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## Wastewater and sewage sludge effects on the absorption of some heavy metals in soil and mint

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### Expanded Abstract

#### Introduction

Due to its especial geographic condition, Iran, as a semi-arid country, suffers from water shortage for domestic, industrial and agricultural usages. As limited water supplies, the use of non-conventional water resources such as industrial or municipal wastewater, is common practice in many parts of the world including Iran. It is estimated that at least 20 million hectares in 50 countries are irrigated with raw or partially treated wastewater. Also, it is estimated that potential volume of wastewater in urban and rural areas in Iran will be 4369 and 823 million m<sup>3</sup>, respectively.

On the other, the application of sewage sludge in agricultural soils has been widespread in many countries around the world and also in Iran. The application of sewage sludge in agricultural has been shown to improve soils such as organic matter, nutrients, porosity, aggregate stability, bulk density and plant productivity. Despite the growing interest in wastewater and sewage sludge usage, excessive application of them may have some harmful effects such as human health problems, runoff and leaching of nutrients to surface and groundwater, undesirable chemical constituents, pathogens, accumulations of heavy metals in plants and soils, negative environmental and health impacts. So, wastewater and sewage sludge application should be under controlled conditions to minimize health risks of pollution to agricultural products, soil, ground and surface water.

The use of medicinal plants and herbal medicines is increasing rapidly all over the world, which shows the importance of cultivation and production of these plants. One of the important needs of medicinal plants, in order to achieve high performance and quality, is plant nutritional needs. Therefore, increasing in soil fertility could be increased yield of medicinal plants.

Today's medicinal plants are commercially cultivated in polluted environments where soil, water and air contain rather high levels of pollutants. These plants appear to be a good choice for phytoremediation since these species are mainly grown for secondary products (essential oil). Thus the contamination of the food chain with heavy metals is eliminated. Aromatic and medicinal plants also have a demonstrated ability to accumulate heavy metals.

The mint (*Mentha spicata*) is a medicinal plants and it has received considerable economic importance due to the large demand for its essential oil in food, pharmaceutical, cosmetic and hygiene industries.

The objective of this study was to determine the use of wastewater, sewage sludge on growth and nutrient concentrations of mint (*Mentha spicata*).

#### Materials and Methods

This study was conducted at the greenhouse of Bu-Ali Sina University located in Hamedan, western Iran. The experiment was run in May 2015- February 2016, including 5 months for soil preparation (in lysimeters) and 5 months for crop cultivation and harvesting. To evaluate the use of wastewater and its sewage sludge on growth

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and nutrient concentration of mint (*Mentha spicata*), a factorial experiment based on completely randomized was designed with three replications in 27 lysimeters. The factors included three types of watering: tap water (W1), raw wastewater (W2) and treated wastewater (W3); three sewage sludge levels: 0 (S1), 50 (S2) and 100  $\text{tha}^{-1}$  (S3); and three time of harvesting (T1, T2 and T3). Therefore, 9 treatments (W1S1 to W3S3) were considered for investigation. It is noted that the time of harvesting factor was not considered to be an independent factor.

27 volumetric lysimeters were applied as Cultivation beds ( $26 \times 30 \times 30$  cm). The soil had two layers: the upper layer (0 to 50 cm) with sandy loam texture, and the bottom layer (50 to 110 cm) with sandy clay loam texture. After beds preparation, mint (*Mentha spicata*) was planted in them. The raw and treated wastewaters as well as sewage sludge were prepared from wastewater treatment plant of Hamedan. Also, municipal compost was prepared from Kermanshah Compost Company. Overall, 11 irrigation programs with 10-day intervals were applied. The plants shoot were harvested at the full flowering stage in three times. At the end of each harvesting stage, the fresh and dry weights, as well as the amount of N, P, K, Ni, Cd and Pb of mint were measured. Also, after the last harvesting, soil samples were taken at two depth of lysimeter: D1: 10 and D2: 40 cm. Soil samples were analyzed for Ni, Pb, Cd, total N, total p and K.

All analyses were performed using SAS statistical analysis (SAS, 1987). Separation of means was performed using Duncan's at  $P < 0.05$ .

### Discussion of Results

The ANOVA test for effects of water quality and compost levels on fresh and dry weight as well as nutrient in mint showed that the amount of N, K, P and Cd were influenced by interaction between water quality and sewage sludge levels. But amount of Ni and Pb in shoot of mint was not influenced by interaction between water quality and sewage sludge levels.

The results showed that using of wastewater and sewage sludge heavy metals in soil, so, compared to control, W2S3 were increases Pb, Ni and Cd in soil 304%, 375% and 208%, respectively.

The heavy metals accumulated in soil surface layers (at depths of 10) and heavy metal concentrations and their ranges decreased with deepening of soil layer. Preferential flow and metal complexation with soluble organic apparently allow leaching of heavy metals. Also, the result showed that application of wastewater and sewage sludge increased fresh and dry weights of mint. As, in comparison control, W3S3 increased fresh weight and dry weight of plant to 257% and 239%, respectively. Also, performance of plant was increased during next harvesting. Many of researchers reported that providing balance nutrients and gradual nutrient release from organic sources during period of growth can be positive role in enhancing the growth of mint. The reasons for increasing the yield of plants include: having the organic matter, increasing soil water holding capacity, strengthening the plant hormone-like activities, increasing nutrient uptake by plants and generally improving the chemical and physical soil structure, noted.

The amount of nitrogen in plant was varied among the treatments. The maximum (4.65%) and minimum (1.11% dry weight) amounts of nitrogen were observed in W2S3 and W1S1, respectively. Total N concentration in W2S3 was 3.12 times greater than that in W1C1. Also, the highest amount of P (0.67% dry weight) and K (3.85 mg in dry weight) was observed in W2S3. Also, the results indicate that using the wastewater (raw wastewater and treated wastewater) and sewage sludge (50 and 100  $\text{tha}^{-1}$ ), compared to the control (fresh water and soil without any sewage), increases heavy metals (Ni, Pb and Cd) of mint. As, maximum and minimum of heavy metals concentration in the shoot of mint were obtained in  $W_2$  and  $W_3$  as well as in  $C_3$  and  $C_1$ , respectively. The concentrations of heavy metals ( $\text{mg kg}^{-1}$  dry wt.) in mint ranged from 0.01 to 0.57 for Pb, 0.02 to 0.71 for Ni and 0.01 to 0.3 for Cd. The results of this study showed that the amount of heavy metals (Ni, Pb and Cd) were lower than the international Cd standard level of FAO. The reasons for the increase in the amount of nitrogen, phosphorus and potassium in plant can be noted rich wastewater and sludge in elements.

### Conclusions

In study, the effects of wastewater sewage sludge on nutrient concentrations and growth of mint (*Mentha spicata*) were studied. The results showed that the use of wastewater (raw and treated) and sewage sludge different levels of sludge were increased performance and uptake N, P, K, zinc, Pb, Ni and Cd in plant, significantly. Although the concentration levels of Pb, Ni and Cd is lower than the limit of FAO standard, long-term use of these wastes should be done cautiously.

**Keywords:** growth parameters, heavy metal, mint, sewage sludge, wastewater.

# Biological treatment of sanitary wastewater in a sequencing batch reactor (SBR) by microalgae *Chlorella vulgaris*: Effect of operational parameters and artificial neural network modeling

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## Expanded Abstract

### Introduction

In this work, by constructing a sequencing batch reactor (SBR) and the use of microorganisms and microalgae *Chlorella vulgaris*, the performance of the system is studied for treating sanitary wastewater of Yazd power plant, Iran. For this purpose, the effect of pH, temperature, influent chemical oxygen demand (COD) concentration and airflow rate is examined on removing of COD and its residual concentration in wastewater. Another aspect of this research is the development of a multilayer feed-forward neural network model to predict the concentration of residual COD during the process of treatment.

### Materials and Methods

#### Operational conditions

The pilot SBR reactor consisted of a wastewater storage tank, an aerobic tank and a settling tank and the used wastewater in this research were sanitary wastewater of Yazd power plant. Each cycle of the reactor was 8 hours including 5 min of filling, 450 min of aeration, 20 min of settling and 5 min of discharge. In order to supply the required microorganisms for the reactor setup, active sludge was prepared from the return line of the sludge of the Yazd power plant wastewater treatment plant. Also, due to the quality of the microalgae of *Chlorella vulgaris* and its accessibility, this microalgae was prepared from the Yazd sewage stabilization pond and both of the microorganisms and microalgae were transferred to the reactor. At the beginning of the operation, the influent COD entered the system with 300 mg/l concentration (minimum organic load). 20 days after the initial setting up of the reactor, the removal efficiency reached its maximum, microorganisms, and microalgae adapted to the existing conditions. Then, at the cycle time of 8 hr, the concentrations of residual COD were obtained at different pH, temperature, influent COD concentration and airflow rate. Sampling of the system was done at intervals of one hour for testing.

#### Artificial neural network

In this study, a multilayer perceptron artificial neural network (MLP-ANN) was developed via employing Levenberg–Marquardt training algorithm in order to predict the concentration of residual COD. The ANN consisted of three layers. Only one hidden layer was used between the input and output layers. Input layer consisted of five neurons, which included pH, time, temperature, airflow rate, and influent COD concentration, and output layer had one neuron, which was residual COD concentration and the optimum number of hidden neurons was obtained by guessing and error. In order to increase the convergence and accuracy of the neural network, the input and output data were normalized and scaled to the range of 0–1. The performance of the ANN model was measured by root mean square error (RMSE) and correlation coefficient ( $R^2$ ) between the predicted values of the network and the experimental values.

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## Discussion of Results

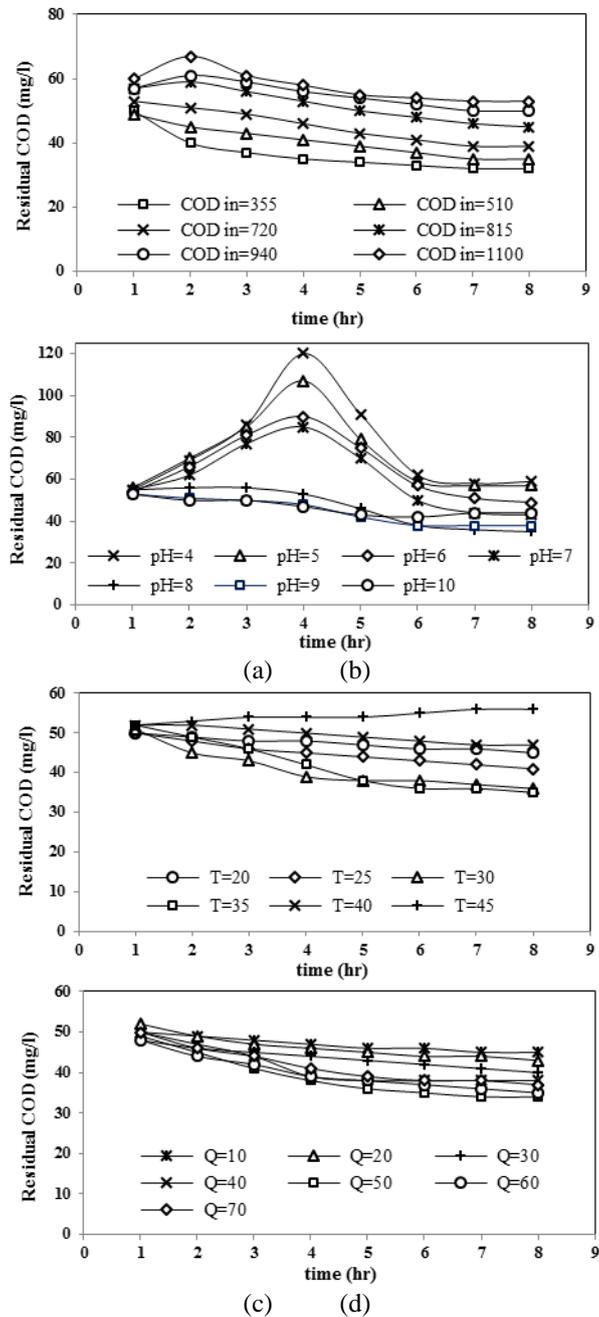
### Effect of different parameters on the performance of wastewater treatment system

One of the important parameters that can have a significant effect on the performance of wastewater treatment is the amount of organic load in the influent wastewater. Figure 1a shows variation of residual COD concentration in cycle time of 1 to 8 hr over influent COD concentration from 300 to 1100 mg/l at a pH of 8, temperature of 30°C, and airflow rate of 80 l/min. As can be seen, increasing of the influent COD concentration, caused to increase the residual COD concentration in the wastewater. It was concluded that according to the destructive effect of increasing the influent COD concentration, control of the influent COD concentration in a constant range is necessary. This will cause the necessary substrate for the growth of microorganisms and microalgae to be provided consistently and sufficiently. The maximum influent COD concentration of the power plant was 1100 mg/l and at least 300 mg/l. Therefore, by establishing a return flow from the effluent wastewater of power plant to the primary wastewater storage tank and adjusting it to the influent COD concentration, the amount of fluctuations in the influent wastewater load was reduced and the influent COD concentration was fixed at 600 mg/l.

