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Investigation of In-situ Remediation of Benzene and MTBE-contaminated Groundwater by Chemical Oxidation Using Stabilized Zero-Valent Iron Nanoparticles (Case Study: Southern Tehran Aquifer)

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Introduction

Contaminated groundwater by gasoline spill is a worldwide environmental problem. Gasoline contains methyl tert-butyl ether (MTBE) and benzene, which are the chemicals of concerns (COCs) among the gasoline components. MTBE is highly water soluble and has a low Henry's law constant and low soil adsorption co-efficient. Therefore, MTBE can easily move through the soil and then accumulate, distribute or migrate in groundwater. Accidental releases of petroleum products from pipelines and from aboveground and underground storage tanks are the most common causes of groundwater contamination in most countries. Due to issues of taste and odor, health concerns, carcinogenic effects of benzene and MTBE, many attempts have been made to remediate contaminated groundwater. Due to the limitations of conventional groundwater cleanup technologies (e.g., pump & treat, air stripping and permeable reactive barriers (PRB)), in-situ chemical oxidation (ISCO) has become one of the attractive remedial alternatives for petroleum-hydrocarbon contaminated groundwater in recent years.

In addition to oxidation-reduction potential (ORP) of oxidants, hydrogeological and geological characters and dispersion diagram of contaminants and other effective factors in aquifer must be identified and considered before designing ISCO system. Based on natural conditions of the case study area including approximately fine grained aquifer, low permeability, low concentration of dissolved autochthonous iron and high levels of scavengers like ions and other organic matters, we need a potent and stable process simultaneously to access an efficient distribution and link between chemical agents and target contaminants. Thus, in this study Fenton chemical oxidation (H_2O_2/Fe) using stabilized nano zero-valent iron particles (S-NZVI) was used. Among different sources of iron as catalyst in ISCO, S-NZVI was opted. This study focuses on in-situ remediation of contaminated groundwater by Fenton's oxidation using stabilized-NZVI particles to gain more efficiency and ROI in special conditions of southern Tehran Aquifer. The main objectives of this study were to 1. assess the feasibility and effectiveness of applying the S-NZVI in ISCO injection system as a catalyst on the control of petroleum-hydrocarbon plume; 2. determine the optimum components of the ISCO materials including H_2O_2, S-NZVI, and in some cases required pH; 3. determine the level of some hazardous by-products including tert-butyl alcohol (TBA) and acetone in simulated conditions; 4. assess the influences of physico-chemical conditions of groundwater on remediation efficiency. The tests were implemented on a bench-scale pilot with a one-dimensional soil column and similar chemical and physical conditions of the region.

Materials and methods

To simulate the qualitative conditions of the contaminated groundwater, MTBE, and BTEX were used as the chemical of concerns (COCs) but only MTBE and benzene were assessed as target contaminants. Uncontaminated and non-uniform sand, silt, and clay (50% fine grained sand and 50% low-Plasticity silt and clay) (Soil Unified Classification: "SM") were mixed as simulated porous media. To achieve the average porosity of n=0.38 and the average hydraulic conductivity (k) equal to 0.001cm/s, a standard was defined for compacting of the soil mixture in the column. Water head of all reservoirs was equal and varied between 140 and 135cm during reaction time and the length of the soil column was 32cm ($i=\Delta h/\Delta l \approx 4.3$).

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Before starting each experiment, soil column was flushed with a 1mM HCl solution at approximately 10 Pore Volume (PV) and then was washed with de-ionized water at 4-5 PV. After this preparation process, predominant dissolved anions and cations in effluent water decreased to below 10 mg/L. Three clean reservoirs considered to inject polluted water, H_2O_2 solution and S-NZVI suspension into the column. Then salts, MTBE, BTEX, sulfuric acid and caustic soda were added to de-ionized water to obtain the required values for each reservoir. To avoid agglomeration, deposition and oxidation of S-NZVI particles by dissolved oxygen (DO) in its reservoir and to keep a homogenous suspension, before and during the injection, N_2 gas was sparged to the suspension for mixing and removing DO. To reduce volatilization of MTBE and BTEX from water, the reservoir was isolated against air with a flexible cap and was cooled too. At the end of each test, a 4mL sample was taken from the last sampling point on the column by a syringe and stored in a sealed glass container with no headspace. It was then kept in the refrigerator for maximum 3 days until analysis time.

Discussion and results

At first, for investigation of system efficiency and finding optimum concentrations of the agents at simulated conditions including neutral pH range, temperatures between 15°C and 20°C and certain COCs and ion levels, different concentrations of agents were injected into the column. The concentrations of MTBE and benzene in the influent and effluent were measured to calculate remediation efficiency. Blank experiments illustrated that approximately 20% of MTBE and 30% of benzene can be absorbed in fine grained particles of soil during the initial passage of contaminated water before the reaction starts. Therefore, a preparation time of 1.5^{hr} was considered to saturate the soil in order to eliminate COCs absorbing capacity of the soil. Degradation of MTBE and benzene can be increased with the increasing of H_2O_2 and S-NZVI concentrations. However, this procedure will continue till a certain level of each one (Fig. 1). It was concluded that for remediation of simulated groundwater polluted with approximately 2mg/L MTBE and 1mg/L BTEX, optimum concentrations of H_2O_2 and S-NZVI were 1500 mg/L and 300 mg/L, respectively. This leads to elimination of 78% of MTBE and 87% of benzene in the pilot with mili molar ratios.

$$\frac{H_2O_2}{MTBE + BTEX} = \frac{44.12}{0.04} \text{ and } \frac{H_2O_2}{Fe^0} = \frac{44}{5.33}$$

Then, to assess the degradation of COCs and hazardous by-products of the reaction (acetone and TBA) during run time, samples were taken from all sampling points on the length of the column. The by-products were generated first and then were degraded as an organic matter by hydroxide free radicals in oxidation process. At least, 90 minutes after the beginning of the reaction, by-product concentrations were obtained less than 0.1 ppm on average. Thus, it can be claimed that the remediation has no problem in this respect. The tests demonstrated that degradation rates of MTBE and benzene are less than values previously reported by other researchers. It is due to differences between complete mixed conditions of batches in other researches and conditions of this study including using porous media (laminar flow), the type of iron, and high levels of scavengers like ions which reduce the availability of radicals to contaminants. S-NZVI unlike NZVI, ZVI, and ferrous salts, supply Fe^{2+} ions continuously to react with H_2O_2 during passing through the column. Thus, hydroxyl radicals are generated continuously (not immediately) and degrade COCs. This process causes more distribution of agents in subsurface media and increases the ROI.

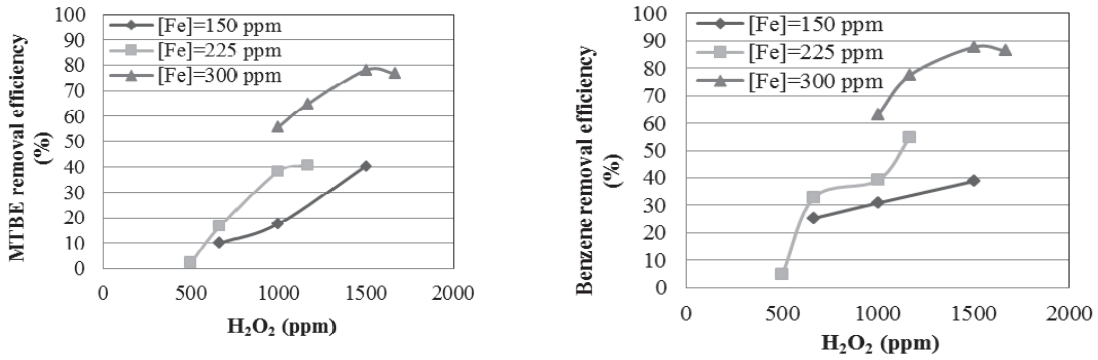

Figure 1. Results of pilot tests to find optimum concentration of H_2O_2/S-NZVI at neutral pH range

In the next part of the study, to investigate the effects of pH on remediation efficiency, the optimum concentrations (H_2O_2=1500mg/L and S-NZVI=300mg/L) were injected and all experiments performed at 16-17°C to simulate ion conditions. The tests demonstrated that the efficiency is more in lower pH so that 90% reduction in MTBE and 96% reduction in benzene occurred at pH=3.2. Thus, alkaline conditions result in drastic reduction of remediation efficiency or waste some of consumed iron. In the other hand, high pH conditions increase iron intake and low pH condition can help iron to be solved in water.

In the next part, to assess the effects of ion concentrations on remediation efficiency, the optimum concentrations were injected and all experiments were performed at 10-15°C, pH=6.5-7, and different ion conditions. Five categories of TDS were selected for injection. Results illustrated that at very low levels of ions, the removal efficiency will be approximately 92% for MTBE and 96% for benzene. Thus, existence of ions up to real concentrations of the area causes 15% and 9% reduction in removal efficiency of MTBE and benzene, respectively. On the other hand, they increase consumption of reaction agents. Ions including HCO_3^-, CO_3^{2-}, SO_4^{2-}, Mg^{2+} and Ca^{2+}have more effect and ions including Cl^-, NO_2^-, NO_3^-, Na^+ and K^+ have lower effect on efficiency reduction. Ions can consume iron particles and cause formation of an insoluble layer on the surface of particles. Using S-NZVI instead of bare NZVI or ZVI, partially, helps the particles to be more stable against the unwanted reactions during passing the media.

Conclusion

This study showed that using S-NZVI instead of micro-ZVI powder can reduce consumption of iron as catalyst and increase the ratio of H_2O_2/Fe^0. S-NZVI unlike NZVI, ZVI and ferrous salts, supply Fe^{2+} ions continuously to react with H_2O_2 during passing through the column. Thus, hydroxyl radicals are generated continuously (not immediately) and degrade COCs. This factor helps the agents to distribute more in the subsurface media and increases the ROI. Results illustrated that in theory MTBE and benzene could be removed in this system significantly. But in practice, full-scale pilot tests must be done after a design process to determine the method sufficiency.

