regression model eliminates the existence of the heterogeneity of the primary model variance and allows the use of OLS. Therefore, it is possible to differentiate factors affecting agricultural land use change from the impact of factors on agricultural land use change. Static software has been used to estimate the two-stage Heckman model in this study.

3. Discussion of Results and Conclusion

The first phase of the Hackman's two-stage method is the decision stage to make land use change. In other words, this is the stage of the intention. Based final effects of significant variables with positive effect, with an increase in the number of farmers in the family, assuming that other factors are constant. The probability of a decision to change the use of agricultural land increases by 0.18 units. For the variable number of agricultural land plots, one increase in the number of land shares, the willingness to decide to change the use of agricultural land is increased by 0.53 units. Also, the level of education and literacy level of a farmer increases by one unit (for example, one section) in his education, his desire to increase the change of user by as much as 0.23 unit's increases. In general, for the variables mentioned, we can say that the population of the farmer's family, the number of land plots and farmer education levels has a direct relationship with the farmer's willingness and decision to change their utilities. That is, with the increase, the change in agricultural land use is also increasing.

On the other hand, regarding meaningful variables with negative effect and their final effect, it can be concluded that farmers' income has a negative effect on agricultural land use change so that by increasing one unit in farmer's income, assuming that other factors are constant. The person's desire to change the use of agricultural land is reduced by 0.8 units. In other words, in summary, one can say that income. The price of a major agricultural product and the amount of rainfall has a negative relationship with the change in agricultural land use. Namely, as these three factors are strengthened, the willingness of the farmer to change the use of agricultural land will be less. According to the results obtained from the probit model, the coefficient of determination of the Mac-Faden model is 0.48 and false R^2 is equal to 0.61, which shows good fit of the model. Therefore, these variables in the second stage of the model are estimated to The OLS method. The number of altered agricultural land lots in the second stage is considered as a dependent variable.

In the second Hackman stage, the presence of the Mills Image Ratio (IMR) in linear regression eliminates the model's heterogeneity and makes use of the linear pattern and serves as a variable in the model.

According to the findings of this research, in order to solve the problem of agricultural land use change, proper control and planning in relation to urban migration and urban areas create more incentives for the farmer through appropriate policies in the price of products, encouraging the farmer to use high-yielding inputs to earn more money, provide water resources management policies for farmers to better access and use water resources and adopt policies to reduce farmer's costs of production in all areas, shipping costs and initial charges are offered.

Keywords: change, Heckman Tobit Model, land, Torbat Hydarieh.

Economic valuation of air and noise pollutions abatement performance

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Extended abstract

1. Introduction

Green plans are among natural blessings which have many functions toward air quality improvement. On the one hand, plants moderate the air pollutants by photosynthesis and beautify the cities. Many other functions have been found for the trees, of course, including the absorption of sound, water and soil pollutions. For this reason, in many nations, the creation of a green belt for inside and outside the cities has been set forth as a serious requirement but in the implementation of such projects, the species to be planted must been selected. The authors' studies indicate that so far, no investigation has been done toward the selection of tree species across the city of Ahwaz [Iran]. This is a city with a hot, arid climate where the temperature rises to 57°C in the summer; and suffers from many environmental problems such as particulates and industrial pollutions. But the landscape planners in the city of Ahwaz are confused and occasionally, the expenses for planting trees are made with little efficiency. The selection of the best air pollution-reducing tree species may help policy makers toward optimal allocation of their limited resources. On the other hand, the budget allocated to the Organization for Landscapes and Parks of Ahwaz City Hall is not proportional to the economic benefits of the real interests of urban landscape. Achieving economic benefits of the best pollution-absorbing tree species may be used as a scientific criterion for optimal allocation of funds to this organization. Also, using the results of this study, the citizens' awareness of the importance of trees is improved which could result in a more friendly treatment of landscape on their part and prevent the cutting of trees for banal reasons.

So far, many studies have been performed in various nations toward valuation and appreciation of natural and environmental resources such as parks, forests, lagoons, etc. (Juutien et al., 2011; Jenkins et al., 2010; Westerberg et al., 2010; Setlhogile et al., 2011; Cui et al., 2012; Newell & Swallow, 2013). However, to the authors' experience, no studies have been done so far appreciating a tree species which might have the most attractive ability in absorbing air pollutants concerning the city of Ahwaz. Additionally, in most studies, the figures obtained for the tendency toward final payment have not been generalized to the overall community benefitting from the advantages; and therefore, the value of natural resources has not been calculated as a natural capital. Moreover, the contribution of natural resource functions value in the provincial, regional, or national gross production has not been considered which is a very important factor in funds allocation and also in the movement toward national green accounting and environmental evaluation of projects.