One of the effective parameters on the performance of the wastewater treatment system is the pH of influent wastewater. Figure 1b shows variation of residual COD concentration in cycle time of 1 to 8 hr over a pH range from 4 to 10. In this case, the influent wastewater had a temperature of 30°C, COD concentration of 600 mg/l, and airflow rate of 80 l/min. As shown in Figure 1b, after one hr testing, the residual concentration of COD was approximately 53 mg/l. After this time, at first, the COD concentration increased at low pH, and even at pH of 4, it reached to 120 mg/l. The reason was that at the beginning of the treatment by microorganisms and microalgae, the digestion of wastewater organic materials was done. The result was the appearance of organic acids that caused the further decrease of pH, thereby reducing the activity of microorganisms and microalgae and increasing of COD concentration. Then, by decomposition of the produced acids and the beginning of the decomposition of proteins and fats, the pH of the system, the activity of microorganisms and microalgae increased and the COD concentration decreased and fixed at about 60 mg/l. At high pH, because of the high activity of microorganisms and microalgae, the residual COD reduction process performed with a suitable gradient during the time and eventually remained constant. As shown in Figure 1b, the most suitable pH for the activity of microorganisms and microalgae is pH of 8, in which case the residual COD concentration has reached the lowest value of 34 mg/l.

Temperature is one of the important effective parameters on activity of microorganisms. Figure 1c shows variation of residual COD concentration in cycle time of 1 to 8 hr over temperatures from 20 to 45 °C at a pH of 8, the influent COD concentration of 600 mg/l, and airflow rate of 80 l/min. As shown in Figure 1c, the best temperature for system operation is between 30-35°C. At high temperatures, because of the reduced solubility of air in the wastewater, enough oxygen and CO<sub>2</sub> were not provided for microorganisms and microalgae, which caused to increase the residual COD concentration, compared to the other temperatures. On the other hand, at low temperatures due to the reduced growth of microorganisms and microalgae, increase of residual COD concentration occurred. According to available data from the power plant, the temperature of influent wastewater was almost 30°C in most seasons. On the other hand, according to Figure 1c, there is no significant difference between the concentration of residual COD at 30 °C and 35 °C, so the optimum temperature of this process was chosen 30 °C.

In aerobic treatment systems, desirable aeration should be done to create suitable conditions for the growth of microorganisms. Figure 1d shows variation of residual COD concentration in cycle time of 1 to 8 hr over aeration conditions from 10 to 60 l/min at a pH of 8, temperature of 30 °C, and influent COD concentration of 600 mg/l. As can be seen, increasing of the aeration generally had a positive effect on the performance of treatment process and with increasing aeration, residual COD concentration has decreased. However, this effect is not noticeable for airflow rate of more than 50 l/min. More aeration will increase the costs, sometimes lead to cell failure, and thus decrease the growth of microorganism and microalgae. Therefore, in this study, the optimum airflow rate of 50 l/min was selected. In this airflow rate, the lowest residual COD concentration was obtained.



**Figure 1.** (a) Variation of residual COD concentration at different influent COD concentrations (pH=8, T=30 °C, Q= 80 l/min). (b) Variation of residual COD concentration at different pH (T= 30 °C, COD<sub>in</sub>= 600 mg/l, Q= 80 l/min). (c) Variation of residual COD concentration at different temperatures (pH=8, COD<sub>in</sub>=600 mg/l, Q= 80 l/min). (d) Variation of residual COD concentration at different airflow rates (pH=8, T=30 °C, COD<sub>in</sub>= 600 mg/l).

### Modeling results by artificial neural network

In this study, 208 laboratory data was used for modeling. Two thirds of the data were randomly selected for training the network and one third remained for evaluation of modeling accuracy. To determine the optimum number of neurons in hidden layer, 1 to 15 neurons were used. The transfer functions of hidden and output layers were selected tangent sigmoid (tansig) and linear (purelin), respectively. The results indicated that the network with the number of neurons equal to seven had the best performances because the root mean square error (RMSE) had the lowest value and the correlation coefficient ( $R^2$ ) had the closest value to one.

### **Conclusion**

In this study, at first, a pilot SBR reactor was installed and operated by microorganisms and microalgae *Chlorella vulgaris*. In the next stage, the system was evaluated with variables such as pH, temperature, influent COD concentration and airflow rate. By analyzing the values obtained from the reactor, optimum values of these parameters were determined to achieve the lowest residual COD concentration. The results showed that at a pH of 8, temperature of 30 °C, influent COD concentration of 600 mg/l and airflow rate of 50 l/min, concentration of residual COD was obtained 34 mg/l, which indicates an increase in efficiency of the system. In addition, an artificial neural network model was developed to predict the concentration of residual COD. ANN predicted results were in good agreement with the experimental data with a correlation coefficient and root mean square error of 0.944 and 0.034, respectively.

**Keywords:** artificial neural network, microalgae *Chlorella vulgaris*, modeling, sequencing batch reactor (SBR), wastewater treatment.

## Physiological and biochemical parameters of response to oxidative stress in macroalgae *Chara sp.* following remediation of malachite green

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### Extended Abstract

#### Introduction

The effluents of wastewater in some industries such as dyestuff, textiles, leather, paper, plastics, etc., contain various kinds of synthetic dyestuffs. The effluents of these industries are highly colored and the evacuation of these wastes into receiving waters causes intense damages to the environment and biological systems. In recent years, a number of studies have focused on some micro/macro-organisms that are able to biodegrade and absorb dyes in wastewaters. Phytoremediation is a newly evolving field of science and technology that uses plants and algae to clean up polluted sites. This technology has been received attention lately as an innovative, cost-effective alternative to the more conventional water treatment methods.

Algae are pivotal organisms in aquatic ecosystems as they contribute substantially to primary photosynthetic production. In most freshwater and marine habitats, algae underpin carbon and oxygen cycles, food chains and webs provide refuges and breeding habitats for vertebrate and invertebrate animals. Algae can degrade number of dyes, postulating that the reduction appears to be related to the molecular structure of dyes and the species of algae used.

In this study, macroalgae *Chara sp.* was used in order to decolorize a dye solution containing Malachite Green (MG). *Chara* is a submerged aquatic macroalgae which grows attached to the soft mud at the bottom, along the margins of fresh water pools, lakes and slow-flowing streams thick masses. Generally, it prefers clear, fresh, hard and still shallow water.

MG, a triarylmethane dye, is most widely used for coloring purposes such as dyeing silk, leather, wool and paper in textile industries. In addition, it is extensively used in the aquaculture industries as a biocide worldwide. Susceptibility to free radical damage has necessitated the development of a complex array of antioxidants to counteract the deleterious effects of reactive oxygen species (ROS). Oxidative stress is defined as an imbalance between the cellular antioxidant defense systems and the production of reactive oxygen species (ROS).

Induction of oxidative stress and the related formation of reactive oxygen species (ROS) are frequent results of environmental stressors. The main purpose of the present investigation was to evaluate the potential of *Chara sp.* in remediation of MG, the study of changes in some physiological and biochemical parameters, including photosynthetic pigments content, phenolic compounds and the activity of some major antioxidant enzymes including peroxidase (POD), catalase (CAT) and superoxide dismutase (SOD) that can be involved in algae resistance to dye and/or its metabolism.

### Materials and Methods

#### Algal biomass and dye removal

The algal species were acquired from Azna-lake (Khalkhal) in North of Iran. The algal species were washed with distilled water to remove macro/ microscopic contaminations. According to its morphology and macro/ microscopic observations, it was identified as *Chara* species belongs to Charophyta.

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The decolorization experiments were carried out with different initial dye concentrations (7.5, 15 mg/L), pH values; (5.5–8.5), temperature; 25 °C and experiment time; 1-8 h. Treatments were carried out at 25 °C and pH=8, and concentrations of 0, 7.5 and 15 ppm. Analysis of metabolites and enzyme assays was performed following two hours of treatment of algae with MG.

### **Algal materials and MG treatment**

Flasks (250 mL) were prepared and each of them contained 150 mL f/2 algal culture medium. MG concentrations were designed as follows: 0, 7.5, 15 ppm. The medium without MG was taken as the control. The initial algal density was 4 g. Algal cells were harvested to determine cell viability, cellular inclusions, physiological and biochemical indicators after MG exposure for 1-2 h. All the flasks and culture medium were autoclaved and all experiments were repeated after 2 h.

### **Enzyme activity assays**

The algae were subjected to 7.5 and 10 mg/L MG in the nutrient solution for 2 h to investigate the effect of the dye on antioxidant enzyme activity compared with a control. The algae biomass were homogenized in 0.1 M phosphate buffer solution (pH 7) containing 1% polyvinylpyrrolidone. The homogenate was centrifuged at 2000 g at 4°C for 20 min. The supernatant was used as the crude extract for enzyme activity and protein content assays.

Superoxide dismutase (SOD, EC 1.15.1.1) activity was assayed by measuring its ability to inhibit the photochemical reduction of nitroblue tetrazolium (NBT). Peroxidase (POD, EC 1.11.1.7) activity was measured by spectrophotometry. Catalase (CAT, E.C. 1.11.1.6) activity was measured spectrophotometrically by following the dismutation of H<sub>2</sub>O<sub>2</sub> at 240 nm for 3 min and calculated using extinction coefficient 39.4 M<sup>-1</sup>.cm<sup>-1</sup>.

### **Non-enzymatic assays**

Plant photosynthetic pigments (chlorophyll a and b and total carotenoids) were measured spectrometrically at 470, 662, and 645 nm, respectively, using equations described by Lichtenthaler (1987) after extraction from leaves with 100% acetone. Malondialdehyd (MDA), as a marker of lipid peroxidation and oxidative stress, was estimated by measuring the thiobarbituric acid-reactive substances (TBARS). TBARS were determined from the solution absorbance at 532 nm.

Total phenolic compounds were determined using Folin-Ciocalteu reagent. The absorbance was measured at 720 nm by spectrophotometer. Flavonoid contents were measured by the aluminum chloride. Colorimetric assay as described previously. After 5 min, absorbance of the solution was read at 507 nm.

## **Results and Discussion**

After 2 h exposure of algae with 7.5 and 15 mg/L of MG, the content of photosynthetic pigments was determined. According to the results, the observed chlorophyll a (Chl a), chlorophyll b (Chl b) and the total chlorophyll content was decreased to 18.3% after 2 h exposure ( $P>0.05$ ). Carotenoid content was significantly ( $P<0.05$ ) increased (48%) compared with control group after exposure with 7.5 and 15 ppm of MG. These results showed that the increased level of carotenoids characterized by the antioxidant properties in response to dyestuffs is probably the part of the strategy adopted by *Chara* sp. to counteract the toxic effect of free radicals generated under oxidative stress. Chlorophyll content decreased may be due to the formation of proteolytic enzymes such as chlorophylls which is responsible for the chlorophyll degradation and damaging the photosynthetic apparatus.

During bioremediation of MG, the levels of MDA increased in the presence no significantly. Oxidative stress initiates lipid peroxidation of cell membrane polyunsaturated fatty acids.

Total phenol compounds were increased in algae by increasing the concentration of dye matter ( $P<0.05$ ). The amount of flavonoids was increased significantly in accordance with the increase of MG concentration ( $P<0.05$ ). Flavonoids were increased by two or three times as much as the concentration of dye matter compared to the control group. Total phenols play a significant role in the regulation of plant and algae metabolic processes and overall plant growth. It has been shown in some studies that synthesis of polyphenols depends on abiotic factors.

### **Enzymatic analysis**

During phytoremediation processes, different plant enzymes (especially oxidoreductases) act on specific recalcitrant pollutants to remove them by precipitation or transformation to other products. SOD neutralizes reactive superoxide radicals to hydrogen peroxide, which is detoxified by other antioxidative enzymes such as CAT and POD. After 2 h exposure to 7.5 and 15 ppm of MG, a significant induction in the activity of SOD was

observed in *Chara sp.*, also the total SOD activity in the *Chara* significantly increased with increasing the MG concentration compared to the control. SOD is one of the ubiquitous enzymes in aerobic organisms and plays a key role in cellular defense mechanisms against ROS. Its activity modulates the relative amounts of  $O_2^{\cdot-}$  and  $H_2O_2$  and decreases the risk of  $OH^{\cdot}$  radical formation. POD activity showed a similar pattern to the SOD activity, at high concentrations of MG, POD activity was increased up to 44% (compared to the control) ( $P < 0.05$ ). Increased POD activity at high concentrations of MG after the increment of SOD activity probably reflects the high demand for detoxification of produced  $H_2O_2$ . The activity of CAT was also decreased in the presence of 7.5 and 15 ppm of MG. After 2 h exposure the activity of CAT was decreased 32% compared with control ( $P > 0.05$ ). In the present work, CAT activity was significantly decreased by MG. Therefore, this enzyme did not appear to be an efficient scavenger of  $H_2O_2$  produced during treatment of MG. The decline in CAT activity might be due to inhibition of enzyme synthesis or a change in the assembly of enzyme subunits in the presence of MG.