Keywords: benzene, fenton chemical oxidation, groundwater, MTBE, Southern Tehran's aquifer, stabilized nano zero-valent Iron.

Purging of Oil Contaminants in Soil Using Combination of Fenton Advanced Oxidation and Sulfate Radical (A Case Study: Masjed Soleiman, Iran)

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Introduction

Oil exploration and production zones are very frequently contaminated with petroleum hydrocarbons or its derivatives. The most important exploration and production zones are located in South-west and South of the country, in Iran. Masjed Soleiman city is located on an oil field. The soil of this region has been affected by the petroleum composition. Mach petroleum seepages and springs (asphalt, oil and gas) with active oil and gas wells in Masjed soleiman caused this contamination. Restoration of soil contaminated with hydrocarbons at the sites has become a very interesting scientific challenge, mainly because of the actual complexity of the matrix. A large number of studies have been reported for the treatment of oil contaminated soil. One of the technologies is advanced oxidation. Advanced oxidation processes has the potential for rapidly treating or pretreating of pollution by TPHs. Applying the advanced oxidation processes have proven to be effective in treating and recovering the soil, mainly because they are faster than the other processes and are able to degrade toxic recalcitrant matter. The aim of this study is to evaluate effectiveness of the advanced oxidation process of oil contaminated soil by combination of Fenton and sulfate radical.

Materials and methods

The study area is located in the Zagros fold belt, and considered as a part of the Dezful embayment. Masjed Soleiman is located on Aghajari, Mishan, and Gachsaran formations. The Gachsaran formation is located inside the Asmari Formation as one of the largest oil reservoirs in southern Iran. Joint and Fractures systems caused oil spills to the surface. The lithology of these formations is composed of gray marl, limestone, brown to gray sand lime stone and carbonate. Due to the weather conditions, the climate of the region is known as the cold and dry. In this study, soil samples contain two types of soil, Petroleum-contaminated soil and clean soil. Sampling locations are shown in Figure 1. Soil characteristics were determined based on clean soil test. Clean soil passed from a 40 mesh sieve. Physical – chemical properties of the samples were, pH (7.3), organic matter (2.59%), Calcium carbonate ($CaCO_3$) (18.75%), clay (5.4%), sand (10.2%), silt (84%), and soil texture (silt loam).

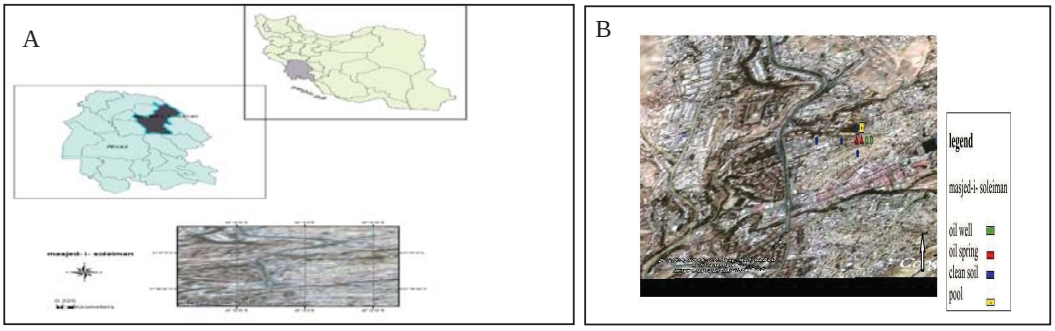

Figure 1. A) Location of study area, B) Sampling points

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In this study, advanced oxidation process was used for cleaning up the contaminated soil in the Masjed Soleiman. Materials used in the experiment are including: Hydrogen peroxide (Merck, 35%), potassium per sulfate (pxtra, 98, India), Optical Spectrometer (GCB model UV/VIS199), sulfuric acid (98%) and potassium dichromate.

Although hydrogen peroxide is highly reactive and capable to oxidize a wide range of pollutants, but the limitations of the peroxide is unstable and rapidly decomposes in the soil texture. Recently, increasing attention has been paid to the sulfate radical due to its high efficiency of mineralization of organic pollutants. On the other hand, one of the systems that contain hydrogen peroxide and per sulfate with H_2O_2 oxidation and stability is resulted from the higher degradation rate of soil. The removal efficiency of contaminants by iron oxide catalyzed by Fenton-like reaction is influenced by parameters such as types and concentrations of iron oxides, H_2O_2 concentration, and the presence of other oxidant-consuming compounds and pH. Initially, experiments were carried out to determine the optimal concentrations of hydrogen peroxide and potassium per sulfate. To obtain optimal concentrations, different amounts of hydrogen peroxide and potassium per sulfate were added to soil samples. Then, samples were added to the dichromate and sulfuric acid to measure the amount of organic matter remaining in the soil. It is used analyzing samples of the spectrometer. The spectrometer was adjusted on 620 wavelengths. This spectrum is based on the use of dichromate. The results are shown in Table 1 and Figure 2. Concentrations selected for this experiment, 0.15 gr of potassium per sulfate, hydrogen peroxide and 4 cc. Other effective factors are the test: pH, temperature and the amount of catalyst. This experiment was done in neutral pH and temperature of 50°C. The iron oxides were used in the soil as a catalyst potential. We used the experimental stage to increase the removal rate. Hydrogen peroxide and potassium persulfate were added in three steps over three days.

Table 1. Different amounts of hydrogen peroxide and potassium persulfate

Concentrations persulfate	Concentration H_2O_2
0	1
0.05	2
0.1	4
0.2	6
0.4	8
0.6	10

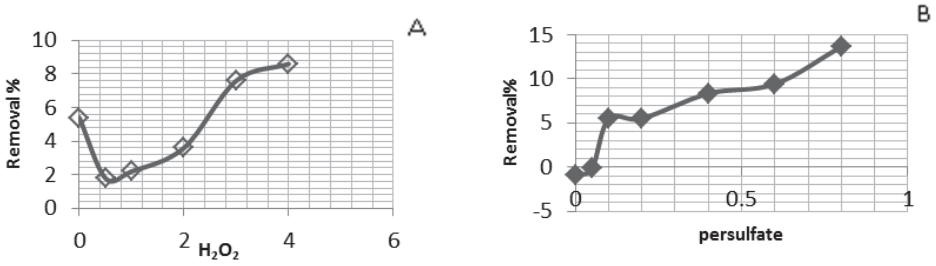

Figure 2. Results of the optimization of A) hydrogen peroxide and B) persulfate Conclusion

The results of this study have indicated that an advanced oxidation process can be used as a powerful method in this study. This method was able to remove a significant percentage of contamination of soil during three days. The first step was to remove 19 percent of contamination. The next steps were to remove the 45 and 48 percent, respectively. The result is shown in Table 2. Although hydrogen peroxide-based oxidation is more powerful for the removal of contaminants, its oxidative strength cannot exist in a remedial system for a long time due to ease of decomposition of hydrogen peroxide and rapid disappearance of hydroxyl radicals. These experiments indicated that both hydrogen peroxide and potassium persulfate have a positive impact on oxidation

of petroleum compounds in soil. According to the most appropriate optimization of hydrogen peroxide and potassium persulfate removal rate, the ratio of 1:0.05 is obtained. It should be noted that although hydrogen peroxide can be activated by ferrous ion and persulfate, ferrous ion is also a scavenger of sulfate and hydroxyl free radicals. Thus, ferrous ion concentrations should be controlled to minimize the adverse effects of ferrous ion on sulfate radical production. In addition, ferrous ion can also decompose persulfate anion according to reaction. Thus, excess addition of ferrous ion may reduce the efficiency of contaminant removal.

Table 2. The result of advanced oxidation process

Testing stage	amount of number with Optical spectrometer	Removal %	Removal Averae %	temperature C°	amount H_2O_2	amount per sulfate
Frist Day	146	21	19.2	50	1.3	0.05
Frist Day	153	17		50	1.3	0.05
Second Day	97	47	45.4	50	2.6	0.1
Second Day	106	43		50	2.6	0.1
Third Day	90	51	48.70	50	4	0.15
Third Day	101	45		50	4	0.15
Control	186	0	0	50	0	0

Keywords: advanced oxidation process, Masjed Soleiman, oil contamination, soil.

Influence of pH on Decomposition of Total Petroleum Hydrocarbon in Soil Slurry-Sequencing Batch Reactors

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Introduction

The contamination of soil and water with petroleum hydrocarbons is a widespread environmental problem. The treatment requirement and removal of this pollutant are becoming more important in these days. Total Petroleum Hydrocarbon (TPH) has been reported to be toxic, carcinogenic, and an endocrine disrupter widely used in developing countries. Various physical, chemical, and biological methods were used for removing TPH in water treatment. Soil Slurry – Sequencing Batch Reactor (SS-SBR) is one of the important in-situ or ex-situ technologies which were able to bio-remediate the soils containing high levels of organic matters. In fact, in this condition the pollutant depletion rates depend mainly on the degradation activity of the microorganisms available in the system. The results obtained generally reflect the actual biological depuration potential of the soil. The application of aerobic SS-SBR is predominant for bio-remediation of soils. A large number of successful laboratory, pilot and full-scale studies and cases of aerobic SS-SBRs have been reported for bioremediation of soils polluted with Polycyclic Aromatic Hydrocarbons (PAHs), pesticides, diesel, and explosives. Slurry-phase bioreactors (SPB) are well-stirred tanks in which soil and water are mixed with air, microbial cells, and nutrients. Soil is sieved to produce a 1mm particle, approximately, before feeding it to the reactor. Many factors influence the feasibility and effectiveness of bioremediation. Some of these are the presence of suitable microorganisms, the availability of nutrients, temperature, and pH. Consideration of these factors is critical for a successful implementation of bioremediation systems. Soil pH is an important process control parameter. The optimum pH for soil biodegradation lies between 6 and 8; however, effective biodegradation can be found outside this range. In this research, the ex-situ methods have been selected. In comparison with in-situ methods, they are faster, simpler and more controllable and can be applied for treating and removing more pollutants and soils. Among ex-situ techniques, slurry phase has been chosen, where contaminated soil is combined with water and other additives in bioreactors and then mixed. Nutrients and oxygen are added, and conditions in the bioreactor are controlled to create the optimum environment for microorganisms to degrade the contaminants. This technique offers two advantages. First, these experimental conditions maximize the contact between the solid and the aqueous phase, thus enhancing the mass transfer and, as a consequence, the biodegradation rate. In addition, slurry-phase degradation experiments give the results that can be promptly transferred to a full-scale process. The biodegradation of oils in a SPB has a higher degradation rate than other biological treatment methods. Various modes of SPB operation have been tested in laboratories and pilot-scale plants, and one of the most common and best performing modes involves an SS-SBR. This research has investigated the optimum pH that afforded best degradation of TPH in SS-SBR with a variation of pH and other fixed conditions.