2. Materials and Methods

The methods applied in this study is the choice modeling method, which assumes the individuals to have a rational behavior so that by choice, they would maximize their desirability considering the budget constraint. Therefore, it is assumed that any respondent has a random desirability function (Ben-Akiva, 1985). A random desirability function consists of a specific, observable component and a random one (Montazer-hojjat & Mansoori, 2016). A random parameter logit model would be suitable to explain such conditions:

$$u_m = \alpha_. + \alpha_1 p + \sum \beta_i A_i + \sum \theta_k A_i soci_j + \varepsilon_m$$

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where u_m is the desirability of the nth individual, a binary variable; p the protection cost for tree species or their improvement across the city; A_i selected quality features of the tree such as air and sound pollution absorption, providing a delightful natural landscape, and educational services; $A_i soci_j$ an action variable of socio-economic characteristics of respondents and quality features of the intended tree species. Obviously, the socioeconomic characteristics of individuals are fixed at the time of their selection among the options and therefore, they appear in the model in action form with the features of tree species. After estimating the above model, the tendency toward final payment is obtained through dividing the estimated coefficient for each feature (β_i) by the estimated price coefficient (α_1):

$$TP = -\frac{\beta_i}{\alpha_1}$$

However, an important stage of this study has been the selection method for the best air-and-sound pollution-absorbent tree species as well as the field survey method applied in this section. For this purpose, three species with the highest frequency across the city of Ahwaz, Concarpus Erectus, Albiza Lebbeck, and Eucalyptus Globulus were selected based on the data provided by the Parks and Landscapes Organization. To select the superior species in terms of air and sound pollution absorption, the Air Pollution Tolerance Index (APTI) was applied. This index is calculated using four parameters, namely, total chlorophyll, leaf extract pH, relative water content, and acid ascorbic concentration) (Pathak et al., 2011). To perform laboratory process and calculate the APTI, the sampling process from the leaves of selected trees was performed in five highly trafficked areas, namely, north (Kianpars), south (Golestan), east (Zeytoon Kargari), west (Kamploo), and downtown Ahwaz (Amaniyeh), randomly.

Leaves from three selected species were collected in three different time frames during June 2015; and for each species in each area, three plants were sampled randomly as replicas. Coevality of the trees, given the commensuteness in diameter and length of their trunks was also taken into account. Leaves collected in frozen environment (zero degrees Celsius) were directly transported to the laboratory.

Later, relative moisture and pH of leaf extract were measured. In order to measure other parameters, collected leaves were stored in 0 °C, so that their properties would not change. Ultimately, the figures obtained from the experiments were fed into SPSS 21 software for analysis.

3. Discussion of Results and Conclusion

The results obtained from the measurement of five parameters, i.e. pH, RWC, ASC, CHL, and APTI, for three selected tree species, led to the selection of Albiza Lebbeck as the superior species in terms of air and sound pollution tolerance/absorption. The benefits of these species were also calculated for city residents. Tendency to final payment for four functions of these species was obtained dividing estimated coefficient for each feature by the price coefficient. They include tendency to final payment for natural landscape (1,418,128.4 Rials); reduced air pollution (1,692,708.9 Rials); reduced sound pollution (1,770,981 Rials); and educational performance (1,653,938.4 Rials). Additionally, the annual value of benefits and capital value of this species were calculated to be 1,167 Rials and 1,852 B, respectively.

Using the figures obtained for annual value of social benefits of Albiza Lebbbeck species, the municipality of Ahwaz will be able to direct the budget of the Parks and Landscapes Organization toward higher efficiency; and to determine its budget based on every citizen's landscape quota and the figures obtained by this study. Additionally, the municipality may use those numbers to determine the tendency of residents to pay renovation and building license charges; and to update previous numbers.

Given the results of this study and the enormous capability of Albiza Lebbeck in absorbing and metabolizing the pollutants, it is recommended that planting these species included in agenda in highly trafficked areas of the city of Ahwaz such as the downtown, along city roads, industrial zones, factories, and other areas where there is a possibility of air pollution. Also, by using the results of this study and the obtained figures, it is possible to improve social awareness on real value of this species' functions, enhancing their sense of responsibility to protect it, and to prevent their unnecessary cutting. Also, the results of this study can be used as a basis to fine the breaching citizens for cutting the trees. Another use for the results of this study is in the field of economic-environmental evaluation of urban projects. The figures obtained by this study can be used to evaluate the projects which might require cutting the trees. Thereby, environmental costs will be included in calculations; and the justification for some projects might even be questioned.

Investigation and Comparison of the Economic Value of Carbon Sequestration Function of Vegetation Cover in Biological Operations (Case study: Sarbishe Rangelands-South Khorasan Province)

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Extended abstract

1. Introduction

Rangeland ecosystems have high capability in carbon sequestration, because they have taken half of the surface of the earth and their carbon storage accounts for 10% of the total carbon stock of biomass in ecosystems and 30% of total soil carbon stock. However, carbon sequestration capacity in rangelands is less than forests, but due to the large extent of these ecosystems, management of these areas plays an important role in the carbon cycle. For this reason carbon sequestration in addition to the protective value has an economic value and it can be as an additional benefit of destruction operation of destroyed lands. Destruction operations such as restoration and protection of vegetation of pastures to increase carbon sequestration in soil and plant has other benefits such as ecosystem services. To increase carbon sequestration in arid and semi-arid regions planting methods are usually used. Using bush plants by deep root can absorb water from deep soil which normally is not available by existing plants in this areas. Su-Yong and Zao (2003), Hill et al. (2003), Schuman and Derner (2007) stated management factors have an important role in soil carbon sequestration and the result of their research showed that under managed range management systems, total soil carbon sequestration has increased significantly in biomass, litter and soil. So, increasing carbon sequestration through vegetation regeneration is equivalent to increasing plant biomass, increasing production and improving land fertility. For this reason, basic and protective values have also economically values. Considering the growing importance of greenhouse gases in the world and the importance issue of global warming and increasing CO_2 is not applicable to a particular country, there are a lot of ambiguous issues related to the ability of the types and different range plants in soil carbon sequestration and their economic value. Responding to these issues depends on extensive researches. Therefore, the present study aims to estimate and comparison the economic value of succeeded aboveground biomass of range plants.