### Conclusion

In the present study, the activity of antioxidant enzymes and other markers of oxidative stress and metabolites in *Chara sp.* were measured during the bioremediation of malachite green by macroalgae. The activity of peroxidase and superoxide dismutase was significantly increased, while the activity of other main antioxidant enzyme, catalase was declined. Concentration of malondialdehyde, as a final product of lipid peroxidation, doesn't changed significantly during the remediation process. On the other hand, the amount of photosynthetic pigments (chlorophyll a and b) was decreased, and phenolic compounds was significantly increased with increasing MG concentration. These data indicated that induction of oxidative stress during remediation of MG by *Chara sp.* affects the activity of antioxidant enzymes and some of the secondary metabolites in macroalgae. Finally, macroalgae *Chara sp.* increases antioxidant enzymes and non-enzyme metabolites to achieve hemostasis during bioremediation process.

**Keywords:** antioxidant enzymes, macroalgae *Chara sp.*, reactive oxygen species, synthetic dyes.

## Performance evaluation and biokinetic coefficients determination of oxidation-ditch process using pollutant elimination models on Tehran south wastewater treatment plant

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### Expanded Abstract

#### Introduction

Kinetic models are widely used in fundamental research of biodegradation processes to examine the hypotheses to control and predict the operation performance in practice and to optimize the reactor design. In this work, different mathematical models including First-order substrate removal model, Grau second-order substrate removal model, Stover-Kincannon model and Monod model were conducted to investigate the reaction kinetics of the oxidation ditch reactor and kinetic coefficients were determined. The aim of this study was to evaluate different mathematical models for describing the COD removal kinetics in the oxidation ditch reactor and to compare the applicability of different models. Since Monod model is one of the most popular models for various reactors and waste water treatments and commonly employ to describe the biodegradation kinetics, only a few studies succeeded in applying the other models to the oxidation ditch reactor. Thus, in order to determination of the biokinetic coefficients of sewage in south region of Tehran, four kinetic models were used to simulate biomass growth in the oxidation ditch reactor and were compared together, and so the best of them has been innovated to be used in design of Tehran wastewater treatment plants. Then, the performance of the treatment plant is evaluated and planned to improve the operation method.

#### Materials & Methods

This cross-sectional study implemented in Tehran South wastewater treatment plant using Oxidation-Ditch (O.D) process. In this study 80 samples from the influent wastewater, reactor and effluent were collected periodically and experimented by the Standard Methods.

The wastewater quality parameters including BOD5, COD, TSS and MLSS were measured in warm and cold seasons. These systems were operated under two different MLSS concentrations in the aeration tank. Then four kinetic models were applied to simulate biomass growth in the oxidation ditch reactor. The kinetic coefficient in each model obtained as below:

Removal efficiency and bio-kinetic coefficients in suitable model were also calculated.

#### First-order substrate removal model

Assuming the first-order substrate removal model was prevailing in the Oxidation ditch reactor, the substrate removal rate is expressed as Eq. (1).

$$\frac{dS}{dt} = -k_1 S \quad (1)$$

where  $dS/dt$  is the substrate removal rate (g/L/d),  $k_1$  is first-order substrate removal rate constant (1/d),  $S$  is the substrate concentration in a reactor (g/L). In the Oxidation ditch reactor, mass balance under pseudo-steady-state is expressed as Eq. (2) or (3) by introduction of the Eq. (2).

$$\frac{Q}{V} (S_0 - S) = -K_1 S \quad (2)$$

$$\frac{(S_0 - S)}{\theta_H} = -K_1 S \quad (3)$$

where  $Q$  is the inflow rate (L/d),  $V$  is the effective volume of the reactor (L),  $S_0$  is the substrate concentration in influent (g/L), and  $\theta_H$  is HRT (d). The value of  $k_1$  is obtained from the slope of the approximate curve by plotting  $(S_0 - S) / \theta_H$  against  $S$ .

#### - Grau second-order substrate removal model

The common equation of a second-order model is given as follows:

$$-\frac{dS}{dt} = K_S X \left(\frac{S}{S_0}\right)^2 \quad (4)$$

where  $k_S$  is Grau second-order substrate removal rate constant (g substrate/g MLVSS/d), and  $X$  is the biomass concentration in a reactor (g MLVSS/L). The Eq. (5) is obtained via integration of Eq. (4) within the boundary conditions of  $S=S_0$  and  $t=0$  to  $\theta_H$ ,  $X=\text{constant}$ , and linearization,

$$\frac{S_0 \theta_H}{S_0 - S} = \theta_H + \frac{S_0}{K_S X} \quad (5)$$

where  $\theta_H$  is HRT. As  $(S_0 - S) / S_0$  can be expressed as substrate removal efficiency and  $S_0 / k_S X$  is a constant, Eq. (5) is modified as follows:

$$\frac{\theta_H}{E} = m + n \theta_H \quad (6)$$

where  $m$  is  $S_0 / k_S X$  and  $n$  is a constant,  $E$  is substrate removal efficiency. The values of  $m$ ,  $n$  and  $k_S$  are easily derived by plotting  $\theta_H / E$  against  $\theta_H$ .

#### Stover-Kincannon model

The Stover-Kincannon model considers the substrate removal rate as a function of substrate loading rate at steady state. The general equation of Stover-Kincannon model is described as Eq. (7).

$$\frac{dS}{dt} = \frac{Q(S_0 - S)}{V} \quad (7)$$

On the other hand,  $dS/dt$  is defined as follows in this model.

$$\frac{dS}{dt} = \frac{U_{max} \left(\frac{QS_0}{V}\right)}{K_B + QS_0/V} \quad (8)$$

Therefore, Eq. (7) is converted to Eq. (9).

$$\frac{1}{Q(S_0 - S)} = \frac{K_B \cdot V}{U_{max} Q S_0} + \frac{1}{U_{max}} \quad (9)$$

where is the substrate removal rate (g/L/d),  $U_{max}$  and  $K_B$  are the maximal substrate removal rate and saturation rate constant, respectively (g/L/d). The values of  $U_{max}$  and  $K_B$  are obtained from the slope of the approximate curve by plotting  $V/Q (S_0 - S)$  against  $V/Q S_0$ .

#### Monod model

Yield Coefficient value ( $Y$ ), the decay coefficient value ( $K_d$ ), the kinetic constant ( $K$ ) and saturation constant value ( $K_s$ ) can be obtained according to Monod model. The substrate removal rate is represented as follows:

$$r_{su} = \frac{\mu_m X S}{Y(K_s + S)} \quad (10)$$

$$r_g = -Y r_{su} - K_d X \quad (11)$$

$$\frac{1}{SRT} = YU - K_d = \frac{Y(S_0 - S)}{\theta X} - K_d \quad (12)$$

where  $Y$  is the Yield Coefficient (mg COD/mgSS), and  $K_d$  is the decay coefficient value (1/d), the values of  $Y$  and  $K_d$  are obtained by plotting  $U$  against  $1/SRT$ .

$$\frac{\theta X}{S_0 - S} = \frac{1}{U} = \frac{K_s}{K} \cdot \frac{1}{S} + \frac{1}{K} \quad (13)$$

where  $K_s$  is the saturation concentration (g/L), and  $K$  is the maximal specific substrate removal rate constant (g/d). The values of  $K_s$  and  $K$  are obtained by plotting  $1/U$  against  $1/S$ .

#### Conclusion & Discussion of Result

Plotting results are depicted in Figures 1 to 4

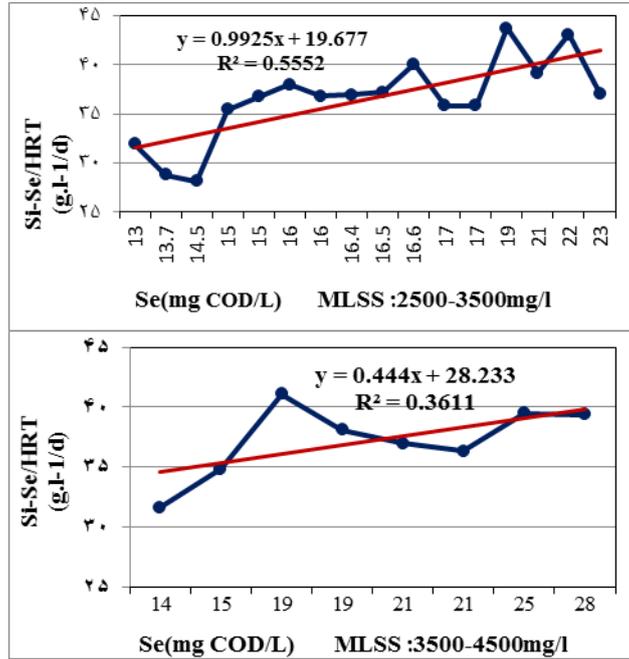


Figure 1. First-order substrate removal model

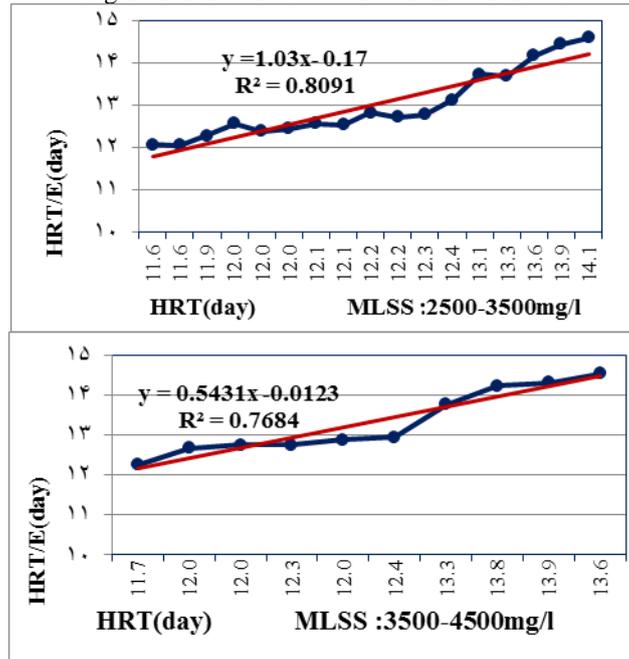


Figure 2. Grau second-order substrate removal model

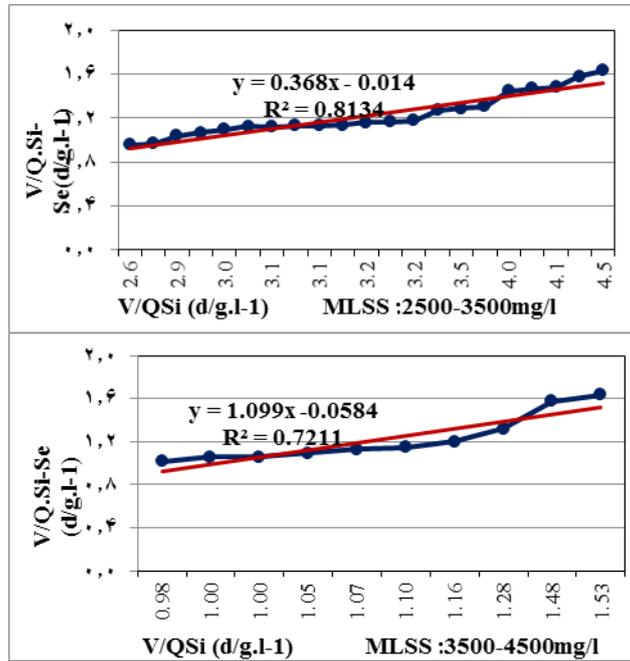
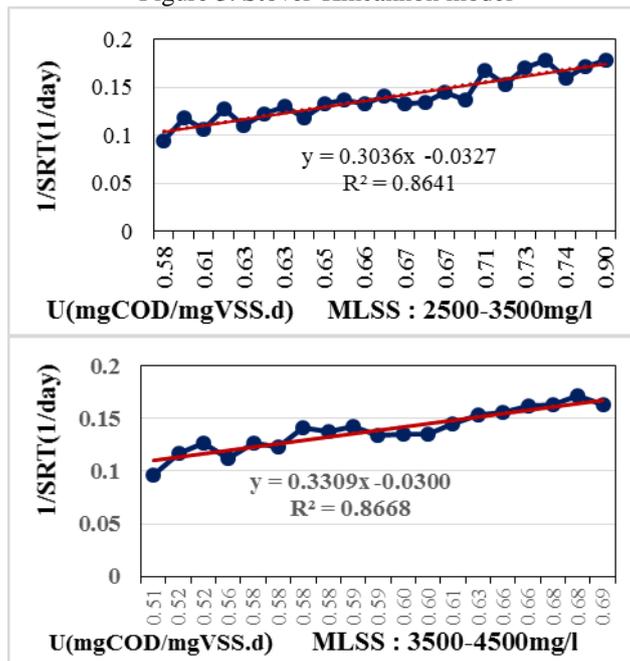
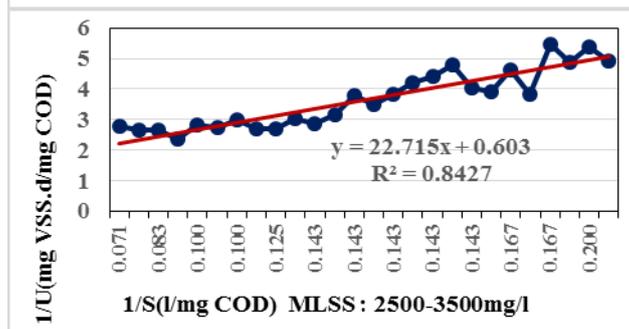
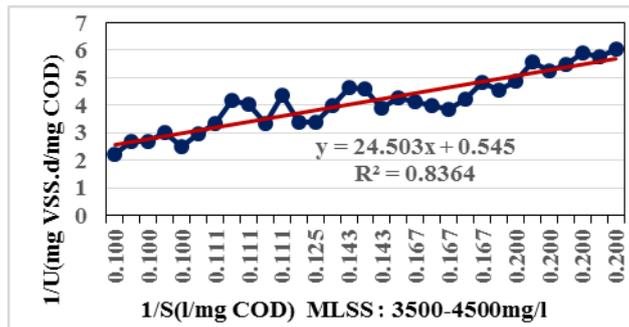
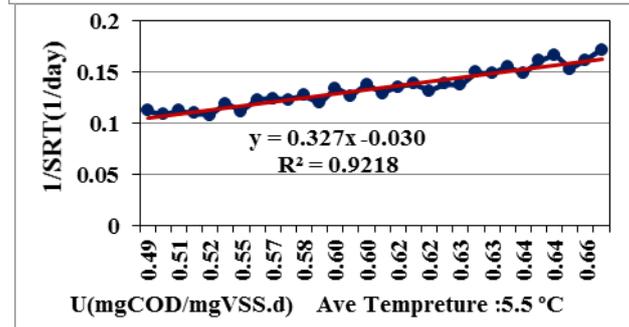
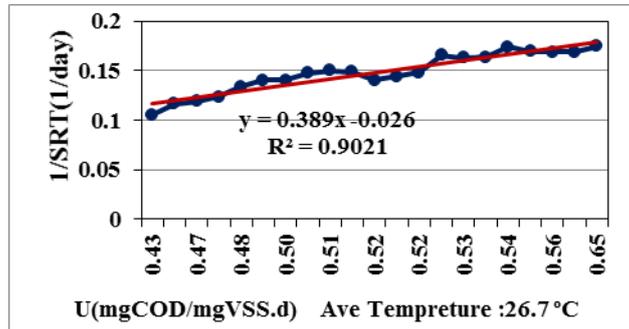