Materials and methods

The HPLC grade n-hexane and dichloromethane have been used for extraction solvents. Anhydrous granular (Na_2SO_4) has been provided. Sulfuric acid and sodium hydroxide were used for pH adjustment. NH_4Cl, K_2HPO_4, and KH_2PO_4 as nutrients have been used for balancing the C:N:P ratio as 60:2:1. All of these chemicals were purchased from Merck, Germany. The soil sample has been collected from Azimabad region in the south of Tehran refinery. The soil main characteristics are shown in Table 1.

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Table 1. The soil main characteristics

Composition	TOC (% w/w)	Total N (% w/w)	pH	Nitrate and Nitrite (mg/kg)	Phosphate (mg/kg)	TPH (mg/kg)	PAH (mg/kg)
Sand and gravel 90%, silt and clay10%	6.4	<0.01	7.5	<0.1	<0.1	67000	Not Detected

TOC and nitrogen have been measured by combustion using an NA2100 Protein Nitrogen Analyzer (Thermoquest CE Instruments, Italy). Nitrite, nitrate and phosphate have been measured in a chromatographic system equipped with a Waters 515 pumping system, a Waters IC-PAK anions column, an UV/V Kontron model 332 detector (Kontron Instruments, Italy), and a Wescan conductivity detector (Wedan Instruments, USA). The pH of slurry has been measured by Metrohm 691 pH meter (Switzerland). Heterotrophic and degrader populations have also been enumerated by the MPN technique.

Two soil-slurry circular reactors made by plaxy glass have been designed and equipped in laboratory-scale with 6 liters volume which its diameter and height is 19 and 30cm, respectively (Fig. 1). In each reactor 600gr of sieved and dried soil has been added with NH_4Cl, K_2HPO_4, and KH_2PO_4, in order. During the research, the pH is adjusted in a range of 5-10 (Table 2). The reactors are continuously mixed and aerated through a fine bubble diffuser from the bottom to provide 5mg/l DO. The reactors have been started with 10% (w/v on a dry weight basis) TPH contaminated soil in sterile tap water. The SBRs have also been started as a batch growth for 14 days pro start up and then carried out six runs by two month retention time. The volumetric feed rate is a function of the desired hydraulic residence time.

Table 2. pH level in Soil slurry reactors in each run

Runs	Run1	Run2	Run3	Run4	Run5	Run6
SBR1	7.5	7	6.5	6	5.5	5
SBR2	7.5	8	8.5	9	9.5	10

Dried soil sample has been mixed with 3x20ml CH_2Cl_2 and n-hexane (1:1) and measured by an Power Sonic 420 (Korea) ultrasonic cleaning system for 5 min in three times. Then, the samples have been poured through sodium sulfate and concentrated in a Kuderna-Danish (KD) concentrator under a gentle steam of nitrogen to nearly 2ml for GC-FID analysis. Before GC analysis, liquid phase has been filtered through 0.45 m cellulose filter paper and LLE with 1 liter sample with 3x15ml dichloromethane/n-hexane (1:1) which added to a decanter and shaken for 10 minutes, strongly for three tomes. The three extracts have been combined and evaporated under a gentle steam of nitrogen to 2ml for GC-FID analysis. TPH in soil samples were analyzed by GC. For GC analysis, 2µL of the sample was injected into a gas chromatograph UNICAM 610 series equipped with a FID. The column was used in the analysis is DB-5 with 30m length, 0.25mm internal diameter, and 0.2 µm film thickness. Nitrogen is as carrier gas. Injector and FID detector temperatures are 280°C and 340°C, respectively. The column initial temperature was 50 °C for 5 min, and then increased to 250°C with 10°C/min slope and remained at 250°C for 40 minutes. The calibration curves have been prepared with weathered diesel standards in concentrations of 1000 to 4000 ppm as shown in Figure 2.

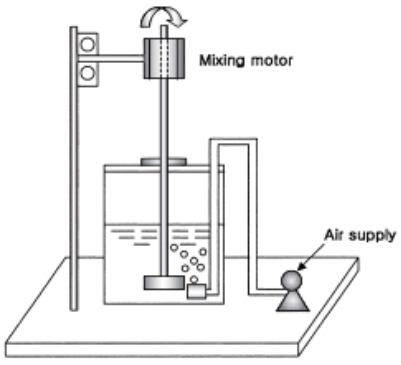

Figure 1. Schematic diagram of SS-SBR pilot

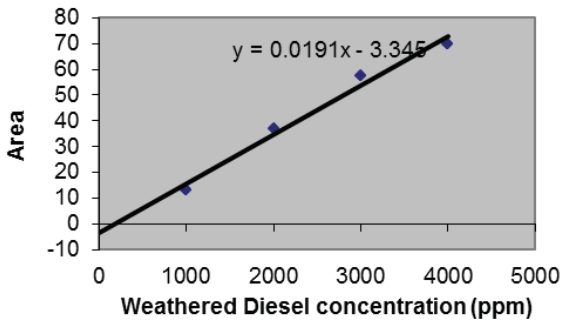

Figure 2. calibration curve of GC with 4 points

Results and discussion

Initial experiments on this soil shows that the type of pollutant is weathered diesel as the chromatograms obtained after soil extraction (Fig. 3). The time zero chromatograms for all conditions are similar to the initial chromatogram and clearly illustrated the large number of compounds present in weathered diesel fuel. In day14 of the reactor operation, the bacterial counts have been numerated suitable, as DO in the reactors is 5mg/l. This study has showed that aerobic soil slurry reactor can effectively remediate TPH contaminated soil. The performance of reactors in TPH remediation in each run is shown in Table 3. SBR1 in second run encompass 88.3% degradation efficiency in pH=7. However, both reactors in first run and SBR1 in third run have to some extent similar results, so, the best pH has occurred on natural pH. Therefore, this is optimum pH for such applications and would be used in farther studies. Figure 4 shows TPH removal percent and results of trend line. TPH solubility of contaminated soil in liquid phase in the reactors is shown in Table 4. According to Table 4, at the end of all runs the amount of pollutants remained in the liquid phase has been less than 1%. Thus, it is clear that in large scales liquid phase could be used in further runs, because the amount of TPH in this phase has been a little. Previous studies by various investigators were focused on the bioremediation of TPH and very few reports on partial degradation of TPH in sequencing batch soil slurry reactor. The aerobic SS-SBR system is promising. The advantage of the slurry reactor is its simple operating conditions; only mixing, aeration, and a carbon source.

Table 3. Performance of reactors

Runs		Run1	Run2	Run3	Run4	Run5	Run6
TPH Degradation Efficiency (%)	SBR1	88	88.3	85	73.2	66.5	52.4
	SBR2	88	87.8	67	55.7	50	49.4

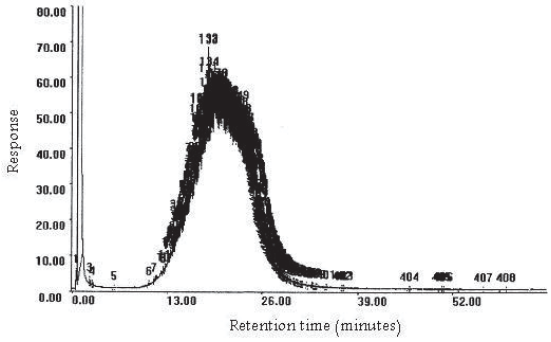

Figure 3. Weathered Diesel contaminant soil chromatogram

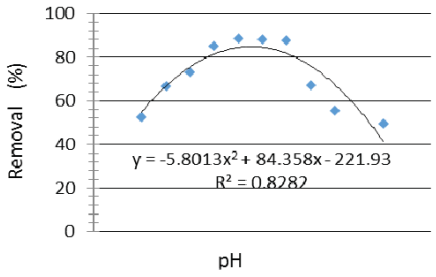

Figure 4. TPH removal percents and results Trend line

Table 4. Solubility of TPH in from solid phase to liquid phase

	SBR1		SBR2	
	solid(%)	liquid(%)	solid(%)	liquid(%)
Run1	99.40	0.60	99.30	0.70
Run2	99.38	0.62	99.40	0.60
Run3	99.00	1.00	99.51	0.49
Run4	99.44	0.56	99.50	0.50
Run5	99.68	0.32	99.65	0.35
Run6	99.68	0.32	99.70	0.30

Conclusion

To reduce costs and increase efficiency, the operating parameters should be optimized. Soil pH is an important process control parameter. In this study we have investigated optimum pH that had the best degradation of TPH in SS-SBR with variation of pH and other fixed conditions. TPH concentration have also been analyzed by GC equipped with a FID and defined optimum pH for bioremediation of TPH-contaminated soil in SS-SBRs in nearly normal pH, i.e., 7.

Keywords: bioremediation, Flame Ionization Detector (FID), Gas Chromatography (GC), pH, Soil Slurry – Sequencing Batch Reactor (SS-SBR), Total Petroleum Hydrocarbon (TPH).