2. Materials and Methods

Hossein-Abad basin is located 40 km away from Sarbishe city, in the south khorasan province adjacent to the Afghanistan border. In order to compare destruction operation, three sites were selected. The sites located at Hossein-Abad in 79° 90' - 80° 55' E and 36° 01' and 36° 04' N, Abbas-Abad in 78° 65' - 78° 79' E and 36° 08'- 36° 11 N', Janat Abad in 78° 20'-78° 50' E and 36° 07'- 36° 09' N. The average elevation of the area is 1830 m. Hossein-Abad rangelands receives an annual precipitation of 188 mm and its average annual temperature approximate 14.5 °C. To measure carbon sequestration in plant, three transect 200 m at a distance of 30 m from each other were established. 10 ($3m^2$) were established in each transect. Specified herbaceous species and their density were measured. To determine the coefficient of carbon sequestration of species into organic carbon, the combustion method was used. The ash of the samples was weighed after cooling in the desiccators. By determining the weight of the ash and with the weight of the original and the ratio of organic carbon to organic matter the amount of organic carbon in each of the plant organs was calculated separately. For valuing carbon

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sequestration function, carbon tax policy and the cost of emissions was used as a shadow value for carbon sequestration.

3. Results and Discussion

There was a significant difference in comparison of the mean of destruction operations with control area in terms of percentage of vegetation, forage production and litter indicators Table 1, 2 and 3.

Table 1. t test results for shrub destruction operations and control area

Feature	Degrees of freedom	t
Plant vegetation cover	58	17.1^{**}
Forage production	58	10.8^{**}
Litter percentage	58	19^{**}

Table 2. t test results for crescent waterfall destruction operations and control area

Feature	Degrees of freedom	t
Plant vegetation cover	58	13.9^{**}
Forage production	58	11.3^{**}
Litter percentage	58	9.3^{**}

Table 3. t test results for seeding operations and control area

Feature	Degrees of freedom	t
Plant vegetation cover	58	13.6^{**}
Forage production	58	7.3^{**}
Litter percentage	58	13.1^{**}

The results of the variance analysis between destruction operations and control sites forage production showed that there was significant difference between the sites of carbon sequestration project and the control site.

Table 4. Analysis of variance of site type and destruction operations on organic carbon

Feature	Degrees of freedom	Mean squares	F
Site	1	7670.1	378.5^{**}
Kinds of destruction operations	2	172.5	8.5^{*}
error	176	20.2	

- **SOC sequestration in plant**

Results of carbon sequestration in plant has shown in Table 5. In organic carbon construction operation, dominant plants in shrub planting operation were *Atriplex canescen*, *Haloxylon persicum*, *Artemisia sieberi*, *Zygophyllum atripoides*.

Table 5. The amount of SOC sequestrated in dominant plant species in Sarbishe rangelands

Sites	Kind of operation	Area (ha)	Dominant plant	Density (ha)	Average carbon in plants (gr)	Total organic carbon in plant (ha)	Organic carbon (kg/ha)	Carbon sequestration ($/ton)	Total organic carbon (ton)
Destruction operation site	Shrub planting	1472	A.Canesces	209	133.61	27.92	343	8.67	504.8
			P. Haloxylon	213	254.81	54.27			
			A.sieberi	10520	21.2	223			
			z. atripoides	268	141.1	37.81			
	Crescent waterfall	1311	A.Canesces	155	129.6	20.08	220	5.56	288.4
			P. Haloxylon	218	238.3	51.94			
			A.sieberi	7150	20.7	148			
	Seeding	370	P. Haloxylon	280	240.6	67.3	171	4.32	63.2
			A.sieberi	6030	17.2	103.7			
Sum									856.4
Control site	Shrub planting	1472	A.sieberi	1653	9.4	15.53	41.75	10.5	61.4
			A.camelorum	2081	12.6	26.22			
	Crescent waterfall	1311	A.sieberi	652	6.5	4.23	12.64	3.18	16.57
			A.camelorum	956	8.8	8.41			
	Seeding	370	A.sieberi	709	7.2	5.1	11.79	2.9	4.36
			A.camelorum	1015	6.6	6.69			
sum									82.33

- **Valuing SOC in plant**

Table 6. Comparison of carbon sequestration levels and its economic value

Sites	Total organic carbon (ton)	Total Economic value of C ($/ton/yr)	Total Economic value of C (Rial/ton/yr)	Economic value of C sequestration (Rial/ha/yr)
Destruction operation site	856.4	60547.48	211916180	67210.96
Control site	82.33	5820.73	203725550	64613.24
Carbon sequestrated weigh	774	5421.8	191526300	60744.15

4. Conclusions

In this study, to estimate the amount of carbon sequestrated in the plant, considering the cost of measurement, only the dominant species of rangelands of the region were measured. So, it is recommended to measure a whole plant species c sequestration in the region. Also, in selecting suitable species for destruction operations, the ability of species in carbon sequestration is one of the indices for selecting the appropriate species. Considering different valuation methods, it is suggested that the economic value of carbon sequestration in the study area compare with other methods of economic valuation and their results with each other.

Keywords: carbon sequestration, economic value, recovery, steppe rangelands, vegetation.