Figure 3. Stover-Kincannon model





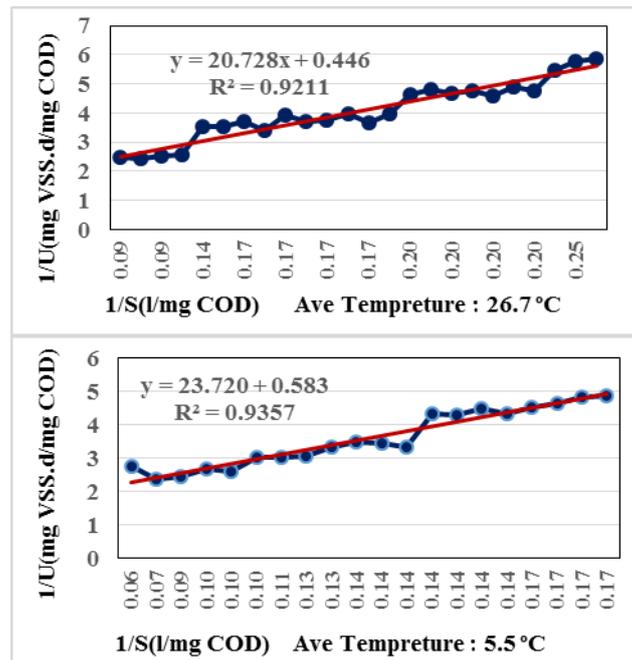


Figure 4. Monod model

The regression line for the plotted linear equation of the model had a  $R^2$  of 0.84-0.87 which was bigger than that found for three other models with  $R^2$  of 0.36-0.81. Removal efficiency and bio-kinetic coefficients in suitable model were also calculated. Monod model provided predictions having the most important relationship with factual data received from the study. In addition, Monod model turned out to be applicable to predict the biomass concentration in the oxidation ditch reactor. The solutions of kinetic studies obtained in this field will provide an invaluable tool in the design and process control of the oxidation ditch reactor.

**Keywords:** biokinetic coefficients, improved operation, Monod model, performance evaluation, pollutant elimination model.

## Biological removal assessment of sequencing batch reactor with suspended and attached growth in saline environment

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### Expanded Abstract

#### Introduction

The restricted conditions of physical and chemical treatment approaches for saline wastewater have restrained their application. Over the past few decades, Sequencing Batch Reactor (SBR) technology has been broadly employed as an effective process for the treatment of domestic and industrial wastewater due to its minimum initial cost and process simplicity. Generally, there are two alternatives for treatment of saline wastewater: 1) physicochemical processes, such as adsorption technique, membrane system, ion exchange, etc. which have drawbacks like above average costs, special tools, and secondary pollution; 2) Biological approaches that have uncomplicated and adaptable process and displayed a high removal efficiency. Biological methods could be classified into two major techniques: a) continuous and b) non-continuous. Non-continuous biological treatment operation like Sequence Batch Reactor (SBR) has higher removal efficiency and process flexibility. Similarly, the use of one tank for the entire process reduces the harmful footprint. Although biological treatment processes have many benefits, there are some inhibitory elements that could cause the deficient performance of these methods. High concentrations of salt could cause shock to bacteria, decreases cellular enzyme activity and eventually cause plasmolysis. Likewise, it could lead to physical changes in suspended sludge and biofilm.

There are some methods that could lessen the damaging impacts of salinity on the activity of microorganisms. Methods like the gradual increase of salt concentration for acclimatization of microorganisms, and the use of cultivated bacteria as a stabilizer to conventional activated sludge process. Hybrid Sequencing Batch Reactor (HSBR) is an improved structure of conventional SBR. In HSBR two different forms of growth, namely suspended and attached growth (biofilm) are accompanied in a single bioreactor. The HSBR method has many benefits compared to SBR. Benefits such as the ability to provide a suitable condition for the reproduction of different types of microorganisms, decrease the adverse effects of inhibitors such as salinity and increase biomass retention time. Biomass carriers provide bedding for the attached growth. The heterogeneous structure of the biofilm and the various quantities of oxygen inside its layers allows the several types of bacteria to cultivate. In deeper layers of the biofilm, anoxic states are prevailed, which is suitable for denitrifiers microorganisms' growth. In such a system, the removal efficiency could be increased as a result of biofilm simple adaptable structure.

#### Material and Methods

An SBR reactor with hybrid performance was employed to analyze the effect of salinity (NaCl), on the biological activity of microorganisms. The HSBR that is used for this study has a working volume of 6.4 L and was fabricated with Plexiglas material. Polyethylene carriers with a specific surface area around 500 m<sup>2</sup>/m<sup>3</sup> and density of 95 kg/m<sup>3</sup> were used to provide a surface for the attached growth. Influent and effluent was controlled by two peristaltic pumps and three analog time switches. The operation cycle was set as 24 h and consist of 1 h feeding, 20 h reaction, 1 h settling and 1 h drawing off. The activated sludge with MLSS around 3250 mg/L were taken from a wastewater treatment plant located in the north of Tehran (Iran). Dissolved oxygen (DO), pH and temperature were kept between 2.6-6.8 mg/L, 7.2-8 and 18-26 °C correspondingly during the study. In a period of 7 months, the main parameters related to reactor performance were measured including COD, SVI, MLVSS,

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and MLVSS. Synthetic wastewater was prepared on a daily basis with tap water, Molasses,  $\text{NH}_4\text{Cl}$ ,  $\text{KH}_2\text{PO}_4$ ,  $\text{KCl}$ , Salt ( $\text{NaCl}$ ) and necessary trace elements.  $750 \pm 10$  mg/L molasses yielded influent COD of  $650 \pm 30$  mg/L. The ratio of COD/N/P was set at 100/6/2 during the experiment and in every step,  $\text{NaCl}$  (0-30 g/L) was added to influent wastewater to provide salinity. Since other sources of salinity have a negligible effect, their influence was not considered.

The reactor was started by activated sludge with 3250 mg/L MLSS, 2750 mg/L MLVSS and SVI of 156 mL/g. Non-salt acclimated microorganisms were obtained from the aeration tank of the wastewater treatment plant.

The bioreactor was introduced with 3 L of fresh wastewater at the beginning of every cycle and after a 20 h reaction period and 1 h settling, the exact amount of 3 L supernatant was withdrawn from the reactor. This cycle continued by introducing the next nutrient batch into the bioreactor for the next treatment operation. Sludge age was set to 30 days by withdrawing sludge from the reactor during each cycle.

For 2 months, the system operated with zero-salt influent wastewater. This followed by adding 5 g/L of  $\text{NaCl}$  to wastewater feed for about 2 weeks for acclimatization of microorganisms to a saline environment. After that, salinity was increased in a step-by-step order to 10, 20 and 30 with considering steady state condition in each salt concentration. The required period to meet steady state conditions was changed in each salt increments. For the purpose of analyzing and measuring parameters like COD, SVI, MLVSS, and MLSS, samples were regularly extracted from reactor at least 3 times a week.

## Result and Discussion

By increasing salt concentration from 0 to 30 g  $\text{NaCl/L}$ , COD removal efficiency decreased from 94.22% to 82.36%. The harmful effect of salinity led to poor performance in the removal of organic matter. The highest removal efficiency of 94.22% was observed at 5 g  $\text{NaCl/L}$ . This brings about by the effect of a small amount of salt (below 10 g $\text{NaCl/L}$ ) on the activity of microorganisms. At the salinity level of 30 g $\text{NaCl/L}$ , after about 2 weeks to meet the steady state conditions, the COD removal efficiency declined by 11.86% compared to the peak performance efficiency at 5 g  $\text{NaCl/L}$ . The high concentration of salt leads to the destruction of cellular activities, dehydration, and inhabitation of many enzymes. Still, the system displayed a good removal performance of organic matter compared to conventional SBR at 30 g  $\text{NaCl/L}$  (82.36%).

The results of this study show that the removal performance of the SBR was impeded less compared to other studies with Conventional SBR system with same amount of salinity as this study. This could be attributed to biological treatment variety; different kind of microorganisms actively participate in biological treatment and distinctive influent wastewater in every study. Furthermore, it could be related to the biofilm unique structure and abilities to provide suitable environment for growth and reproduction of many kind of bacteria. Combination of attached and suspended growth in single reactor outweigh the conventional suspended method. It could intensify multi-cultural bacterial growth and therefore produces high active biomass. Also, biofilm provide multiple reaction site for interaction of substrate and microorganisms. Moreover, some substance like organic polymer which secreted by microorganism and performed as a defense structure in severe environment, could grow easily in biofilm than suspended sludge.

For assessing the mass of viable and total microbes, MLVSS and MLSS were measured. Initial MLSS measured around 3250 mg/L and by increasing salinity to 5 g  $\text{NaCl/L}$ , MLSS values increased to 3820 mg/L. By adding more salt until 30 g  $\text{NaCl/L}$ , MLSS increased to its highest level around 5120 mg/L. As a result of the saline environment, the growth and reproduction of many species become suppressed and consequently, the number of dead cells increasingly dominated. In contrast, salt-resistant bacteria such as halotolerant and halophilic bacteria, grow more favorably. MLVSS showed the same behavior as MLSS and increased with salinity from 0 to 5 g  $\text{NaCl/L}$ . After that, MLVSS experience constant values until the end of experiments at 30 g  $\text{NaCl/L}$  salinity. This is implied that the total mass of microbes including live and dead cells, viable and active cells stay stable. As mentioned above, salt-resistant bacteria like halotolerant and halophilic which were not dominant at stage one, could grow and stay alive in a saline environment and consequently, the total of viable biomass stayed unchanged.

**Keywords:** biofilm, biological process, hybrid growth, hybrid sequencing batch reactor, saline wastewater, suspended and attached growth.

## Factors affecting air pollution created in the transportation sector of Iranian provinces

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### Expended Abstract

#### Introduction

One of the most important and fundamental activities in each economy is transportation activities, so this part of the activities can be very important in promoting the growth and development of each society. The expansion of transport activities, on the one hand, will increase economic growth and increase welfare and, on the other hand, will reduce welfare and economic growth by causing adverse effects through harmful emissions. The geographical scope and climatic characteristics of Iran in utilizing the transport infrastructure require special attention to the issue of environmental pollution and greenhouse gases emitted by the usual transportation activities. Also, if necessary, specific measures should be taken to control the air pollution generated in this section. The service sector provides a demand-driven demand for many of the products of society that play a significant role in gross domestic product formation, such as mineral products, commercial and tourism activities. Given the direct effect of the transport sector's activities on the environment and air pollution, the development of other economic sectors could increase environmental pollution. We have calculated the contribution of different economic sectors to carbon dioxide emissions in this research. According to the statistical reports in the energy balance sheets published by the Ministry of Energy over the years, carbon dioxide gas has been the largest contributor to pollutant and greenhouse emissions in Iran during the study period. The share of carbon dioxide emissions in the transport sector (including road, air, sea and rail), compared with other sectors, including household, commercial and public sectors, agriculture, refineries and power plants, during the same period the average was 23.61%. The transportation sector provides a demand-driven demand for many of the products of society that play a significant role in gross domestic product formation, such as mineral products, commercial and tourism activities. Given the direct effect of the transport sector's activities on the environment and air pollution, the development of other economic sectors could increase environmental pollution. Considering the significant contribution of transportation pollution in total pollution and taking into account the social costs resulting from it, as well as considering the negative effects of pollution on economic growth, health expenditure of the household and the health of citizens and the high level of transport sector activities with the activities of other sectors, the study and research on the factors affecting the amount of pollution in this part is important and necessary.