The Concentration and Spatial Distribution of Mercury, Lead, and Cadmium in Surface Sediments of Mangrove Forests Using Geostatistics in GIS Environment

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Introduction

Environmental pollutants are considered among the factors disturbing natural ecosystems. Among them**,** heavy metals due to their toxic effects and having a high bio-accumulation are known as one of the most dangerous pollutants. This leads to the concentration of these metals in the food chain, in the top of the pyramid. Many of these metals are natural components of aquatic ecosystems and some of them play a critical role in the survival of living organisms. However, if the concentration of heavy metals exceeds a certain limits, aquatic life will be threatened and ecosystem degradation will be occurred**.** Heavy metals have not the ability to be refined in aquatic ecosystems, so with gradual blurring of these ecosystems, they can easily accumulate in sediments. In fact, it can be said that the marine sediments are considered often as a final repository for the accumulation of metals. So, we can say that the sediments are considered as an important indicator of pollution and it is used to estimate the amount of pollution in the environment, especially in aquatic ecosystems**.** The spatial distribution of toxic metals in marine sediment in the explanation on the contamination history of aquatic ecosystems and location of pollution sources is very important and effective. Spatial and visual assessment of the pollutants is important for a better understanding of the threats of pollution sources. This can be achieved by Geographical Information System (GIS) techniques. A GIS-based and geostatistical approach provides the possibility of the spatial datasets processing. Using of the geostatistical principles, in addition to describing the spatial pattern of the observed data, provides the possibility of creating contamination maps with minimum variance. It is believed that the spatial assessment and visualization of the pollutants is essential to better understanding of threats of the pollution sources. For this reason it is recommended to use GIS techniques in the studies about the distribution of pollutants in the environment.

Persian Gulf supply major part of the global oil and gasenergy and is known as a potentially oil contaminated ecosystem. Since there is only a narrow exchangeable path between the Persian Gulf and Oman Sea, it takes a very long time to transfer water in the entire Persian Gulf into open seas. One of the most important and sensitive ecosystems in the Persian Gulf is mangrove forests. Mangrove ecosystems have many environmental and social-economical functions. Therefore, metal contaminants entering to Persian Gulf through the exploration of oil and tanker shipping, due to the high toxicity and bioavailability, are one of the main concerns for these ecosystems. The purpose of this study is an investigation on metals of lead, mercury and cadmium concentrations in surface sediments of mangrove forests. This is in order for getting a correct spatial distribution pattern of these pollutants in this very sensitive ecosystem. The spatial distribution modeling involves using GIS and principles of geostatistics.

Materials and methods

Study area of this research is the mangrove forests in the Hormozgan province (in 55˚33'42" to 55˚47'23" E and 26˚46'21" to 26˚58'49" N). Sampling was conducted from 42 stations in three parts of Qeshm Island, Khamir Port, and middle part from the surface sediments 0-5c min, March 2010. Geographic locations and characteristics of each station were recorded and finally samples were transported to the laboratory in boxes of

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ice-containing. To determine the concentrations of lead and cadmium after preparation and digestion of the samples, they were analyzed by graphite furnace atomic absorption spectrophotometer Model AA-67OG. To determine the concentrations of mercury, the samples were also placed into the freeze dryer at -63°C for 48 hours. They were crushed to be prepared for analysis. In order to measure the total mercury, the 0.03 to 0.05 g of each sample was placed directly in the Advanced Mercury Analyzer Model AMA254. This is designed specifically for determination of mercury concentration in liquid and solid samples. To determine the level of contamination in surface sediments of mangrove forests, the mean values of the calculated concentrations for metals were compared with the NOAA and SQGs standards. In fact, these standards represent concentrations of pollutants that in the lower values of them, biological effects are rarely observed. On the other hand, if the concentration of pollutants is greater than this amounts, many incompatible biological effects will be occurred.

In order to model the spatial variations of toxic metals of mercury, lead and cadmium in surface sediments of mangrove forests, seven of different geostatistical methods were used. These methods were: Radial Basis Functions, Local Polynomial Interpolation, Global Polynomial Interpolation, Inverse Distance Weighting, Simple Kriging, Universal Kriging, and Ordinary Kriging. The cross-validation method was used to compare the methods used in this study and selection of the most appropriate geostatistical method. For performance evaluation of geostatistical methods, the statistical parameters such as Mean Bias Error (MBE), Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE) were examined.

Results and discussion

The results showed that the highest concentrations for the metals lead and cadmium were in Qeshm Island and the highest concentration of mercury was found in the Kamir port. However, Duncan's test results at 1% significance level were indicative of the lack of significant differences between the estimated concentrations for each metal in the three investigated parts. The mean concentrations of the metals lead and cadmium in the mangrove forests were obtained 1.86 and 0.21 μg/g, respectively, and that of mercury obtained 8/04 ng/g. In order to understand and evaluate the contamination of surface sediments of mangrove forests in these metals, specified concentrations for them were compared with NOAA and SQGs guidelines and the results showed a significant difference for all metals in the study area ($P<0.05$) and the concentrations were lower than these standards. In order to make a modeling the spatial variations in the studied variables, before any calculations, test of the normality was conducted with Kolmogorov-Smirnov test on data sets. The results of the tests showed that mercury and lead follows a normal distribution trend. Cadmium values were transformed to their logarithms to obey normal distribution.

Finally, after the implementation of geostatistical methods on a dataset, the simple kriging because of having the lowest values for RMSE and MAE and nearing the Mean Bias Error (MBE) parameter to zero was selected as the best approach for modeling the spatial variations of the variables. Superiority of kriging methods can be due to the nature of these methods in minimizing variance of the estimation and use of the variogram techniques in the modeling the spatial distribution of the pollutants. The best experimental variogram was plotted for each of the metals after fitting and checking of various models. The spatial structures of these metals were studied and the results showed that the spatial distribution of mercury, lead and cadmium are following the gaussian, exponential and circular models, respectively.

Conclusion

Although concentration of the metals in mangrove forests in terms of toxicity for organisms is not threatening, but this is one of the most serious dangers that is threatening the mangrove ecosystems in Persian Gulf. The sediments of these forests are low-oxygen and water-saturated that takes a time to clean up oil pollution in these areas. This makes the oil floats on water that may cause death of the tree roots in mangrove forests. Finally, the structures and relationships in the mangrove forests may be broken down.

But as laboratory analysis of sediment samples in this study showed, fortunately a number of natural factors reduce the accumulation of toxic pollutants in mangrove forests. First, the flow is counterclockwise in the Persian Gulf. This can convey clean waters into Persian Gulf from northern parts of the Qeshm Island. After crossing the northwest and western parts of the Persian Gulf, where there are the highest concentration of oil wells and oil exploration projects, it gets out from southern parts of the island. Therefore, it is expected that the sediments of northern parts of Qeshm have less pollution in comparison with those of southern parts. This is also confirmed by the results of previous studies. It is also noteworthy that the issue of the mangrove forest floor is full of microorganisms that can degrade petroleum compounds into simpler substances. This can be revealed by the toxic metals found in crude oil before accumulation in surface sediments, by marine counterclockwise currents driven toward the inner parts of the Persian Gulf,i.e., where they deposited. On the other, Qeshm Island is located in such a way that serves as a protective barrier to protect physically a large portion of the mangrove forests against contaminants.

In this study, due to the lack of extensive sampling of the total mangrove forest areas, we used of geostatistical methods to model the distribution pattern of toxic metals. In general, we can say that employing human development in data processing techniques and using remote sensing and GIS, mapping of pollutions in environment (water, soil and air) is easier and faster and that geostatistical methods are very useful due to spatial extent and the problems associated with sampling.

Keywords: geostatistics, heavy metal, mangrove, modeling, sediment.

Influence of Magnetic Field on Polyhydroxyalkanoate Production by Activated Sludge

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Introduction

Polyhydroxyalkanoates (PHAs) are naturally occurring polyester that can be accumulated in bacterial cells as a carbon and energy storage compound. They are metabolized by many microorganisms. These biopolymers accumulate in microbial cells under stress conditions such as limitation of nitrogen, phosphate, sulfur, oxygen, and excess carbon source. Currently, PHAs have attracted increasing interest as promising alternatives to conventional plastics. This is due to their biodegradability capability in being produced from renewable resources.

The major barrier to wide application of PHAs is their current high cost. Biological waste water treatment is in wide use in the world, and produced large amounts of activated sludge that requires some way of disposal. Moreover, some organisms in activated sludge are known that they have ability to accumulate PHA. Consequently, it is intuitively obvious that production of PHAs from excess activated sludge would be a beneficial economical process.

A number of studies have been carried out on influence of magnetic field on bacterial activity, removal of chemical oxygen demand (COD), sedimentation of activated sludge and etc. Some of these studies indicated that a magnetic field tended to increase bacterial activity and this effect was far more noticeable in heterogeneous culture (waste water) than in pure culture. But, the results of all researches about influence of magnetic field on microorganism performance were inconsistent. Some of them showed negative and positive effects on PHA production. One of them indicated that positive and negative effect of magnetic field on PHA production depended on the intensity of magnetic field. In this study, we attempted to show the effects of different intensities of magnetic field on PHA production by activated sludge. We studied influence of magnetic field with intensity of 0, 5, 10, 15, 20, 25, and 50 mT.

Material and methods

Seven batch reactors, with individual working volume of 1 L were used for this experiment. In these systems, excess activated sludge, with sludge retention time (SRT) of 5 days, was transferred into the reactors. Activated sludge was collected from municipal waste water plant in Kerman City, Iran. Sewage cannot produce the polymer alone, upon activated sludge was fed with sodium acetate (as excess carbon source), with concentration of 3000 mg L^{-1}, at a level. Reactors were aerated with air compressors and oxygen rate was 1L min^{-1}. The activated sludge in batch reactors were sampled at regular intervals and the amounts of PHA were determined. The reactors were operated under the seven different magnetic fields, without pH and temperature control. The magnetic fields were generated by magnets and their intensities were measured by Tesla meter.