Evaluation and determination of urban land use resilience based on sustainable development approach (Case study: district one of Tehran municipality)

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Extended abstract

1. Introduction

Land-use planning plays a vital role in achieving a proper level of risk assessment and risk management in urban development processes. Assessing the literature and experiences regarding the improvement of land use planning procedures is an effective approach to mitigate the risks of hazard in urban environments because of any land use planning that is based on risk assessment and prospective and preventive measures focuses on addressing the urban vulnerabilities and thus contributes to prevention or reduction of disaster impact. Therefore, the land use planning is considered as one of the most important urban planning principles and the main responsibility of city planners is to make prospective decisions regarding to the urban land-use and then monitor the proper implementation of these decisions. The last decade has seen a growing interest to the topic of hazard resilience. Researchers often define the resilience as the ability of a system, community or society to withstand the effects of a natural or social hazard. So, for a system to be flexible, it must first have the ability to absorb or deflect the impact of adverse event. By this definition, vulnerability and resilience can be considered as two opposite concepts: a system with greater vulnerability has less resilience, and a system with more resilience is less vulnerable. The land use planning can be used as an effective tool to improve the urban resilience. There is an extensive literature devoted to the topic of urban resilience and the assessment of this concept with respect to various deferent factors, and studies is conducted by Colton et al. (2008), Allen and Bryant (2010), Taylor et al. (2011), Ajiad et al. (2013) and Leon and March (2014). But the literature lacks a study on the topic of land use resilience specifically based on sustainable development approach. Therefore, this paper is an attempt to evaluate, organize and prioritize the urban land use factors with respect to their effect on resilience and with an emphasis on sustainable development approach.

Tehran's district 1 has a high concentration of population and is a house to several administrative and economic centers, but its geological and geographical characteristics make it highly exposed to natural and man-made hazards, which overall makes this district an ideal subject for a case study.

So, the present study aims to determine and clarify the dimensions and criteria of urban land use resilience, and to measure and evaluate these dimensions and criteria for Tehran's district 1, in order to takes effective steps toward reducing the vulnerability and improving the resilience of the study area.

2. Theoretical principles of research

Numerous studies have been carried out to determine the relation of resilience dimensions and components with the urban land use. In the end, several dimensions and criteria considered more prominent by the experts (specializing in the field of environmental planning, urban planning and geography) have been proposed for the concept of land use resilience. The dimensions of urban land use resilience are listed in Table 1.

Table 1. The dimensions of urban land use resilience

Dimensions
Structural-natural
Structural-physical
Socio-cultural
Economic

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Structural-natural dimension is among the main measures of a resilient community, and describes the various structural-natural capacities of a city or a district affecting its ability to prevent and withstand the crisis and its quick return to normal status after the crisis. Any city or district lacking structural–natural resilience will have a very low environmental quality and will be very vulnerable in the face of a disaster. The structural-physical dimension is another main aspect of urban land use resilience. Improving the resilience of cities in this aspect is an appropriate and effective way to strengthen the city to deal with crises and natural and unnatural hazards. Paying proper attention to this aspect increases the quality of normal city life before the crisis, reduces the damage and casualties in the event of crisis, and accelerates the return to normal conditions after the crisis by speeding up the relief and aid efforts. Another important aspect of urban land use resilience is its socio-cultural dimension. Paying proper attention to the socio-cultural aspects of urban land use resilience increases the environmental quality and improves the lives of citizens. Another advantage of socio-cultural dimension of resilience is its ability to increase the mental, psychological, and spiritual readiness of citizens against the events that happens before, during and after the crisis. The economic dimension is another key aspect of urban land use resilience. Economic resilience describes the economic capacity of a region to prevent and withstand the crisis and to make a quick return to normal status after the crisis. Any city lacking the economic resilience will be highly vulnerable to natural and unnatural disasters and will not be able to quickly return to equilibrium after the crisis.

3. Materials and Methods

The study area is the first district of Tehran municipality. Given the current Tehran northern borders approved by Tehran City Council, the area of this district is 4574.24 hec. This district is bounded by 1800 m contour line of the southern slopes of the Alborz Mountains in the north, by the Chamran highway (between Hotel Azadi and Sadr bridge) in the south, by Darakeh river basin in the west, and by the Artesh highway, cement factory, and Tehran's northeast oil depot in the east.

At the first step of this research, the theoretical framework was determined by collecting data from library and electronic resources and related articles. Then the important criteria and sub-criteria for assessing the urban land use resilience were determined by incorporating the expert opinions and reviewing the previous research. Then the FAHP method, which incorporated the opinions of 15 experts and faculty members in the field of environmental planning, urban planning, rural planning and urban development, were used to make pairwise comparison between important dimensions and criteria. At this stage, all valuations were based on experiences and studies of those experts. After making pairwise comparisons, the maps of district resilience factors were standardized in Idrisi environment, and then the weight of each resilience factor was applied to the layers in the GIS environment. The maps were then merged to determine the resilience of the district, and finally the TOPSIS technique was used to prioritize the resilience of each zone within the district.

3.1. Results and Discution

The following steps were taken to assess and determine the urban land use resilience in Tehran's district 1.

• **Step 1. Obtaining the weight of each land use resilience criterion**

After the determination of criteria affecting the land use resilience with respect to sustainable development approach, the fuzzy numbers listed in Table 5 and the FAHP method, which incorporated the opinions of 15 experts and faculty members in the field of environmental planning, urban planning, rural planning and urban development were used to make a series of pairwise comparisons between these criteria, and ultimately the weight of each criterion was extracted.

• **Step 2. Development of the fuzzy maps with respect to land use resilience criteria**

The map related to each criterion was standardized in IDRISI environment.