Despite the various studies carried out in the field of air pollution, no study has ever been done on the factors affecting pollution in the provincial transport sector in Iran.

#### Materials & Methods

In the literature of the research, the panel data model (combination of time series and cross-sectional data) is used to investigate the effect of factors affecting transportation pollution in the provinces of the country. Among the information research variables, carbon dioxide emissions are not available in the province, but according to published statistics on the rate of use of fuel and oil products of the provinces in the annual energy balance sheets and based on the standard announced by the inter-agency State of Climate Change (IPCC) in 2013, carbon

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dioxide emissions in the transport sector were calculated for provinces around the country between 2010 and 2015. Other data are also extracted from library resources.

Before the model was estimated to ensure long-term relationship between variables, the co-integration test was performed between the variables of the research. The result of the pederoni coincidence test, which consists of seven different indexes in the next and next dimension for the panel, confirmed the relationship between the variables. The result of the F test showed that the calculation F is less than the F value of the table, which cannot be ruled out by the  $H_0$  assumption that the widths of the originals are equalized; in fact, the data model is in the simulation of the model and the use of the least squares method is recommended for model estimation. The study of the classic assumption of regression model estimation showed that the model has an inconsistency of variance and the low camera-Watson statistic also shows the self-correlation in the model. In order to solve the problem of self-correlation, the dependent variable with a delay period as an independent variable was introduced into the model. In order to solve the problem of heterogeneity of variance, the final estimation of the model was done using generalized least squares (GLS) method. The value of the t-factor estimator shows that all coefficients are statistically significant at the upper level. The values of F and the coefficient of determination represent the high degree of validity of the estimated model. Performing a single root test for disrupting sentences in the estimation model also showed that the sentences are station in all levels, which means that there is an accumulation among the variables used in the model. According to the results, all explanatory variables have a positive and significant effect on the production of carbon dioxide in Iran's provinces in the transport sector. Regarding the use of logarithmic data at the model's estimation stage, estimation coefficients are interpreted as the traction of pollution in the transportation sector relative to each of the explanatory variables. Accordingly, during the reviewed period, the interconnection between production in the economic sectors and the transport sector is confirmed. In fact, with the increase in production, transportation services are expanding, in this context, the lack of proper and standard facilities in the transport sector will lead to further pollution. According to the research results, an increase of 1% in the number of numbered vehicles also resulted in an increase of 0.49% in carbon dioxide emissions in the transport sector of the provinces on average. This finding confirms the role of polluting vehicles that are often produced internally. Comparison of the estimated stretch marks indicates that the pull of the pollution per capita value added service is more than its elasticity over other sectors. This result seems to be due to the greater share of the service sector's activities in creating the value added of the entire country and the significant difference in this share in relation to the value added of other sectors. Also, a one percent increase in carbon dioxide emissions with a one-year lag in the transport sector has had a positive and significant effect of 0.8% on carbon dioxide emissions in the transport sector this year during the period under review.

### Discussion of Results

Regarding the use of logarithmic data at the model's estimation stage, estimation coefficients are interpreted as the elasticity of pollution in the transportation sector relative to each of the explanatory variables. Accordingly, during the reviewed period, the interconnection between production in the economic sectors and the transport sector is confirmed. In fact, with the increase in production, transportation services are expanding. In this context, the lack of proper and standard facilities in the transport sector will lead to further pollution. According to the research results, an increase of 1% in the number of numbered vehicles also resulted in an increase of 0.49% in carbon dioxide emissions in the transport sector of the provinces on average. This finding confirms the role of polluting vehicles that are often produced internally. Comparison of the estimated elasticity marks indicates that the pull of the pollution per capita value added service is more than its elasticity over other sectors. This result seems to be due to the greater share of the service sector's activities in creating the value added of the entire country and the significant difference in this share in relation to the value added of other sectors. Also, a one percent increase in carbon dioxide emissions with a one-year lag in the transport sector has had a positive and significant effect of 0.8% on carbon dioxide emissions in the transport sector this year during the period under review.

### Conclusions

In this paper, the effect of factors affecting pollution in the transportation sector of the country using provincial statistics in the framework of an econometric model of data panel during the period of 2015-2010, the results of which, while conforming to theoretical foundations, with the result of other studies in this issue are also aligned. The results of the research showed that the number of numbered vehicles, the per capita value added of services, which includes transportation activities, added value of agricultural and industrial and mining sectors had a positive and significant effect on. There are contaminants created in the transportation sector of the country's provinces. The positive effect of vehicles on transport pollution indicates the contamination of vehicles used by citizens, and the positive and significant effect of economic value added on transport pollution contributes to the direct relationship between production and pollution, which is the finding corresponds to the first region of the

Kuznets curve. In fact, it can be said that the increase of provincial production, although increasing provincial income facilities and causing economic growth and development, but social costs increase the pollution of the economy of the provinces, which can reduce social welfare while introducing environmental damages. Accordingly, it is necessary to address the policy of decreasing air pollution through tools such as improving production efficiency, observing the standards required in the production of various economic sectors, and accurate monitoring of the state on the activities of enterprises and the stopping of the firm's activity. Contaminating and violating environmental regulations should be considered by provincial authorities. At the

end, practical suggestions have been made to reduce the pollution of the provincial air:

- Shortening transportation routes and expanding communication networks, especially road and rail routes, according to the demand for cargo and passenger transportation on that route.
- Reduce fuel consumption by improving technology and replacing power consumption with petroleum products in the urban and suburban transport sector.
- Modernization of inland and outbound transport fleet by supporting private sector with the aim of using more efficient technology.
- Improving the quality of construction of domestic automobiles through the obligation of car makers to comply with polluting standards.

**Keywords:** air pollution, environment, Iranian provinces, panel data model, transportation.

# Analysis the role of psychological factors on intention to apply environmental and meteorological information by farmers of Dehloran Town (The combined application of social cognition theory and technology acceptance model)

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## Expanded Abstract

### Introduction

Climate change is a topical subject worldwide and there is evidence that this phenomenon is taking place. Climate change is expected to have serious economic and social impacts. Mounting evidence suggests that climate change will have both short- and long-term impacts on agriculture and the natural resources. Although there is some uncertainty as to the extent of the problem, and when exactly climate shifts will occur, it is anticipated that increases in temperature will lead to more heat stress for crops and make pests and diseases more prevalent. Literature noted agriculture is one of the sectors most affected by climate change and due to smallholder farmers heavy reliance on rainfed agriculture, climate change will increase vulnerability of the rural populations due to food and nutrition insecurity. Climate change is expected to affect agriculture in different ways and to a different extent in different parts of the world and in different agro-ecosystems. In particular, communities in most developing countries have been identified as being the most vulnerable to climate change because of multiple stressors and reduced adaptive capacity. Adaptation is one of the policy options for reducing the negative impact of climate change in agriculture sector. It is a key factor that will shape the future severity of climate change impacts on food production. A wide variety of adaptation options has been proposed as having the potential to reduce vulnerability of agricultural systems to risks related to climate change. In this regard, environmental information includes meteorological and hydrologic observations, analyses, and forecasts are valuable resources.

Meteorological information and forecast can be of value when used in decisions involving risks posed by adverse weather or climate. In fact, climate information is an important pre-requisite for informed decision-making in risk management and adaptation that would help prevent climate extremes from becoming disasters and threats to livelihoods of smallholder farmers.

Climate information and forecast have shown potential for improving adaptation of agriculture to climate shocks, but uncertainty remains about whether farmers would use such information in crop management decisions. Despite tremendous efforts to improve weather and climate predictions and to inform farmers about the use of such weather products, farmers' intention toward forecast use remain poor and farmer use of forecasts has not increased. Because little is known about the motivations underlying farmer decisions to use or not to use weather and climate forecasts, we designed and conducted a survey based on the combining social cognitive theory and Technology Acceptance Model to gather such information from farmers in Dehloran, Iran.

The Technology Acceptance Model (TAM) is a frequently used behavioral model for predicting and explaining information technology usage. A key purpose of Technology Acceptance Model is to provide a basis for tracing the impact of external variables on internal beliefs, attitudes, and intentions. The Technology Acceptance Model identifies two most important factors namely perceived ease of use and perceived usefulness. To date, the Technology Acceptance Model has been used to address why users accept or reject information technology. This model is an adaptation of the theory of reasoned action proposed by Fishbein and Ajzen to explain and predict

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the behaviours of people in a specific situation. Social cognitive theory (SCT) also is a theoretical framework for analyzing human motivation. Social cognitive theory is a widely accepted, empirically validated model of individual behavior. The theory defines human behavior as a triadic, dynamic, and reciprocal interaction of personal factors, behavior, and the social systems. Social cognitive theory argues that a person's behavior is partially shaped and controlled by the influences of social network (i.e., social systems) and the person's cognition (e.g., expectations, beliefs). While social cognitive theory has many dimensions, Bandura advanced two major cognitive forces guiding people's behavior self-efficacy expectations and outcome expectations. In whole, the social cognitive theory consists of factors influencing behavior intention. Therefore, we used environment factors, perception of others' behavior, outcome expectancy and self-efficacy as variables of social cognitive theory in our integrated model. Hence, in our integrated model, two factors of perceived ease of use and perceived usefulness were considered as independent factors, perception of others' behavior, outcome expectancy, self-efficacy and environment factors as mediated and intention to use or not to use weather and climate forecasts as dependent factor. To our knowledge, no studies up to this date have been designed to investigate intention to use meteorological information in Iran. Therefore, the aim of this study is investigate intention to use meteorological information by Iran farmers.

## Materials & Methods

In this paper, we address the questions of whether smallholder farmers in Dehloran would intend to use climate forecasts in making crop management decisions and whether such use would lead to benefits. A structural equation model was developed to explore relationships between factors affecting intention to use climate information and forecast. The study was designed as a cross-sectional survey. Target population of this study consisted of 3820 wheat growers. Using a multistage stratified random sampling method, 350 farmers were selected for this study. The sample size was determined using the Morgan table. Data were collected based on a questionnaire structured to assess the components of combining model. We use a self-report questionnaire to examine the proposed research model empirically. A self-report method refers to an approach in which observation data are provided by participants instead of raters or coders. The data were gathered based on a face-to-face survey of farmers. The respondents were assured about anonymity and confidentiality. They were also given the right to refuse participation and also to refuse to answer any question they deemed to be too sensitive or that they felt uncomfortable about. Those declining participation were replaced by other students. No payment was made to the respondents. Answering time for the questionnaire was about 15-20 min. The questions were scored on a 1-5 point scale (very low, low, moderate, high, very high) to reduce the statistical problem of extreme skewness. The survey was pre-tested and piloted on 30 farmers from outside the study area. Cronbach alpha reliability coefficients were calculated for the pilot study and used to refine the questions for the final questionnaire. All scales indicated good-to-excellent reliability, generally 0.76-0.89.

## Results

Regarding demographic variables, the participants were aged between 22 to 85 and had a mean age of 44.59 years ( $SD= 14.24$ ). The farmers' agricultural experience, how long they had been farming at the time of data collection, was distributed across a 1-60 year range, with an average length of farming experience of 18 years ( $S.D.= 13.65$ ). In main analysis, structural equation modeling (SEM) was used to assess the causal relationships being hypothesized in the proposed model. The results of structural equation modeling obtained for the proposed conceptual model revealed that relative chi square  $\chi^2/d.f.= 1.98$  ( $P < 0.001$ ),  $GFI= 0.83$ ,  $RMSEA= 0.053$ ,  $NFI= 0.79$ ,  $RFI= 0.78$ , and  $CFI = 0.88$ . Accordingly, the summary of the overall goodness-of-fit indices indicated good fit of the model and data. ( $\chi^2/d.f.$  value was less than the recommended threshold value 5,  $RMSEA$  value was less than the recommended threshold value 0.08).