For Measuring of PHA, 5mL of samples were centrifuged at 6000 rpm in 30 min. Then 2 mL of chloroform and 1 mL of acidified methanol containing benzoic acid as the internal standard was added to the deposit sludge. Samples were heated for 2 hours at 100˚C by COD reactor (model WTW). After cooling, 1mL of distilled water was added and they were shaken for 1 min to separate phases. Then, 2 µL of bottom phase was injected into gas chromatograph (model Varian CP 3800) at 250˚C, which was equipped with a flame ionization detector (FID) and column (Capilary cp – sil 8 cp, 30m×1µm). The detector temperature was 280 ˚C. Helium was used as the carrier gas. Initial oven temperature was 80˚C which was held constant for 1 min. Then, the temperature was increased to 150˚C at a rate of 25˚C/min and retained for 1 min. Calibrations of PHA were done with a standard poly (3- hydroxybutyric- co- 3- hydroxyvaleric acid) (12 wt% PHV)(Sigma, USA).

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Discussion and result

Access of microorganisms to oxygen can be an obstacle for PHA production. Therefore, in order to achieve ideal aeration time for control sample, activated sludge was sampled in defined times during 48 hours for measurement of PHA. The results of this step showed that increasing aeration time causes food restriction on the microorganism and conditions are provided to produce more polymers. The highest amount of PHA was 0.6 $g.L^{-1}$. This occurred after 30 hours of aeration. After this time, microorganism entered into death phase and microbial population was changed. Thus, the best position to PHA production is stationary phase. In other words, activated sludge in this phase produce bio polymer more than death phase.

We investigated influence of magnetic field intensity of 5, 10, 15, 20, 25, and 50 mT on PHA production. The results of this study were simultaneously compared with the results of PHA production without the magnetic field (control sample). These results demonstrated that the magnetic exposure had definitely influenced the PHA content and it was depended on magnetic field intensity. The maximum PHA content reached 0.75 gL^{-1} at 20 mT. This was 25% higher than that of the control and the minimum occurred at 50 mT, which is equivalent to 0.55 gL^{-1} (Fig. 1).

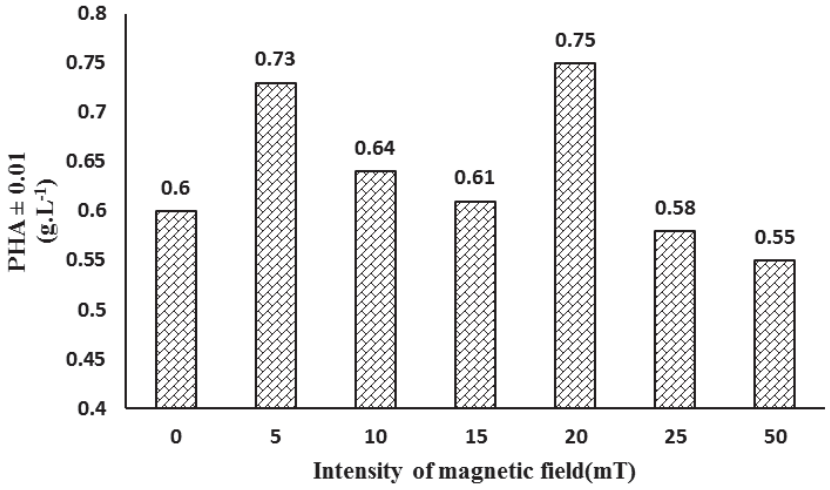

Figure 1. Influence of magnetic field on PHA production

In the general case, in this research, magnetic field intensities was less than 20 mT and increased PHA content (positive effect). The magnetic field intensity higher than 20 mT had negative effects on PHA production. The reason of this inconsistent is the effect of magnetic field on enzyme behavioral change in microorganism's cell, microorganism's performance, bacterial activity, substrate consumption rate, lipid solubility of the substrate in cell membrane and etc.

The results also showed that magnetic field influenced type and amount of monomers in copolymer PHA. Type and amount of monomers were studied at 20 and 50 mT. Since, biosynthesis of polyhydroxybutyrate (PHB) and polyhdroxyvalerate (PHV) are similar together but with deferent enzymes. The magnetic field may accelerate electron motion during enzymatic processes. The result of this is an increase in the activity of some enzymes. At 20 and 50 mT, amount of HB were 74 and 24% and the amount of HV were 26 and 76%, respectively (Fig. 2).

PHB and PHV biosynthetic processes are quite similar together, but they are done by different enzymes. In some previous researches, effect of magnetic field on activity of enzyme and enzyme reaction has been confirmed. Blanchard and Blackman certified that magnetic field influenced on performance of enzymes and their potential. On the other hand, there were always unpaired electrons during in biological process of enzymatic reactions, where exposure to magnetic field could influence the reaction by changing the electrons spin state. The influence of magnetic field on enzymes will change the reaction.

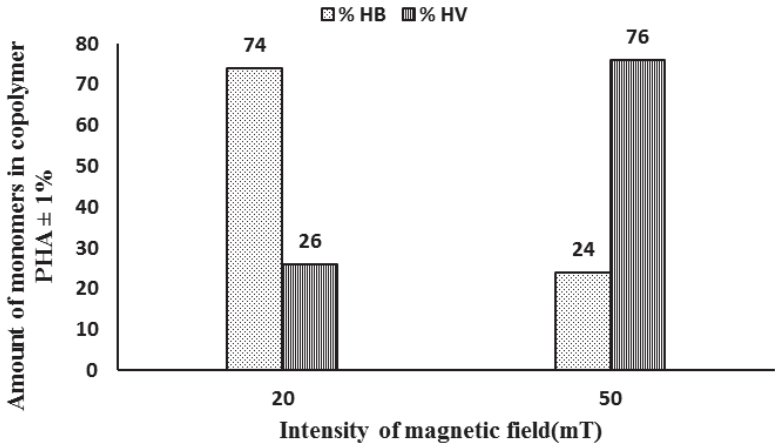

Figure 2. Type and amount of monomers in copolymer PHA

Conclusion

According to the magnetic field effect on the type and amount of monomers in copolymer PHA and the aims of using magnetic field (increasing production of copolymer PHA in comparison with the control sample or increasing production of specific monomer in copolymer, regardless their positive and negative effect on PHA production) recommended that the effect of magnetic field was investigated for every culture separately.

Keywords: activated sludge, aeration time, magnetic field, polyhydroxyalkanoate.

Investigation about Cd (II) Immobility in Contaminated Soils Using Phosphate Fertilizer, Heat, and Lime ($CaCO_3$)

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Introduction

Cadmium is one of the most important environmental pollutants that can be resulted from different ways. It can easily contaminate soil and water resources. Since phosphate ions for stable complexes are available with cations such as Pb and Cd, so it can cause a decrease in the solubility and mobility of heavy metals in soil. Liming is the most widely used treatment that leads to precipitation of the metals as metal–carbonates and significantly decreases the exchangeable fraction of metals in contaminated soils. Temperature is also an important factor in stabilization of heavy metals. Heat causes loss of water and hydration around cations to move them to empty spaces in clay part of soil. The aim of this study was to investigate the effect of heat and lime, and phosphate application on immobilization of Cd in contaminated soil with incubated days.

Materials and methods

Samples of soil were collected from waste mining of Angorane in Zanjan area. After air-dried and homogenized, they were sieved at about <2mm. For stabilization, two levels of lime 0, 5% and 0, 2.5% phosphate fertilizer and mixed of lime (0, 5%), phosphate fertilizer (0, 2.5%) were selected and mixed with 300 gr of soil. Treatments as six different temperatures 25, 200, 400, 600, 700 and 800°C were heated with electrical oven (Shimiran f.47) and loaded in distilled water for different times (7, 30, 60days). At this time, every day the samples were shaken in 15 minutes. Samples were centrifuged for 5 minutes at 2500 rpm and passed through a filter paper and the filtrate concentration of the supernatant was harvested. Cadmium concentration was measured in the supernatant using atomic absorption model (Shimadzu 6600). All analysis of variance and mean comparison were performed using SPSS and MSTATC applications.

Discussion of result

Table 1 showed characteristics of soil samples in the tested soil. The soil was acidic and saline due to the existence of salts of Cd and Pb. The high amount of salts increases the Ionic strength of soil and affects the absorbing processes. It is poor in lime 0% (total $CaCO_3$), so the salts may be sulphate of Cd and Pb. The soil fraction less than <2mm is characterized as silt loam. The result of XRD showed Kaolinate, Ilite and smectite. Total Cd concentration was 225mgkg^{-1} that showed more contaminated soil. Based on the America's environmental protection agency (EPA) standards the allowable limit for the existence of Cd in soil is 3 (mgkg^{-} 1). Thus, concentration of the metal in the soil was standard and introduced as a contaminated soil.

Table 1. Characteristics of sample soil

Total Cd (mg kg^{-1})	CEC (meq100^{-1}g)	pH	Ec (dSm^{-1})	CCE	Clay	Soil Texture
				%		
225	8.6	5.5	20.4	0	23	Salty loam

Statistic analysis

Analysis of variance (ANOVA) indicated that independent effects of heat treatment on the time interval of 7, 30, and 60 days were significant (P<0.001) and the independent impact of factors did not propose any certain meaning by passing the time (Table 2).

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Table 2. Analysis of variance for effects of heat and treatment (phosphate, lime, and time) on desorption of Cd

Source	Df	Mean-square		
		7day	30day	60 day
Heat	5	4463.23***	7292.329***	749.665***
Treatment	3	2788.32***	1015.749*	345.475***
Heat*treatment	15	934.87***	414.153^{ns}	72.979^{ns}
Error	24	116.86	222.455	38.739
CV(%)		8.5	16	13

no significant (ns), significant on the 0.1 (***), significant on the 0.05 (*)

Influence of heat in desorption of Cd

The results indicated that desorption of the Cd depends on the thermal changes and in all of the case studies desorption of Cd have increased by the heat increasement. At 400, 600 and 700℃ more effects can be observed in release of cd. The heat increasement up to 600℃ leads to the increasement of desorption which is significant. But in higher temperatures the decrease of desorption or fixity is not significant in accordance with the samples (Fig. 1). It seems that the heat treatment causes structural changes in the clay minerals and other different minerals. The increase of phosphate may change direction effect of heat at stabilized cadmium.