• **Step 3. Development of urban land resilience maps with respect to sustainable development approach**

At this stage, the maps corresponding to different criteria were overlaid on each other (in GIS environment) to obtain the resilience of each urban land use resilience dimension.

• **Step 4. Development of urban land resiliency map**

After applying the weights of criteria on their layers and merging them in GIS environment, Tehran's district 1 urban land use resiliency map was developed.

• **Step 5. Classification of urban land use resiliency**

Five levels of resilience were defined to classify the district 1 urban land use resiliency. These levels include fully resilient, resilient, moderately resilient (moderately vulnerable), vulnerable, and fully vulnerable.

• **Step 6. Classification of resilience of different zones in district 1 by the use of TOPSIS method**

At this stage of study, TOPSIS method was used to classify the resilience of different zones in district 1 with respect to structural-natural, structural-physical, socio-cultural and economic dimensions.

• Step 7. SWOT strategic analysis on Tehran's district 1 resilience

At this stage of study, a SWOT analysis was performed to determine the strengths, weaknesses, opportunities and threats related to the subject of district 1 resilience and therefore achieve a broader and more precise understanding about the research findings.

4. Conclusion

In this study, first the factors affecting the resilience of land use were examined, and then these factors were evaluated for Tehran's district 1. The results of these evaluations showed that average resilience of this area is approximately 0.61 which indicates that this district is moderately resilient (moderately vulnerable). Therefore, according to the research findings, the following results can be concluded:

1- According to experts' opinions, the structural-physical dimension plays the most important role in enhancing the urban resilience. In this dimension, the criteria of buildings condition, access routes, high-risk land uses, public safety land uses, green open spaces, and quality of residential centers were evaluated. Ultimately, district 1 gained an average resiliency score of 0.53 in this dimension, which indicates a medium resilience (or medium vulnerability) with respect to this dimension.

2- According to experts' opinions, the socio-cultural dimension also plays an important role in enhancing the urban resilience. This dimension consisted of 8 criteria including population density, and land uses related to healthcare, education, culture, tourism, sports, law enforcement, and religion. After overlaying all layers corresponding to criteria, district 1 gained an average resiliency score of 0.69, which indicates the resilience of this district with respect to this dimension.

3- The structural-natural dimension was placed third in terms of importance in enhancing the urban resilience. The criteria of this dimension included natural hazards, composition and distribution, vegetation, and physiography. District 1 gained an average resiliency score of 0.78 in this dimension, which indicates the resilience of this district with respect to this dimension.

4- The economic dimension included the criteria of commercial land uses, economic activity, employment and unemployment. Assessments in relation to this dimension revealed that District 1 has an average resiliency score of 0.47, which indicates the medium resilience (or medium vulnerability) of this district with respect to this dimension.

Keywords: metropolises, resilience, sustainable development, urban land use.

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The affecting factors on forming and development of Tehran with an emphasis on relationship between city and nature

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Extended abstract

1. Introduction

According to historical documents, up to the middle of the period of Nasir al-Din Shah, the growth of Tehran City has been along the eastern-western axis and within the fence of Tahmasebi. At the end of this period, with the demolition of the fence, the city's growth occurred from Darvazeh Dowlat towards the north and the Alborz slopes. But so far, the interaction between the Golestan Garden and Tehran City and the impact on the growth and development of the city has not been investigated. In other words, by studying the history of researches on the formation and development of Tehran, it became clear that no probe is yet carried out to find out the main reason of the formation and growth of Tehran with this perspective that the garden can be the main reason for the birth and development of the city as a part of the natural environment. Considering that in the architectural perspective of Iran, the architecture is born from the garden and comes from it, this important factor can be investigated for Tehran City and the effect of existence of the historical garden of this city which was not initially more than a theorem can be investigated.

Based on studies from historical maps, the garden (Golestan) is identified as the primary core for the formation of the city and has affected its development and growth.

Therefore, this article seeks to show that the main factor for the creation and growth of Tehran is the existence of the garden (Golestan) and there is a mutual relationship between the natural context and the garden, and the city and the architecture.

To achieve this, we need to identify the following basic questions:
- Is it possible to state that the existence of Tehran is originated from the garden?
- Has the development of the city been based on the garden element?
- How is the role of Golestan Garden in this regard?

As it is clear from the nature of the problem, expressing the hypothesis about the physical and spatial changes of Tehran and examining the main cause of these changes, is done taking into account a motive factor called the garden. And finding out the effect is based on the two-way natural context, and the city and the architecture on each other. Therefore, the main hypothesis can be expressed as follows:
- There is a direct relationship between the growth of a city, especially Tehran and the garden (Golestan Garden) as the primary core and natural context.
- With regard to the process, when the city is seen and the places where disjunctions and conjunctions are created in the city, then the interaction between the natural context and natural factors and its formation is found.

2. Materials and Methods

Considering that based on the context approach, access to natural and historical layers of the city and the natural context is a reasonable and scientific method to study how cities grow and develop. Therefore, this method is used to evaluate and document the relationship of Tehran and natural factors in this study.

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In order to achieve the goals of the research, the process of city changes related to the garden, the garden related to the architecture, and the architecture related to the decorations should be first achieved from historical texts. According to this method, by collecting and studying the documents, historical documents, travel logs, and images, the data related to the above items is collected and then by analyzing these studies, layers of required information is provided in order to analyze the growth process and orientation of Tehran and its level of relationship with natural factors and natural context. Thus, after data collection, the analysis of the relationships between the garden and the city, and the architecture and the natural context from this information is dealt with, and ultimately, information analysis is qualitatively dealt with, in a hermeneutical approach.