The finding indicates that Technological Acceptance Model factors (perceived ease of use and perceived usefulness) significantly positively affect three factors of the social cognitive theory (self-efficacy, outcome expectancy and perception of others' behaviour). Perceived ease of use has direct effect on self-efficacy ( $\beta= 0.80$ ,  $P < 0.001$ ) and outcome expectancy ( $\beta= 0.27$ ,  $P < 0.001$ ) and perceived usefulness also has direct effect on perception of others' behavior. Also, perceived ease of use has direct effect on perceived usefulness ( $\beta= 0.74$ ,  $P < 0.001$ ). In addition path relationships revealed that outcome expectancy ( $\beta= 0.58$ ,  $P < 0.001$ ) and self-efficacy ( $\beta= 0.26$ ,  $P < 0.001$ ) had a positive direct relationship with intention to use meteorological information. In fact, findings suggest that respondents' self-efficacy and outcome expectancy help predict whether an individual intends to use weather and climate information. Regarding indirect effect, perceived usefulness and perceived usefulness had a strong indirect effect on intention. The model accounted for 59% of variance in intention to use climate information and forecast. Also, the structural equation modeling revealed that the perceived usefulness ( $P < 0.001$ ,  $\beta= 0.72$ ) can explain 52% of the variation in perception of others' behavior. The finding showed that the perceived ease of use ( $P < 0.001$ ,  $\beta = 0.74$ ) accounted for 55% of the variation in perceived usefulness. Also,

finding revealed that the perceived ease of use ( $P < 0.001$ ,  $\beta = 0.27$ ) can explain 62% of the variation in outcome expectancy ( $P < 0.001$ ,  $\beta = 0.27$ ) and 64% of the variation in self-efficacy ( $P < 0.001$ ,  $\beta = 0.80$ ). Also, our finding indicates that in suggestion model environment factors ( $\beta = 0.01$ ,  $P > 0.05$ ) and perception of others' behaviour ( $\beta = 0.56$ ,  $P > 0.05$ ) failed to make a significant and consistent contribution to the prediction of intention to use climate forecast and meteorological information.

## Conclusion

Farmers have to varying degrees had to cope with and adapt to climate variability and change for centuries. To successfully transfer costly weather and climate products into meaningful information that farmers can use in their decisions, farmers must understand the products and have the intention and motivation to extract the relevant pieces of information and apply them to specific decision contexts. This study integrated two socio-psychological theories, namely social cognitive theory, with a widely used information system technology acceptance model to provide a comprehensive behavioral model of understanding elderly farmers intention toward using meteorological information. The framework was extended from the original technology acceptance model by considering the relationships among technological factors (perceived ease of use and perceived usefulness), and social cognitive factors (system self-efficacy, environment factors and perception of others' behavior, outcome expectancy), and behavioral intention to use the meteorological information and forecast. The aim of this study was two fold: (1) to understand which socio-psychology factors influence intention to use meteorological information, (2) to examine the use and efficacy of our integrated model in the information technologies.

The study leads to two major findings. First, results revealed that the self-efficacy and outcome expectancy are directly significant predictors of the intention to use climate meteorological. In other word, with increasing self-efficacy and outcome expectancy, farmers will have more intention to use meteorological information. Outcome expectancy was the most effective predictor of intention to use climate information. Perceived usefulness is indirect predictors of intention. Second, regarding the samples, the integrated model fitted considerably well. The proposed model has been proven to be valuable for evaluating and predicting the behavioral intention of climate information and forecast because it provides an integrative perspective that prompts researchers and practitioners to pay attention to the interdependence of these aspects. This study is a justification for using the constructs of this model in politics and decision making that encourages farmers to use meteorological information. The proposed integrative cognitive-technological model may serve as a theoretical basis for future research and can also offer empirical foresight to practitioners and researchers in the agricultural departments and rural communities.

**Keywords:** climate change, farmers, meteorological information, weather forecast.

## Evaluation of trend in vegetation variations using time series images and Mann-Kendall test over Gavkhuni basin

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### Extended abstract

#### Introduction

Investigation of the trend of changes in the density and health of the vegetation due to climate and land use/land cover changes can be useful in ecological and environmental studies using time series data especially in dry and semiarid brittle ecosystems. Time series analysis is a powerful tool to investigate the trends of natural phenomena in the past and present. The satellite time series provides the most appropriate data for analysing the trend of changes in natural and human phenomena and predicting for the future. A time series is the collection of statistical data collected at regular intervals. In general, the time series is the variable to be predicted and available in past periods. Trend analysis is the long-term variation in the average of the time series or the natural course of the long-term series of times, in which case the overruns of the time series is ignored. Determining the trend (increasing, decreasing and unchanged) of the vegetation can be one of the ways to help manage vegetation monitoring. In this regard, the use of statistical tests to determine the trend of time series data is essential. There are different methods to determine the process, which are divided into two sets of parametric and nonparametric methods.

The process of changing the pixel spectrum of the vegetation to identify areas susceptible to rapid changes can be determined by remote sensing methods. This approach can lead to improved conservation capabilities by monitoring changes occurring in ecological conditions and assessing the usefulness of management without causing further overstep on the lands. Since satellite imagery is one of the best time series illustrations, the use of these data in trend studies is fruitful. With the availability of valuable spectral information, long temporal resolution, acceptable spatial coverage, and the possibility of convenient access to time series data, the MODIS sensor has made remote sensing an ideal instrument for considering vegetation dynamics on a large scale. Hence, it plays an important role in monitoring and evaluating vegetation. Vegetation indices are used to monitor and evaluate vegetation dynamics using satellite imagery. The satellite Normalized Difference Vegetation Index (NDVI) is the most famous useful in plant monitoring. The NDVI, which is measured from the combined ratio of infrared and red bands, is used as a useful indicator of photosynthesis capacity identification, usually used to examine environmental and ecological changes. Therefore, remote sensing through the NDVI satellite index can measure surface vegetation changes due to the strong correlation between the vegetation and this index. The NDVI is also reliable for identifying vegetation stress because, as a result of degradation of vegetation in the land, vegetation characteristics such as health, density are majorly changed. In the other word, the NDVI can be

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a general criterion reflecting the condition and health of the vegetation and recognizing the health of the plants, as the amount of NDVI decreases in vegetation due to plant degradation in the ecosystem with reduced vegetation. The main objective of the present study is to investigate the fluctuations of long-term annual mean vegetation changes using the monthly MODIS NDVI time series data and determine the trend of its changes using the Man-Kendall test from 2003 to 2014 in Gavkhuni basin.

## Materials and Methods

The studied area is Gavkhuni basin, one of the most important basins in the country, which also includes Zayandehrud basin. This area is about 41,347 M<sup>2</sup> in the central plateau of Iran with a dry and semi-arid climate. The average precipitation is in the region of 209.5 mm. A large part of the Gavkhoni wetland, which according to Ramsar Convention is one of Iran's most important wetlands, has dried up for various reasons. This wetland plays a vital role in ensuring the sustainable development of the inhabitants of the central part of Iran. On the other hand, from the point of conservation, this wetland is considered one of the most valuable ecosystems in the centre of Iran. The vegetation is very limited around the wetland and is mainly limited to halophyte species. There is no significant vegetation outside wetlands. The vegetation of the watershed area is often composed of good, moderate, weak ranges and moderately forest, crops, rainy and irrigated farms and orchards, and growth periods in the Gavkhuni basin is from April to October.

The MODIS sensor is sensitive to vegetation variations as an affordable sensor with global coverage at least once a day. Accordingly, monthly MODIS NDVI times series images from the MOD13A3 series, with a cell-length of 1km×1km, were collected from the site of NASA from 2003 to 2014 (144 images). Then the images from Gavkhuni basin have been extracted to determine the trend of vegetation changes.

Mann-Kendall test was presented based on the significance of the Tau Kendall correlation coefficient ( $\tau$ ) and then developed. Correlation coefficient measures the relationship between two series of variables to determine if the first variable increases with increasing the second variable, or decreases or the patterns of change are not relate together. This method is widely used to handle time series. In general, Mann-Kendall statistical test can be used to determine the uniform trends of ubnormal distribution data based on the ranking. Given that the Mann-Kendall test, in addition to the trend, also specifies the type of trend occurring, this model does not require the input of normal data. In the test, for time series data trends, positive values indicating incremental trends and negative Z values represent decreasing trends. The assumption of zero is assumed to be random and there is no trend, and acceptance of a hypothesis implies a trend in the data series and is rejected for Z values greater than ZI-N2.

## Results

Vegetation fluctuations of mean monthly MODIS NDVI time series images of Gavkhoni basin from 2003 to 2014 were presented. The maximum vegetation cover is observed in spring months. This increase reached its maximum during the course of the study in 2007, and then reached its maximum four months later and then sharply declined in 2008. In 2009, vegetation cover in Gavkhuni basin is relatively modest. In fallowing, the fluctuations are almost the same, but declined sharply in 2014. In addition, the highest vegetation density is observed in the western and central regions of Gavkhuni basin. Also, this figure shows that vegetation density is high in 2003-2006 and has declined significantly by 2014. Accordingly, the vegetation cover increased in January 2003 through January, a dramatic drop in February, a slight decrease in March to May, a modest increase in June to July, a slight increase in the months of July to September, in October and November has been a slight decrease, and December has seen an increase in vegetation.

The trend of long-term vegetation changes in Gavkhuni basin based on 144 images of the monthly MODIS-NDVI (12 months of 12 years) were implemented in the Idrisi Tersset software. At first 144 time series images were converted into TSF file format. The resulting trend map indicates that the vegetation trend is incremental with a value of  $\tau$  equal to 0.68 to a decreasing trend with the value of  $\tau$  equal to -0.65. Accordingly, the trend of increasing vegetation is more dispersed in the north-eastern and central to west parts of the basin, and slightly to the south of Gavkhuni basin. In addition, the largest decline in vegetation occurs in the central regions of the east and south of Gavkhuni basin. This trend is evident in the northern and western basins as well as in the south of the basin. In addition, decreasing trend of vegetation is more concentrated in areas of basin which referring to the use/land cover map are aquaculture. This trend indicates a sharp decrease in the rain-fed agriculture. Referring to the land use/land cover map, the vegetation cover of the Gavkhuni wetland during the study period has also been subject to decreasing or unchanged trend. The vegetation of the rocky areas of the north-east of the basin has also increased marginally. Accordingly, the most extensive areas indicates unchanged trend of vegetation in Gavkhuni basin from 2003 to 2014.

### Discussion of Results & Conclusion

In the present study, the approach of monitoring and analysing the process of determining the trend of monthly time series of MODIS NDVI was used to discover vegetation variations in the regional scale. The regional variations of vegetation in Gavkhuni basin from 2003 to 2014 through the time series images of MODIS NDVI was determined using non-parametric Mann-Kendall Tau and contextual tests, and areas with increasing, decreasing and unchanged vegetation cover were determined. The results showed that the extent of the vegetation variation trend as well as the extent of the decreasing trend in the Contextual Mann-Kendall method was more than Tau Mann-Kendall, and the trend in most of the area remained unchanged, which only indicates whether vegetation is present in this area or not. This case is achievable by comparing the trend map with land use/ land cover map in 2014 or following years.

In addition, it was revealed that the decreasing trend with the sever vegetation decline has occurred in the central regions of the Gavkhuni basin and along the Zayandehrud River and also in the urban areas, which can indicate the high urban growth and land use/ land cover change from the vegetation to the construction site in this basin. Accordingly, a sharp decreasing trend was observed in the northern and western regions as well as in the south of the basin, which with referring to the land use/ land cover maps and type/ vegetation maps. These areas are highest proportion of rangeland vegetation and fertile farming along the Zayanderroud River. These lands affected by land cover/ land use and have been severely subjected to land degradation due to the dryness of Zayandehrud Rive in recent years. This urged urgent measures to prevent land degradation. In addition, since the highest reduction in temporal monitoring in the Gavkhuni basin has been observed in the months of April to June, and these months are growth season and cultivation in the Gavkhuni basin, this necessitates a serious actions to mitigate the risks. Also, the study of vegetation trends showed that during the study years, saline lands in the Gavkhuni basin increased and the agricultural land was significantly reduced. Finally, based on the nonparametric test results, the study of vegetation trend analysis through satellite time series images of MODIS NDVI and comparing the vegetation trend maps resulted from the Mann-Kendall test with current land use/ land cover map of the area in Gavkhoni basin is well-recognized and indicates its effectiveness.

**Keywords:** Gavkhuni, land use/land cover, Mann-Kendal test, trend analysis, vegetation monitoring.

## Prioritizing urban districts according to their needs green spaces; (Case study: 15 selected districts of Isfahan)

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### Extended abstract

#### Introduction

These days profitable development and the need to create new urban land uses to ask needs of urban residents has gradually declined and these located in the incorrect place. It causes, the distribution of green spaces in the city was often inappropriate and social injustice is created. The purpose of this paper is to evaluate the 15 regions of the Isfahan municipality in order to determine regions which have priority for the development of urban green space. Isfahan is one of the metropolises in Iran that has many environmental problems such as drought and water crisis, lack of proper urban land for developing of green space, air pollution, increasing population and vehicles, etc. So, a systematic planning in the field of optimum locating for green spaces is very necessary. This paper looking for answering this question: What is the priority of creating green spaces in 15 regions of Isfahan? So, at first 18 parameters which are effective in the construction of green spaces have been determined. Based on the data available of these parameters in the 15 regions, F'ANP model has been used in order to build composite index and evaluate regions.