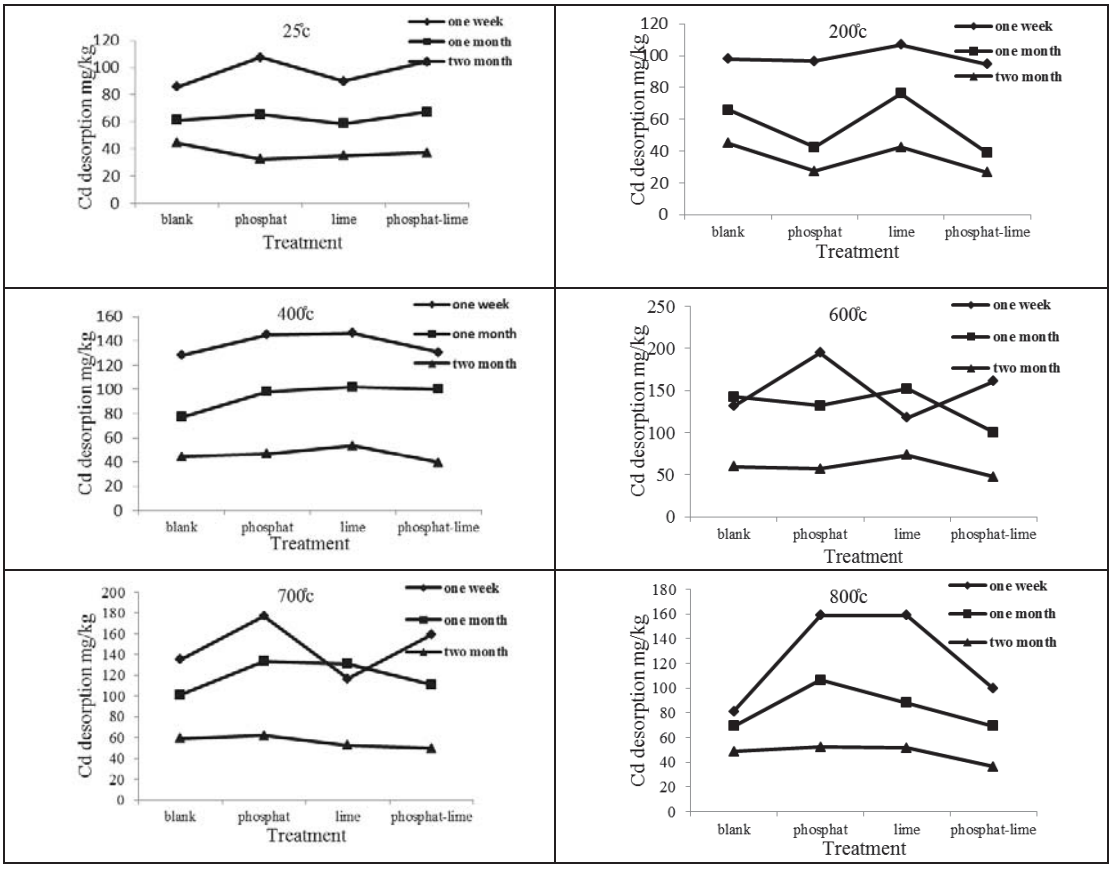

Figure 1. The main effect of heat treatments in desorption of C.

Influence of phosphate fertilizer and lime

The results indicated that application of lime can decrease Cd sorbtion in soil with high salinity. Lime content decreased constantly as the temperature inclined. Loss of carbonates as CO form is the reason that causes the release Cd in heated soil. But phosphate fertilizer application causes the decrease of release Cd in soil sample at $200^{\circ c}$ (Fig. 1). The researchers showed that by increasing phosphate, phosphate ions lead to precipitation of Cd-phosphate. The combined effects of phosphate and lime synergistic mode (Synergism) cause increase in soil pH. Under these conditions an increase in temperature had a lower effect on destruction of structure in clay minerals and stabilization process.

Conclusion

Ione phosphate leads to stabilization of Cd. The increase of temperature causes the change direction effect of phosphate at stabilized cadmium and increased solubility and transport in the soil. Therefore, cadmium gets more stabilized by passing time. Furthermore, use of lime for cadmium stabilization in saline soil appeared to be ineffective but use of phosphate source was effective.

Keywords: Cd, contaminated soil, heat, lime, phosphate, stabilization.

Contamination Assessment of Heavy Metals in Dust of Selected Roads in Karaj, Iran

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Introduction

Air pollution is today a major problem for modern societies. It has long been recognized as a potentially lethal form of pollution. Increasing pollution levels due to rapid urbanization and growth in emission related to vehicular transportation are now caused major concern. The mobilization of heavy metals into the biosphere by human activities has become an important process in the geochemical recycling of these metals. Pollution of the natural environment by heavy metals is a worldwide problem because these metals are indestructible and most of them have toxic effects on living organisms. While some of these elements are essential for humans, at high levels they can also mean toxicological risks. According to numerous studies, the pollution sources of heavy metals in environment are mainly derived from anthropogenic sources. In urban soils and urban road dusts, the anthropogenic sources of heavy metals include traffic emission (vehicle exhaust particles, tire wear particles, weathered street surface particles, brake lining wear particles), industrial emission (power plants, coal combustion, metallurgical industry, auto repair shop, chemical plant, and etc.), domestic emission, weathering of building and pavement surface, atmospheric deposited and so on.

In recent times, studies of air pollution especially in the urban environment have focused largely on road deposited dust. Street dust, particles deposited on road, originates from the interaction of solid, liquid and gaseous materials produced from different sources. Road dusts have been implicated to have the potential to carry a high loading of contaminant species such as heavy metals and organic pollutants. Dust kicked up by vehicles traveling on roads may make up 33% of air pollution. Street dust consists of deposition of vehicle exhausts and industrial exhausts, tire and brake wears, dust from paved roads or potholes, and dust from construction sites. Street dust represents a significant source contributing to the generation and release of particulate matter into the atmosphere. Control of street dust is a significant challenge in urban areas, and also in other spheres with high levels of vehicular traffic upon unsealed roads. It is easily re-suspended back into the atmosphere, where they contribute a significant amount of trace elements. Dust borne heavy metals accumulate in topsoil due to atmospheric deposition by sedimentation, impaction and interception.

Materials and methods

Karaj is as the capital city of Alborz Province in Iran. At the 2011 census, population of the city was 1.9 million, making it the third-largest city in Iran. It is situated 36 km west of Tehran, at the foot of the Alborz Mountains.

Twenty sampling sites were selected for road dust sample collection. The samples were collected from Karaj-Qazvin highway (10 samples), Mallard road (7 samples) and Taleghani Boulevard (3 samples). Karaj-Qazvin highway experiences intense traffic and Mallard road is selected because a power plant is located in 7 km of the road. Taleghani Boulevard was selected for comparing, because it is a road with light traffic and away from any

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industrial activities. At each sampling point, approximately 50 g of road dust particles was collected from three points at the road sides with a brush and transferred into polyethylene tubes for transportation to the laboratory. All the samples were dried at 105 0C for 24 hr to drive out moisture. On cooling each sample was sieved through a sieve of 250 µm diameter. Then, the sieved road dust samples were digested using the milestone Ethos one microwave digestion system. Finally, the total concentrations of Cr, Cu, Ni, Pb, Zn, and Mn were determined by AAS.

The assessment of soil or sediment enrichment can be carried out by many ways. In this work, the index of geoaccumulation (Igeo), Enrichment Factor (EF), Contamination Factor (CF) and Pollution Load Index (PLI) have been applied to assess heavy metals (Cr, Cu, Mn, Ni, Pb and Zn) distribution and contamination in the road dust samples of the various categories of roads in Karaj. The Igeo is used to assess heavy metal contamination in urban soils by comparing current and pre-industrial concentrations. It is also employed in pollution assessment of heavy metals in urban road dust. Geoaccumulation index is computed using the following equation: Igeo = log2 ((Cn) ×1/ 5Bn

Enrichment factor (EF) has been employed for the assessment of contamination in various environmental media by several researchers. Its version was adapted to assess the contamination of various environmental media as follows: EFX = [XS / ES (ref)]/ [XC / EC (ref)]

To assess the extent of contamination of heavy metals in road dust and also provide a measure of the degree of overall contamination along a particular road, contamination factor and pollution load index has been applied. Enrichment Factor (EF) of an element in the studied samples is based on the standardization of a measured element against a reference element. A reference element is often the one characterized by low occurrence variability. In this study, Mn was selected for this purpose. The contamination Factor (CF) and pollution load index parameters are expressed as:

CF = C metal / C background PLI = n√ (CF1 × CF2 × CF3 × ..... CFn)

The results of contamination assessment indices that mentioned above for three roads are showed in Table 1.

Table 1. Enrichment factor, Contamination factor and Geo-accumulation index of heavy metals in urban road dusts in Karaj

location	index	Mn	Pb	Ni	Cu	Zn	Cr
Malard road	EF	-	6.3	1.7	5.2	6.0	0.7
	CF	1.1	7.0	1.8	5.7	6.7	0.8
	Igeo	-0.4	2.2	0.3	1.9	2.2	-0.9
	PLI	2.76					
Karaj-Qazvin freeway	EF	-	13.0	0.7	6.4	9.4	0.6
	CF	1.1	14.5	0.7	7.1	10.6	0.7
	Igeo	-0.4	3.3	-1.0	2.3	2.8	-1.2
	PLI	2.90					
Taleghani boulevard	EF	-	2.9	0.4	3.2	3.6	0.4
	CF	1.3	3.6	0.5	4.0	4.6	0.5
	Igeo	-0.2	1.3	-1.7	1.4	1.6	-1.5
	PLI	1.67					

Discussion and conclusion

The range of heavy metals concentration in road dust samples is as follow: Pb: 48-629 µg/g, Ni: 19-224 µg/g, Cu: 86-271 µg/g , Mn: 609-784 µg/g , Zn: 282-1212 µg/g, Cr: 40-117 µg/g. Heavy metal contents and their possible sources in (The concentrations and sources of the heavy metals) road dust samples collected from the selected roads in Karaj have been examined in this study. Four contamination indices namely, enrichment factor (EF), geo-accumulation index (Igeo), contamination factor (CF) and Pollution Load Index (PLI) were used in the assessment of level of metal contamination in the study area. The Igeo, EF, and CF obtained for Pb, Zn, and Cu in all the roads give an indication of anthropogenic origin. The EF calculated for the elements showed that Cu, Zn, and Pb gave moderate to significant enrichment of the elements in road dust. The computed Index of Igeo

gave values in the range of unpolluted (for Ni, Cr and Mn) to extremely polluted (for Zn, Cu and Pb) indicating the accumulation of Zn, Cu, and Pb from anthropogenic sources. In some stations (m5, m6 and m7) at the Mallard road the concentrations of Cr and Ni were found to be higher than the alert values. It is probably due to industrial activity of the power plant, because the electric utility industry is the number two emitter of nickel and chromium. However, the average concentration of these two elements in all the roads showed that they have low level of pollution.