3. Results and Discussion

In general, by comparing historical maps and images, and overlapping the aforementioned maps and analyzing the documents, the following points can be deduced:

3.1. On the macro scale

According to written maps and documents, it was revealed that:
- The first engineering map of Tehran was produced before 1844 by the Russian orientalist, Elyanikovich Barazin, which reflects the state of Tehran after the period of Fathali Shah. As it is seen, at that time, wide fields of east and west of Tehran, connected to the fence, was covered by gardens and farms.
- "The Darul Khalafeh Teheran Map" was depicted in 1858 by August Kreshish, the Austrian teacher of the Dar Al Fonon. Comparing this map with the Barazinmap shows that over almost 20 years, all of Tehran's vacant landshad gone under construction, leaving scattered pieces from among city gardens; the largest of them on the southwest of the fence was connected to the Davazeh Qazvin.
- "The map of the city of Dar al-Khalifa Naseriof Tehran" has been drawn by Abdul Ghafar Hamedani in 1849. Green-marked parts are gardens and farms within the city limits (Naseri's moat). These gardens were formed in the Nasseraddin Shah period, mainly in the north and west of the city.
- By overlapping the maps, it's seen that there is a balanced relationship between the natural and historical context of Golestan Garden and this relationship has led to the early development of the city at the primary settlements of Golestan Garden. This relationship between the garden's structure and the city's growth continues until the Pahlavi period in 1950s.
- Generally, the development of the city began from the east and west of the Golestan Garden, then continued to the north and northeast. These changes first appeared in the map of Abdul Ghafar in 1890, and then in the map drawn in 1944, which shows the most orientation towards the north.
- The part size of gardens, especially the Golestan Garden, has changed within the fence by develping city and political-social changes, and gradually diminished. It is clear that the amount of gardens within the city decreases with the passing of years and increases the density of the city. This growth and density has led to the destruction of gardens.

3.2. On a middle scale:

- Garden changes (Tables 2 and 3) not only affected the city's growth, but also affected the architecture, especially on the geometry and orientation of the buildings within Golestan Garden. In such a way that the construction priority has been with garden geometry and buildings are prioritized the second and the possibility of changing the orientation and the lack of specific geometry for buildings is often seen. This effect has continued until the fence remained around the garden.
- The geometry of the garden, which is mostly square or rectangular, not only affects the formation of the buildings within the garden, but also affects outside the garden and the direction of the streets and the city's gardens as well.
- In the Qajar period, contrary to its previous periods, the visual relationship between the garden and the distant landscapes, such as urban prominent elements, cultivation and mountain landscape, replace the visual relationship of the garden's inner landscape along the axis between the building and the gate.
- It can be said that Golestan Garden and the citadel and structures within, is actually a city in another city, based on the system of changes and its effect on the growth of Tehran.

3.3. On the micro scale, interaction of the garden with decorations

The images used in the Golestan Palace are vegetarian, animal, geometric, human, landscape and inscription where vegetarian designs had the most application. Based on this, it can be said that the decorations of the Golestan Palace are also formed in the interaction with the garden.

4. Conclusion

The primary core of the Tehran is the garden and vegetation and the route of the water network (Qanats) in the Alborz mountain range. One of the most effective gardens on this formation is Golestan Garden. As the city grows, the number of these gardens decreases and goes up towards outside Tehran to the north. In general, it can be said that the primary Tehran, as a city, had a direct relationship to natural elements, and this relationship has continued until Pahlavi period. The interaction between the city and the garden and the natural context can be divided into three parts according to the research: the relationship between nature and the city on a large scale, nature and architecture on the middle scale, decorations and nature on the micro scale.

On the macro scale, the garden led to the construction of the city and the creation of urban changes and its orientation. In the middle scale, the Golestan Garden and the set of buildings within is itself as a city inside another. Its primary core is the garden and its growth is northward. The priority of the construction and modification within, it is the preservation of the geometry of the garden in the form of square and rectangle (the principles of Iranian gardening); and by preserving the priority of its construction, it has affected the architectural spaces. On the other hand, the change in the landscape of the gardens within the city towards the slopes of the Alborz mountains and the remote landscapes during the Qajar period led to the orientation of the growth of the buildings within the garden, and in turn, the orientation of the growth of the city towards north and the hillside. On the micro scale, the importance of nature and natural elements such as tree, plant, and water can be seen in such a way that for the entire royal space, tiles and painting decoration with the image of these landscapes can be seen.

Analysis of the Effect of Land Cover Spatial Configuration and Physical Characteristics of Buildings on the Surface Urban Cool Island Phenomenon

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Extended abstract

1. Introduction

The expansion of metropolitan areas has led to several physical, socioeconomic and environmental issues. One of the negative consequences is the intensification of urban heat islands (UHI) phenomenon in urban areas with more moderate climate. Studies on surface UHI have shown that in more arid environments there is a possibility for urban areas to have a lower temperature than the surroundings; a phenomenon that is called surface urban cool islands (SUCI) or surface urban heat sink.

Studies on the SUHI have shown that in addition to spatial composition and abundance of land covers, the shape of a land cover and its relative placement to other land covers (spatial configuration) is also important. These studies have pointed out that the land surface temperature (LST) decreases, as the complexity of urban patches in more moderate areas increase. However, studies on SUCI have mainly focused their attention on analyzing the effect of time of data acquisition and also the influence of the composition of land covers on the land surface temperature.