#### Materials and Methods

Isfahan, with an area of over 550 km<sup>2</sup> and a population of more than two million, is the third metropolis in the center of Iran. Service range of this city consists of 15 regions which have been studied separately. Any prioritization requires the selection of indicators and criteria which related to that category. The importance of each of these indicators is indicated with considering the weight for each indicator. Among the effective indicators choosing the right place (which was discussed in the theoretical foundations), indicators which are compatible with conditions of Isfahan, were selected and studied in the 15 regions

In the first step, 18 key indicators have been extracted from theoretical literature. In the second step, these indicators according to documents and information available are calculated in the 15 regions and required data have been provided in order to analyze indices. In the third step, obtained data are considered as model's inputs. The reason for using this method is that it covers one of the most important methodological problems in the field of location and prioritization. Previous studies show that prioritizations have so far been according to the subjective methods. In order word ,weight of influencing parameters have been done by experts and researchers. Mentality of the parameters' weight are resolved by F'ANP model. In fact, the Isfahan's environment determines parameters' weight and how to prioritize by determining relationships between parameters. This paper is in the category of applied research and its methodology is analytical-descriptive.

In this model, the adequacy of the sample size evaluated by test Sphere s'Bartlett and Kaiser- Meyer- Olkin (KMO) is more important than the amount of the sample size. So, as long as the values of these two tests do not reach the standard level, the sample size should increase or communalities should change. In this paper with regards to limitations of checked options (15 regions), suitable amount of these tests is obtained by reducing the number of variables. Therefore, 8 parameters deleted in order to increase the accuracy of the model. Then the factors are named according to the gender and nature of the indicators (Table 1). After removing some indicators, the amount of KMO and Bartlett's test are arrived to the standard value (Table 2). These values show that the accuracy of the model is acceptable.

**Table 1. Extracted factors, component, name of factors**

Name	Component	Value of explained variance by each factor (% of Variance)	Extracted factors
Noise pollution	0.906	33.972	Physical and Functional needs
Comfort access	0.816		
Incompatibility	0.801		
Private traffic	0.785		
Water	0.808	23.52	Natural and Environmental needs
Earthquake risk	-0.79		
Soil	0.785		
Population	0.396		
Land price	0.79	17.617	Economic and Social needs
Per capita	0.777		

**Table 2. The final values of KMO and sig**

KMO and Bartlett's test		
Kaiser-Meyer-Olkin measure of sampling adequacy.		.532
Bartlett's Test of Sphericity	Approx. Chi-Square	78.634
	df	45
	Sig.	.001

At the end of the research, composite index of need for green space development is calculated. So, achieved weights are multiplied by the values of each indicators. The result of this operation shows values of indicators. The following formula has been used in order to build composite index:

$$NGSD_i = \sum_{j=1}^J W_{F'ANPj} QV_{ij}$$

In this formula,  $NGSD_i$  (Need for Green Space Development) is composite index of need for green space development which belongs to region  $I$ ,  $W_{F'ANPj}$  is the relative weight of indicator  $j$  which is obtained from  $F'ANP$  model as output. And  $QV_{ij}$  is the amount of score indicator  $j$  in region  $i$ .

Then 15 regions of Esfahan have been prioritized by achieved composite index. These scores mean that the each region which is weaker in each indicator, it's score is lower too. In fact, less score indicates the more critical in existing green space in the region. So, that region should be located at the higher priority of developing of green space.

## Conclusions and Discussion of results

Green space in the city is one of the most important indicators which affects on the quality of life. With the growing urbanization, green spaces have been damaged by city managers for supplying other needs of citizens or by land traders. So, these days choosing, the right priority of the development of green spaces and right place to create green space is more important than the past. So, we can say this is one of the most important managerial needs in the modern cities. So far, many studies have been done in theoretical literature on urban planning and the environment. Lack of systematic approach which is far from the minds of experts is one of the most important gaps in this theoretical literature. The purpose of this article is to provide a method which is based on a systematic approach.

For this purpose, 18 parameters which explain how to prioritize the development of green spaces have been evaluated using the  $F'ANP$  model.

The results indicate that three factors of "physical and functional needs", "natural and environmental needs" and "economic and social needs" explain the priority of the need to develop green space in Isfahan.

The findings show that regions of 8 and 10 placed in the top priority and region of 9 placed in the least priority. The results of this research have been checked with reports of the need to develop green space which is done in the municipality of Isfahan that results confirm the prioritization of this model.

This indicates that we can achieve valuable results in terms of prioritization by applying a systematic approach to this issue and by using systematic multivariate methods of evaluation.

**Keywords:**  $F'ANP$  model, location criterions of green space, prioritization of green space development, 15 regions of Isfahan.

## An analysis of the thermal effects of built-up and non-built-up lands on each other using reflective and thermal remote sensing data

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### Extended abstract

#### Introduction

In the last decades, the earth's surface has experienced various changes due to some obscure reason being caused by human activities consisting of deforestation and cities expansion. These widespread human changes pose several adverse problems. For instance, an environmental qualitative decrease which culminates in the reduction of living quality is the result of these adverse changes. Warming of the urban environment owing to oblivious effects of unstable urban expansion, replacing of natural land cover with urbanization phenomena, inter alia, pavements, buildings, concrete and other urban constructions, are discerned as the main factors of creating heat island, which cause the vanishing of land surface cooling effects. Moreover, skyscrapers and narrow streets were diminished the airflow and given rise to an increase in the environment temperature. The remote sensing images are known as an appropriate information source for preparing heat maps and also benefiting from widespread applications for the precise investigation of climate changes and urban and non-urban land use changes, due to the continuous and extensive coverage, timeliness and the ability to acquire information in the reflective and thermal range of electromagnetic waves. The population of Babol city steadily increase as a result of population growth and villagers' emigration and bring about excessive and unplanned constructions, alteration in the physical model of the city and finally expansion of the city in various directions. Physical expansion leads to numerous changes in urban land use and suburbs agricultural uses. Consequently, several serious problems occur including adversity in uses, the urban environment disorder as well as the vanishing of suburbs agricultural lands and their land use change into urban uses (residential, industrial and etc.). One of the adverse effects of urban physical expansion, declining of green space and changing of agricultural land use into the urban land use is the rise in the surface temperature. The aim of this study was to investigate the effects of Babol city expansion on changes in temperature classes and the thermal effects of built-up and non-built-up lands on each other during the period of 1985-2015.

#### Materials & Methods

Multi-temporal landsat images were used in this study. For calculating the land surface temperature, single channel algorithm were used, and maximum likelihood algorithm was also applied to classify images. Therefore, land use changes and land surface temperatures (LST) were examined, and thereby the relationship between land-use changes was analyzed with the land surface temperature. Surface temperature changes map for the period of 1985-2015 was prepared and analyzed regarding land use changes map for the study area to investigate the effects of land use changes on surface temperatures changes. By using the mean and standard deviation of normalized thermal images, the area was divided into three thermal classes. The status of each land use in the specified thermal classes and the impact of surface temperature in built-up and non-built-up lands on each other was investigated.

#### Results & Discussion

The results indicate that most land use changes in the studied area belong to the change of agricultural and green space uses into built-up use in suburbs, which are 740.52 and 472.14 hec, respectively. As it was shown through the findings, 92% rise was observed for the built-up use area. These changes are more significant in the

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periphery of the city. The use of green space has risen from 1656.55 hec in 1985 to 2036.52 hec in 2015, which shows an increase of 23%. The trend of growing the use of green space on the periphery of the city is clearly characterized by the conversion of agricultural land to citrus gardens. The growth of the use of green space is less than the growth rate of built-up use. The built-up use has experienced a significant growth trend over the study period, as area of built-up use has risen from 19% in 1985 to 52.52% of the area in the studied area in 2015. The results of the LST mean survey of land use types for the study area show that the built-up lands than the other lands have the highest LST for all years. Water lands have the lowest LST owing to the high water heat capacity. In most of the years, arable land has a lower LST mean than green space land, which is mainly due to the high moisture of the arable land and the greater activity of evapotranspiration. Most changes in surface temperature of the area are related to the distance of 0-800 m of built-up area. The main reason could be the conversion of the agricultural and green space lands into the built-up lands in the area. The most prevalent temperature class in all years is the medium temperature class which covers the suburb lands. The hot temperature class is more highlighted in the center of the city, streets and ways out of the city. Although the adjacent of the city is covered by medium temperature class, cold temperature class is located far from the built-up urban area. Cold temperature class which follows a decreasing trend, is related to lands which are far away from the city. Also, hot temperature class at which the area increases annually, is adjacent to the city core and exit ways of the town. The highest temperature changes belong to areas which transformed from the other uses into built-up use during the past 30 years.

Due to human activities which produce heat, the area which has remained in the form of built-up land use during this time period has had a noticeable temperature rise. Green space and agricultural areas which have not transformed into other land uses benefit from the least temperature changes during this time period. On account of growing of built-up land use, an increase has occurred in the area of hot temperature classes and a decrease in the area of cold temperature categories. Built-up lands have direct effect on their adjacent land surface temperature. The results of the survey with regard to arable lands and green space in different temperature classes indicate that the areas of green space and arable lands, located above the upper temperature, are proportional to areas of the land that are located in lower temperature classes and they are located in the average distance closer to the built-up lands. In other words, the green space and arable lands that are located closer to the built-up lands have higher temperature relative to the green space and arable lands which are far from the built-up lands. Also, green space lands which are located in urban environments have a higher temperature in proportion to the area of the green space lands adjacent the city owing to the high temperature of their surrounding areas. Green space lands in the urban environment, which have no high area, are more affected and classified into hot temperature classes. Built-up lands, which are located in the urban environment and adjacent to the green space, also have a lower average surface temperature than the green space, and sometimes located in the middle temperature class. This refers to the effect of moderating surface temperatures in built-up lands by green space lands. The severity of the impact is associated to the area of the green space lands and by increasing the area of the green space lands, the amount of the heat that attracts from the surrounding area increases as well.

## Conclusions

As a result, non-built-up lands with higher temperature classes are in a lower average distance from built-up lands compared to those with lower temperature classes. Built-up lands in the adjacent agricultural and green space lands have lower surface temperature compared to other built-up lands. As a result, these lands are considered to be medium temperature class. The results of this study showed the importance of planning and management for preserving agricultural and green space lands and preventing them from being transformed into built-up lands which increases the surface temperature and negative environmental impacts.

**Keywords:** built-up and non-built-up lands, changes, environmental effects, thermal effects, thermal remote sensing.

## Investigation and comparison of aerosol optical indices over two urban areas in Iran

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### Extended abstract

#### Introduction

Atmospheric aerosols, including solid and liquid particles suspended in the atmosphere, are a mixture of particles in the air, as different sizes, shapes, chemical compositions, and, physical properties. They affect the earth's radiative budget and climate directly by absorbing and scattering the solar and earth electromagnetic radiation, and indirectly by acting as cloud condensation nuclei.

Aerosols have both direct and indirect effects on the climate by scattering and absorbing solar and terrestrial radiation as well as modifying cloud cover and radiative properties of clouds. They have been concerned in health effects and visibility reduction mostly in urban and regional areas. Aerosol types which contribute to the scattering include organic particles, water-soluble inorganic species and dust. The population and activities in urban areas lead to the formation of aerosol emission sources, which have a potential to impact on global and regional climate.

In urban areas, the principle particle species absorbing radiation is black carbon, that is produced from incomplete combustion processes mainly from diesel engines. Natural aerosols are generally larger in size than the secondary aerosols produced from gaseous precursors and combustion, and their chemical composition depends on their sources. However, aerosols produced from natural and antropogenic sources are mixed together and thereby each aerosol particle is a composite of different chemical constituents.

Atmospheric aerosol optical and physical properties are two of the major uncertainties in global climate change which are also responsible for many impressive atmospheric effects. Therefore, retrieval of the aerosol optical parameters is an important issue for the atmospheric research communities. Investigations of aerosol characteristics and their optical properties will lead to a better understanding of both the regional and local behavior of aerosols over a region.

#### Materials and Methods

In this paper, the four years (2010–2013) record of aerosol optical properties in two urban areas are studied. Aerosol optical indices such as aerosols optical depth, Angstrom exponent, single scattering albedo, but asymmetry parameter is the most important characteristics of aerosols which is influenced by the physical properties and concentration of particles. These properties also play an important role in the Earth's climate and radiation budget.

Aerosols optical depth is a key factor to measure the degree of atmospheric pollution and to study the climate response to aerosol radiative forcing. Its value shows the aerosol density, while Angstrom exponent is an intensive parameter depends on the aerosol size distribution and increases with decreasing particle size. In other words, Angstrom exponent is the slope of the logarithm of aerosol optical depth versus the logarithm of wavelength. It is commonly used to characterize the wavelength dependence of aerosols optical depth and provides some information on the aerosols size distribution. When scattering is dominated by fine particles, Angstrom exponent has large values (i.e., around 2); it approaches to 0 when scattering is dominated by coarse particles.

Remote sensing of aerosols from satellite-based sensors turn into an important instrument to monitor and quantify the aerosol optical properties over the globe. Study of aerosol optical properties provides a detailed knowledge of both the regional and local behavior of aerosols as well as their influence on the Earth's climate,

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radiative forcing, visibility and photochemistry. Although considerable development has been taken in understanding aerosol properties, they are poorly quantified because of the lack of adequate information on temporal and spatial variability of aerosols.