To compare whether the three roadways suffer contamination or not, the Pollution Load Index (PLI) described earlier was applied. The PLI is aimed at providing a measure of the degree of the overall contamination at all the sampling sites and along the various roadways. The results of the PLI indicated that k1 (Kalak) and m6 (power plant) are the most contaminated site followed by k7(Kalak) and k2 (Fardis) in that order. The results of PLI for all the roads show that the pollution load in Karaj-Qazvin freeway is the highest.

EF, Igeo, and CF values for Pb in Karaj-Qazvin were higher than others. Karaj-Qazvin Freeway is a road with high traffic capacity in vicinity of Karaj. Chen et al attributed this high Pb contamination to the emission of Pb from automobile exhaust and its deposition near highways and roads which has been reported worldwide.

The major industrial source for Zn is smelting. Therefore, zinc used as a vulcanization agent in tires was the most likely source. The source of Cu in street dust was indicated by research as being due to corrosion of metallic parts of cars derived from engine wear, thrust bearing, brushing and bearing metals.

Keywords: air pollution, assessment index, heavy metals, Karaj-Qazvin Freeway, road dust.

Assessment of Sources and Concentration of Metal Contaminants in Marine Sediments of Musa Estuary, Persian Gulf

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Introduction

We can obtain useful information about aquatic systems by studying heavy metals in surface sediments. Marine sediments can bring out the aquatic contamination. Due to heavy metal toxicity, hard biodegradation and easy bioaccumulation in aquatic ecosystems, various indices have been developed such as sediment quality guidelines (SQGs), enrichment factor (EF), pollution load index (I_{POLL}) and index of geo-accumulation (Igeo). Sediment-bound heavy metals may be desorbed from surface sediment and accumulated on fine grained particles which finally move into the depositional. Grain size is an important factor to evaluate heavy metals concentration in the sediment. The recommended size for particles is <63 μm for analysis of sediment contamination. Persian Gulf is a part of Indian Ocean, situated in Southwestern Asia, between longitudes 48°- 56° E and latitudes 24° - 30° N. It is a semi open sea with the area about 40000 m^2 and there are about 400-450 types of fishes. The aim of this study was to determine sediment contaminations and ecological risk assessments in the Musa Estuary. The study area is located in the Northwest of the Persian Gulf and is surrounded by ports, harbors, and large petrochemical industry plants.

Materials and methods

Surface sediment samples were collected in July 2012 from 16 sites in Musa Estuary. Samples were collected using a Zinc-plated Peterson grab. A Teflon spatula was used to extract the sediment samples from the center of grab. After collecting surface sediment samples, they were immediately packed in air-tight pre-labeled polyethylene bags and preserved at 4°C for metal analysis. Grain size fractions less than 63 μm were separated for geochemical analysis. All the sediment samples were gently air-dried at 50°C and then sieved. The sediments were weighted and placed into a Teflon beaker and were digested using 7 mL of aqua-regia (1: 3HCl: HNO_3). The mixture was heated at 95°C for 1 hour, and refluxed for 5-10 min until the brown fumes were no longer visible. After cooling, 5 mL of hydrogen fluoride (HF) were added. Then, the samples refluxed to room temperature. Sediment samples were filtered by Whatman 0.45 μm membrane and brought to 50 mL volume using 1N HCl. The concentration of elements (Al, As, Ba, Co, Cr, Cu, Mn, Ni, Sr and Zn) in sediment samples were determined by inductively coupled plasma atomic emission spectrometry (ICP-AES). Organic matters were measured by recording the Loss on Ignition (LOI) through heating the samples for 4 hours at 450°C in a muffle furnace. Finally, the origination of metals was investigated. In this study, we used single step chemical extraction. About 2 gr of each sediment sample was placed into a Meyer flask, and mixed with 15 mL of 1N HCl. Sample bottles were shaken for 30 minutes by a shaker. Then, they were filtered by Whatman 0.45 μm membrane and brought to 50 mL volume using 1N HCl. Concentration of metals of Al, As, Ba, Co, Cr, Cu, Mn, Ni, Sr, and Zn in sediment samples were determined by ICP-AES. In accordance to the quality assurance program, procedural blanks, duplicates and MESS-1, standard sediment samples were run alongside the other sediment samples. The accuracy of analysis was about ±4% for all elements. Pollution assessment and evaluation were carried out using several techniques including Enrichment factor (EF), Geo-accumulation index (Igeo), Pollution index (I_{POLL}), and Effective range median (ERM).

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Table 1. Elemental concentration and organic contents (LOI) of surface sediments in Musa Estuary

	As	Ba	Co	Cr	Cu	Mn	Ni	Sr	Zn	Al	LOI
	mg/kg									٪	
Min	6.3	40	1.3	34	14	273	49	289	57	0.76	2.83
Max	26.2	82	6.1	48	58	415	70	501	145	1.20	6.54
Mean	10.5	56	3.0	43	22	351	62	380	93	1.01	4.49
SD	5.1	10	1.2	4	10	33	6	45	26	0.13	1.12
Meancrust	1.5	330	20.0	35	50	850	80	465	75	8.10	–

Results and discussion

According to table 1, there is a significant difference between mean concentration of Al and the correspondent mean crust. The organic contents range from minimum 2.83 to maximum 6.54% with a mean value of 4.49%. The results revealed that the concentration of As is between 6.3 and 2.6 mg/kg with the mean value of 10.5 mg/kg. The maximum concentration of As was found at the station 13. Cu ranges from 14 to 58 mg/kg with a mean value of 22 mg/kg. The maximum, minimum, and mean concentrations of Co are 6.1, 1.3 and 3 mg/kg, respectively. EF is a useful index to differentiate between anthropogenic influences and those from natural procedures. The EF of all elements can be calculated using the following equation.

$$EF = ([(M_c)/(M_r)]_s)/([(M_c)/(M_r)]_b) \quad (1)$$

Where, Mc is the concentration of metals, Mr is the concentration of reference elements, s is the studied sample, and b indicates the background. The obtained mean EF values for various metals were between the minimal enrichment and extremely high enrichment. The maximum mean EF value belongs to As (As=42.6) indicating extremely high enrichment, and also the minimum mean EF value is seen for Co (Co=1.2) showing minimal enrichment. In order to determine the degree of contamination in each sediment sample, Igeo index values are calculated using the following equation:

$$I_{geo} = \log_2\left(\frac{C_n}{1.5B_n}\right) \quad (2)$$

Where, Cn is the content of metals in sediment samples, and Bn is the geochemical background concentration for each element. Muller's formula was modified as follows:

$$I_{POLL} = \log_2\left(\frac{B_n}{L_p}\right) \quad (3)$$

Where, Bn and Lp represent bulk concentration and lithogenous portion, respectively. The Igeo index and the Pollution index have seven classes. The results show the limitation of Igeo index in the assessment of pollution. A considerable amount of Cu and Cr were found in the lithogenous portion. The results of Chemical partitioning studies have revealed the arrangement of natural portions for the metals as follows: Cu(96%) > Cr(43%) > Co(34%) > Sr(33%) > Ni(31%) > Mn(24%) > Zn(19%). The values obtained from Ipoll index are indicative of a broad range (from no pollution to strong pollution) for various studied elements. Cluster analysis (CA) is a statistical method which identifies the group of samples that behave similarly or show a significant relationship between different clusters.

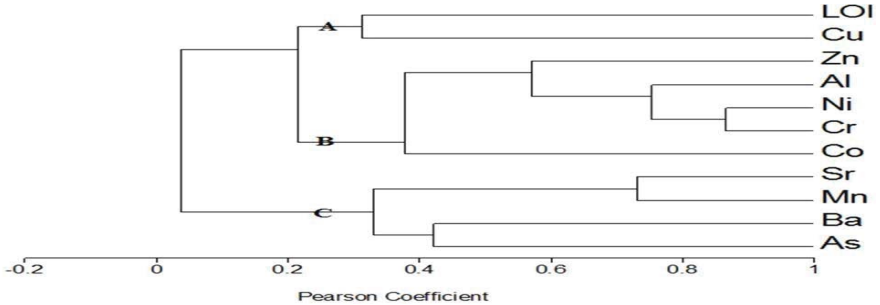

Figure 1. Dendrogram showing clustering of metals and LOI

Based on dendrogram, three distinct clusters are identifiable: (A) LOI-Cu, (B) Co-Zn-Al-Cr-Ni, and (C) As-Ba-Mn-Sr. The cluster analysis revealed that Ni joined to Cr by high similarity coefficient which indicates that Cr could be originated from oil sources. Dendrogram also shows that a part of Cr and Ni are derived from lithogenous source as they are linked to Al. Pearson coefficient amongst Zn, Al, and Ni shows that Zn is probably originated from both lithogenous and oil sources. Sr and Mn joined together with a relatively high coefficient that is indicative of a common source. Since LOI is linked with the other clusters at an insignificant level, it can be inferred that the organic contents do not play a major role in elemental concentrations. In order to consider the possible additive toxicity effects of the combined toxicant groups in different concentration, mean SQG quotients were calculated as follows:

$$m - ERM - Q = \sum \frac{C_i / BRM_i}{n} \quad (4)$$

Where, Ci is the sediment concentration of compound i, ERMi is the respective Effect Range Median for compound i and n is the number of compound i. Based on the classification of metals contamination, all sediment samples can be categorized as medium-low priority sites with 30% probability of toxicity.