Another matter that has been somehow forgotten is the effect of building density and plot size on LST. Previous studies have noted the positive impact of the increase in building density on LST. However, the effect of plot size on the SUCI phenomenon has been significantly neglected.

Therefore, the purpose of this study is twofold. First, it tries to investigate the role of spatial configuration of land covers in the formation of SUCI in Shiraz urban area and then to assess the effect of urban density and plot size on the intensification of SUCI.

2. Materials and Methods

The process of the study involved three stages. First, the SUCI intensity for four different seasons was studied to determine if the SUCI phenomenon can be seen in Shiraz. Then, by conducting linear regression and with the use of landscape metrics, the relationship between the mean LST and the shape complexity and fragmentation of land covers was examined. Afterwards the effect of building density and plot size of the mean LST was studied.

Shiraz, the fifth largest city of Iran in terms of population with 1.869 million, has a hot semi-arid climate according to the Köppen climate classification.

2.1. Retrieval of LST

The methodology proposed by Sobrino et al. (2004) and Sobrino et al. (2008) was used to retrive LST for each year from the thermal bands of the images (band 6 of Landsat TM). It should be noted that the land surface emissivity was calculated for the thermal band with the simplified of Normalized Difference Vegetation Index (NDVI) Thresholds Method (NDVI^{THM}).

2.2. SUCI intensity

A 10-km rural buffer around the core urban area which does not include water bodies was selected to compute the SUCI intensity.

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2.3. Indicators to analyze the effect of landscape composition and spatial configuration and building characteristics on LST

The effect of landscape composition and spatial configuration on the intensification of SUCI was studied by using composition indices and landscape metrics. The composition indices, which are including NDVI and NDBI, measure the abundance of vegetation and non-vegetative land covers, respectively. Two metrics of Landscape Shape Index (LSI) and Fractal Dimension Index (FRAC) measure the shape complexity of land covers by studying the relative amount of perimeter per unit area. Landscape Division Index (DIVISION) is the third spatial configuration index to study the degree to which land covers are broken up into separate patches.

The effect of building characteristics was also studied through examining the building density (Floor Area Ratio) and the size of plots in each census tract.

3. Discussion and Results

3.1. SUCI intensity

There were distinctive temperature differences between urban areas and the surroundings throughout the year. Also, the SUCI phenomenon in Shiraz was at the highest level in summer. While the SUCI intensity was 6.62 degrees in summer, it was 3.42 degrees at the lowest level in winter.

3.2. The effect of landscape composition on LST

The value of NDVI showed that vegetation had no effect on the reduction of LST in urban area of Shiraz (Fig. 1a). Although a great deal of vegetation of the city is within conservation areas in a few census tracts which had lower LSTs. On the other hand, the NDBI represented a significant effect of the built-up area on reducing land surface temperatures (Fig. 1b), contrary to studies on urban heat islands.
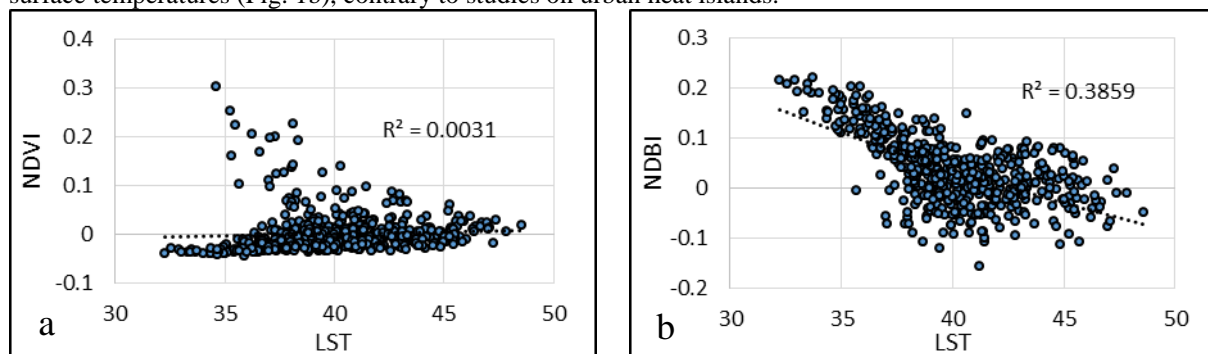

Fig.1. Scatter plot with regression line for LST and composition indices. a) The Normalized Difference Vegetation Index (NDVI), b) the Normalized Difference Built-up Index (NDBI)

3.3. The effect of shape complexity and fragmentation of built-up areas on LST

Examining the landscape metrics showed that as the complexity and fragmentation of urban patches increased, the mean LST of census tracts rose as well (Fig. 2). The increase in shape complexity and fragmentation of urban patches means these urban patches will have more adjacency with other land covers (such as vegetation or soil) on their edges.