In this paper, using the satellite data from the Ozone Monitoring Instrument (OMI) aerosols optical depth and Angstrom exponent are investigated over two megacities in Iran, Tehran and Mashhad, during the period from January 2010 to December 2013. OMI was launched in July 2004 on NASA's EOS-Aura satellite, also part of the A-train constellation. In this study, the AOD values at three wavelengths (354, 358 and 500 nm) are used. The values of Angstrom exponent were calculated in the wavelength interval of  $\lambda_2 - \lambda_1$ , i.e. 354–500 nm, using the AOD data based on the following equation:

$$AE = -\ln\left(\frac{AOD_{\lambda_2}}{AOD_{\lambda_1}}\right) / \ln\left(\frac{\lambda_2}{\lambda_1}\right)$$

The reasons of choosing these urban areas are mainly the existence of a large number of populations and substantial sources of emissions from natural and anthropogenic emissions. Previous studies show that the increasing emissions of aerosols during the past decades in these two area have affected their local climate. Here daily, monthly and seasonal variations of aerosol properties in terms of optical depth and Angstrom exponent are analyzed to provide a detailed insight into the variation of aerosols loading and their possible causes.

## Discussion of results

Temporal variations of the AOD at 500 nm over the two cities are compared. As aforementioned, AOD indicates the aerosol loading in the vertical atmospheric column. Results concerning the seasonal frequency distribution of aerosols optical depth (AOD) at 500 nm revealed that values of this index in Tehran are higher than Mashhad in all seasons. It shows the existence of higher aerosol density causing the higher atmospheric turbidity over Tehran than Mashhad. During the study period, the daily amount of AOD over Tehran is ranged from 0.2 to 1.6, while over Mashhad the daily AOD is ranged from 0.1 to 0.9. Results show that 73% of AOD values are less than 0.6, however, in 95% of the cases, values are less than 0.6. High values of aerosol optical depth are obtained during the spring and summer seasons, respectively, and low values are seen during the winter in the both cities.

There are also significant variations of Angstrom exponent over the two cities. Based on the results, AE over Tehran ranges between 0.06 to 0.16, showing that the dominant mode of aerosols over Tehran is a mixture of fine and coarse particles. Fine particles are dominant over Mashhad. Therefore, it can be deduced that turbidity in Tehran is subject to a complex mixture of aerosol types, including anthropogenic aerosols and dust, while anthropogenic aerosols are dominant over Mashhad.

To further understand the seasonal variations of aerosols, AOD was studied at different wavelengths for each season. Results show the seasonal dependency of AOD values are mainly related to various emission sources.

In order to investigate the origins of aerosols and transports of the air masses toward the understudy regions, back trajectory analyses based on the NOAA HYSPLIT model (National Oceanic and Atmospheric Administration Hybrid Single Particle Lagrangian Integrated Trajectory) was performed. For six days, as the representatives of polluted and clean days, air mass back trajectories were computed using HYSPLIT model. Results indicate the existence of different patterns of particles transport over the two cities. It is seen that the sources of aerosols over Tehran are both from local emissions and from the long range dust transport, while aerosols over Mashhad are more likely from local sources.

## Conclusion

An investigation of optical properties of aerosols was carried out in two urban areas in Iran, Tehran and Mashhad, from 2010 to 2013, using the satellite data from the Ozone Monitoring Instrument (OMI). Result shows the higher aerosol density over Tehran than Mashhad. High aerosol loading are obtained during the spring and summer, respectively, and low values during the winter in the both cities. The dominant mode of aerosols over Tehran is a mixture of fine and coarse particles, however, fine particles are dominant over Mashhad. Seasonal investigation shows the seasonal dependency of AOD values which are mainly related to various emission sources. Trajectory studies indicate different patterns of particles transport over the two cities. Case studies show that the source of aerosols over Tehran are both from local emissions and from the long range dust transport, while aerosols over Mashhad are more likely from local sources.

**Keywords:** aerosols, aerosols optical depth, Angstrom exponent, OMI.

## Explaining the components and indices of environmental sustainability in Iran's educational spaces, with an emphasis on Green Educational Building Evaluation Systems

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### Introduction

Sustainability has become one of the major concerns of development over the past few years. The emergence of several environmental crises has created many problems for governments and forced them to identify effective factors and frameworks. Construction has also been one of the most important factors that affect environment. This has led architects seek new solutions to provide a desirable human environment.

Although educational spaces account for less urban land per capita than other uses, the move towards the establishment of sustainable schools is a tangible way of achieving the goals of sustainable development and the development of environmental culture. Sustainable and green construction of schools can encourage and educate students more effectively since students spend about half of their time in schools and can develop these approaches in the future, both in individual and family behavior and in their careers.

Hence, this strategy can be more effective by environmental education in harmoniously constructed spaces. Finally, another aspect of the importance of creating and paying attention to green schools is a new approach to establish schools in the natural environment, which is on the agenda of many developed countries. Therefore, paying particular attention to the sustainable design of schools and the creation of appropriate environmental conditions should be the main factor in physical development.

Now, looking at the current situation of schools in Iran, there is a lack of green schools among official schools. According to studies conducted, in spite of the disparate efforts made to apply environmental criteria in some schools, the scarce number of schools that have been implemented under the name of green schools are at very early stages due to the lack of standard and indigenous criteria. Failure to adhere to the principles of sustainable architecture in the construction of existing schools has resulted in many consequences, including the emergence of climate issues, the use of enormous amounts of energy to provide environmental comfort conditions, the isolation of native architecture, the lack of attention to the environment and climate in the process of construction and so on. This makes the necessity of the existence of criteria that will enable decision makers to create the above schools more evident.

The need to address this issue has led many studies to take place in advanced countries. Researchers have introduced several criteria for assessing sustainable schools, which also have a logical convergence. These criteria have been introduced as "Green School Assessment Systems" in different countries. Evaluation systems assess green educational buildings based on existing technology, environmental performance and efficiency, the production process and operation of the building from a full perspective and according to the life cycle of the building. They also create a final standard of what makes a building green in terms of design, construction and performance. These systems include components and indicators that are rated according to their importance and impact, thus quantitatively measuring the effects of environmental and human impacts on the design, construction, operation, and maintenance of the building.

The study of green school assessment systems in the world and a review of existing documents and practices in Iran suggest that despite the efforts made, it is unfortunate that there is no system for the design, operation and evaluation of sustainable schools. Also, sustainability components and indicators of these schools have not been formulated based on cultural, social and economic conditions. This has led to the fact that despite the importance of constructing green schools in the leading countries, Iran has given more attention to environmental education. In these small numbers of schools that are currently active as green schools, individual education has been

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emphasized. The existence of a comprehensive Environmental Charter (2015) and the stated objectives also confirm this issue. Therefore, the issue of identifying the components and criteria of architectural design of sustainable schools in Iran is one of the topics that although the necessity of addressing it is clear to everyone, but no serious action has been taken so far.

Investigating the research carried out in Iran on the subject of the present research shows that although these researches have been carried out based on global evaluation systems, they have focused on just one system, in particular LEED evaluation system. As a result, the same components and indicators have been used, and finally, the analytical hierarchy process method has been used to design new evaluation system for prioritizing and rating indices. Therefore, except for the use of expert opinion to determine the priority of components, local and regional priorities that affect many indicators have not been taken into account. This is while the present study first identified the systems for assessing green educational spaces and by comparing and analyzing them, two systems that are practiced in almost all countries are selected (BREEAM and LEED). Then, based on their comparison and integration, a new category is presented. Finally, recommendations are made to adapt the components and indicators to local and regional conditions.

## Materials and Methods

Accordingly, the purpose of this study is to propose components and indicators of environmental sustainability design in schools in Iran, seeking to answer the questions of what are the global standards of designing sustainable educational spaces? what are their components and indicators? and how they can be used in designing educational spaces in Iran? The research method is descriptive-analytical and a combination of field, content analysis, and comparison is applied. Data collection method is library-documentary.

Accordingly, in order to do theoretical studies, we investigate the research background, similar studies in the world and Iran.

Having reviewed the research literature, some accounts of sustainable schools and their characteristics are presented. It is concluded that green schools are schools come up with better learning environments for learners, as well as savings in resources and spending. Besides encompassing different aspects of sustainability, the schools themselves are means of sustainable education. The advantages of designing such schools are financial, environmental, and human. In these schools, environmental education is carried out both through individual (human) education and education via the environment. Given the broad scope of the present research, education via the environment was in the spotlight. Thus, according to the studies, the values and efficiencies of green schools can be summed up as follows:

1. Effect of environmental health and comfort using sustainable energies and safe water supply
2. Reducing fossil energy consumption and recycling
3. Encouraging students to engage in sustainable purposeful activities
4. Contextualizing selection of jobs and responsibilities consistent with future sustainable approaches.

In the next phase, the research conducted on the most valid systems of green building evaluations was reviewed. The studies on 70 green building evaluation systems in the world were reviewed. In these studies, six valid evaluation systems namely LEED, BREEAM, CASBEE, SBTtool, HQETM, and DGNB were chosen out of 70 systems in accordance to four criteria. These criteria are exclusive focus on building, the number of references given in Scopus and Elsevier databases, application in the design and construction of over 500 valid projects, and consistent development of regions (during at least a five-year program). In another study, the assessment systems proposed for green educational spaces were introduced.

In the end, the studies conducted, the review of the performance of the most important and valid evaluation systems of green buildings in the world and proposed evaluation systems for green educational spaces and their comparison with each other led to the identification and introduction of the most valid evaluation systems of green educational spaces. These systems include LEED, BREEAM, CASBEE, and DGNB. Following the introduction of the foregoing systems, their components, indicators, as well as scoring method were presented. Next, an analogy was made between the four systems in accordance with four parameters of their effect, evaluation process, scoring criteria, the least score obtained and criteria categorization. Eventually, scoring systems of LEED and BREEAM were the most valid international systems in terms of evaluation of green educational spaces.

In order to determine the convergence and difference of LEED and BREEAM evaluation systems, their components and indicators were compared with each other. The results of comparing the components and indicators of the two selected systems led to 7 component and 46 indices. Considering their importance, they can be used as components and indicators affecting environmental sustainability of educational spaces in Iran.

## Discussion of results

Considering that some of the components and indicators proposed are under the local and climatic conditions of the region or country and should be made localized, the indicators can be categorized into three broad categories:

1. Indicators that are not affected by local and climatic factors and are applicable and evaluated in all countries according to international standards (such as non-use of volatile organic compounds, reduction of optical pollution, reduction of noise pollution, provision of public transport, cycling facilities, low-emission air conditioning systems, lighting control with energy labels and so on);
2. Indicators that should be determined for each individual country under the effect of local and climatic factors and then used in the assessment (such as sufficient daylight, natural ventilation, microbial contamination, site selection, thermal effects' reduction, reduction of optical pollution, and so on);
3. Indicators that are sub-components of innovation in design and, depending on the designer's point of view, can provide solutions for improving environmental quality and energy efficiency.

Therefore, what is important is how to use these components and indicators in Iran according to the local conditions (cultural, social, economic and climatic conditions) of the country. Since the present study focuses on the components and indicators of environmental sustainability of educational spaces, suggestions regarding the localization of indicators under the climatic conditions are presented.

Since, Iran has different climatic zones, attention to the climatic conditions of the area can have a significant impact on the sustainable design of the building. The most important affective climatic factors can be temperature, precipitation, humidity, wind, and amount of sunlight. To determine how these components affect on the environmental sustainability indicators, depending on the area in question, meteorology stations' data and related analysis, can be used. In addition, the impact of factors such as latitude, distances and proximity to the sea level, vegetation cover and soil type, etc. should also be considered on the components and indicators.

On the other hand, the impact of climatic conditions on educational spaces is different due to differences in the type of operation and the time of use in comparison to other uses. In these spaces, the time or pattern of occupation and density in the space, which are considered as the main features of the educational spaces, are different from ordinary spaces. These places also have a significant internal load, which affects on the thermal needs of space.

## Conclusion

In order to create optimal conditions for the quality of the indoor environment as well as saving resources (water, energy, land and materials), it is recommended that as other countries use International Building Codes (IBC) and its related regulations such as the International Green Building Regulation (AIA), US Green Building Council (USGBC), Environmental Protection Agency Regulations (EPA), Federal Emergency Management Agency Regulations (FEMA) for localization, Iran should also use publications approved by the country's management and planning organizations and the renovation, development and equipping of schools. It may provide educational spaces (for example, publication number 697 of educational building design guidelines; publication number 343 of educational space acoustic design guide; publication number 406 of preparation of schools against earthquakes; the design of educational spaces regulation: protection against fire; standard 1848 of schools' lighting, and etc.) as well as standards for housing and urban planning, the country's engineering organization, the environmental protection agency, and all organizations that are somehow involved in the construction and conservation of resources. Some of these regulations are general building regulations (topic 4), design and implementation of electrical installations of buildings (topic 13), energy saving (topic 19), and health facilities (topic 16), and so on. Due to the fact that some of the cases have not been addressed in the approved circulars and magazines or have been paid less, reference materials, such as Iran's climate zoning-educational buildings, can be used. In this way, the items proposed in foreign regulations and rules are compared with similar cases in Iran and domestic items are used depending on local conditions.

**Keywords:** educational spaces, evaluation system, Green schools, sustainable architecture.