3.4. The effect of building characteristic on the intensification of SUCI

The value of FAR pointed out that as the building density of each census tract increased, the mean LST decreased. On the other hand, the smaller the size of plots in a census tract, the lower the mean LST. This can be clearly seen in historical areas of Shiraz in which the size of plots is smaller (Fig. 3).
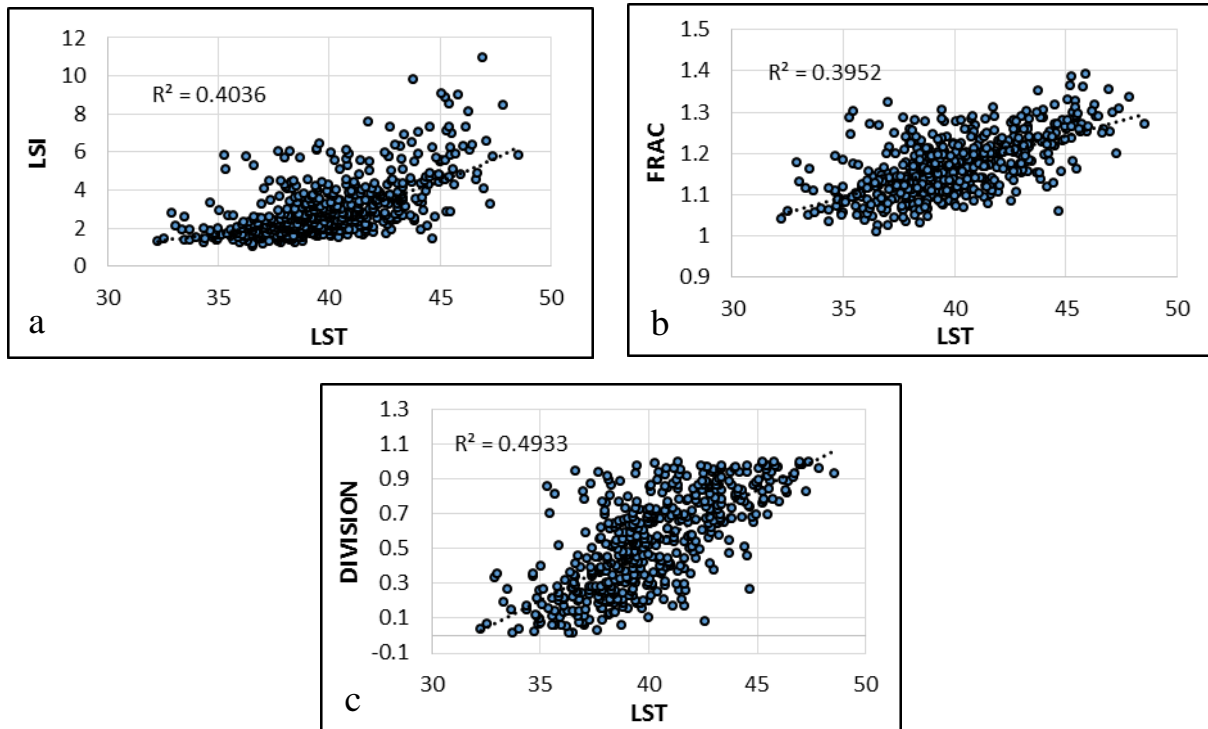
Fig. 2. Scatter plot with regression line for LST and spatial configuration indices. a) Landscape Shape Index (LSI), b) Fractal Dimension Index (FRAC), c) Landscape Division Index (DIVISION).
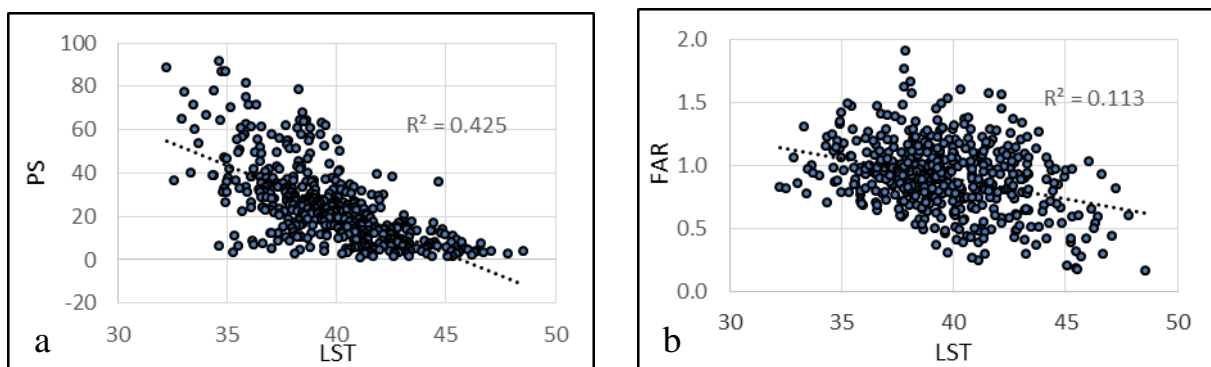

Fig. 3. Scatter plot with regression line for LST and building characteristics. a) Plot size (PS), b) Floor area ratio (FAR)

4. Conclusion

The results of this study revealed that the surface urban cool islands in Shiraz was significantly affected by the expansion of built-up areas. The analysis of landscape metrics showed as the built-up areas grew more irregularly, LST decreased. In other word, the shape complexity and fragmentation of urban patches led to an increase in LST. The shape complexity and fragmentation of urban patches means they have more adjacencies with other land covers such as vegetation. The analysis of building density and size of plots also showed the height of buildings and the size of plots affected the land surface temperature. In fact, the increase in building density and the decline in the size of plots led to the mitigation of LST and the intensification of SUCI. To sum up, while the expansion of built-up areas has a distinctive impact on mitigating LST, the SUCI phenomenon intensifies as this expansion occurs with higher density and in a smaller area.

Keywords: building density, landscape metrics, land surface temperature, plot size, surface urban cool islands.