Conclusion

The mean enrichment factor values for various metals were between minimal and extremely high enrichment. The maximum mean EF value was for As (As=42.6) showing the extremely high enrichment, and also the minimum mean EF value was for Co (Co=1.2) indicating the minimal enrichment. The unpolluted I_{geo} designation is obviously not confirmed by the other methods for calculating the metal pollution impact in Musa Estuary. A considerable amount of Cu and Cr was found in lithogenous portion. The results of partitioning studies revealed that the arrangement of anthropogenic portions for the metals are as follows: Cu (96%) > Cr(43%) > Co(34%) > Sr(33%) > Ni(31%) > Mn(24%) > Zn(19%). The CA revealed that Ni joined to Cr by high similarity coefficients, which is indicative of oil origin for these two elements.

Keywords: chemical partitioning, cluster analysis, metal pollution, Persian Gulf sediment contamination.

Spatial and Temporal Distribution of Heavy Metals Concentration in Atmospheric Dust in Kerman City

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Introduction

Atmosphere health is an important environmental issue and air pollution is not a local problem in a given area of the world. Particles produced by either humans or the nature enter the atmosphere and return the Earth's surface at local, regional, or global scales after physico-chemical interactions. According to the reports by WHO, each year 2.4 million people lose their lives worldwide due to air pollution. In recent decades, numerous investigations have been carried out on the status of heavy metals in atmospheric dust. This is mainly due to their importance and also impacts on the environment and humans. Heavy metals present in water, air, dust, soil, and sediments play an important role in human life.

Not much information is available on the concentration of heavy metals in atmospheric dust and the total inputs of heavy metals from atmospheric deposition to the urban area of the Kerman city. Therefore, the objective of this research was to evaluate the rate and spatial and temporal variability of selected heavy metals in atmospheric dust of Kerman City.

Materials and methods

This study was carried out in the urban area of Kerman City having an area about 13100 km^2. Kerman is an important industrial city where a lot of industries and mines including Jalalabad iron ore, Zarand coal mine, Barez tire producing plant, Kerman cement factory, Sarcheshmeh copper mine, and Momtazin cement production company. They are actively functioning in the area.

To collect dust samples and investigate heavy metals, dust collectors were set up at 35 different locations distributed in the city. Dust samples were taken monthly from April 20 to November 20, 2012. To compare the concentration of heavy metals in dust with that of soils in the region, 60 surface soil samples (0-10 cm) were also taken along 3 different transects including Kerman Rafsanjan, Kerman-Zarand and Kerman-Mahan. Besides, 35 surface soil samples were collected from Kerman urban area. The concentration of major heavy metals was determined in all the dust and soil samples using an atomic absorption spectrometer following digestion with 6N HNO_3.

Results and discussion

Statistical description of the concentration of heavy metals indicated that the concentration of metals in dust followed the order of Mn>Zn>Cu>Pb>Ni. The results also showed that, with exception of Ni and Mn, the concentration of the heavy metals decreased as the temperature increased. There was a significant correlation among Cu, Pb, and Zn and also Cu, Mn, and Ni concentrations suggesting two different sources for heavy metals. The calculation of total heavy metals entered the soil through dust deposition indicated that the highest rate of heavy metal deposition occurred in April as well as in September when the activity of polluting sources restarted due to changes in climate.

The results also indicated that the total concentration of the heavy metals in urban soils was much higher than that of the rural soils. Furthermore, the concentration of heavy metals in dust was very much higher than that of the soils studied. In addition to natural parameters, anthropogenic sources seem to have greatly influenced the status of heavy metals in atmospheric deposition in the city.

The spatial distribution patterns of dust heavy metals (Fig. 1) indicate that the concentration of Cu, Zn, and Pb follow the same spatial distribution which is different from that of Ni and Mn. Therefore, it can be concluded that the source of these two groups of heavy metals in atmospheric dust is different. Besides, the concentration of the heavy metals in dust is higher in the western part of Kerman city as compared with the east of the city.

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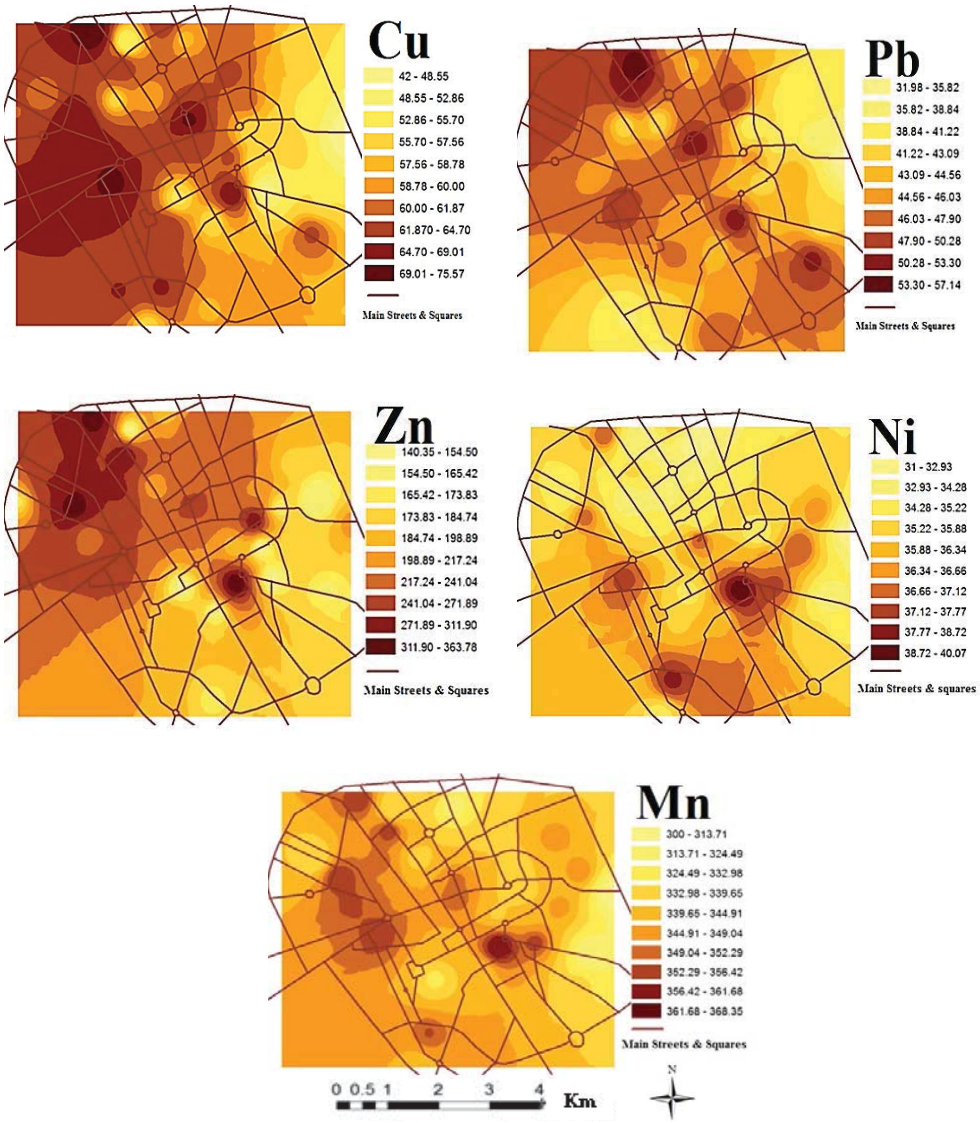

Figure 1. Maps showing the spatial variability of mean heavy metals concentration (mg/kg) in atmospheric dust in Kerman during the 7 months studied.

The comparison of dust heavy metals concentration and rates of deposition in Kerman have been compared with those of other areas of the world in Table 1. The results clearly show that the amount of heavy metals deposited through dust in the study area is very much higher than that of the European and industrial countries. This is mainly due to higher dust deposition rate as well as more polluted dust in Kerman. Table 1 also indicates that atmospheric dust in Kerman is less polluted as compared with other industrial cities in Iran such as Isfahan and Zanjan.

Table 1. The deposition rate and the concentration of heavy metals in dust from Kerman city (current study) as compared with findings from other areas in Iran and the world.

Area	Unit	Ni	Zn	Pb	Cu	Mn
Zanjan	g ha^{-1} yr^{-1}	ND	299.3	1043.9	ND	ND
Isfahan	g ha^{-1} yr^{-1}	79.8	453.8	220.3	67.1	520.6
England	g ha^{-1} yr^{-1}	16	221	54	57	ND
Europe(Average)	g ha^{-1} yr^{-1}	10	227	38	34	ND
Virginia(USA)	g ha^{-1} yr^{-1}	2.4	41	4.4	7	20
Kerman	**g ha^{-1} yr^{-1}**	**36.8**	**356**	**47**	**62.4**	**223.5**
	mg kg^{-1}	**35.5**	**214.4**	**45**	**60.4**	**341.8**
Saudi Arabia	mg kg^{-1}	26	141.8	66.8	36.4	318.9
Isfahan	mg kg^{-1}	82.2	470.3	223.5	71	540
India (Industrial area)	mg kg^{-1}	78.4	706.6	54.7	215.5	1384
Mazowieckie	mg kg^{-1}	40	4443.3	576.9	521.6	29.5

ND: Not detected

Conclusions

This investigation shows that human activities around the study area have caused a great degradation of soil, which in turn, resulted in a high rate of dust deposition in urban areas of Kerman. Among the heavy metals studied, Pb, Zn, and Cu in dust appear to have been derived from the same source, mostly anthropogenic activities. In contrast, other heavy metals, namely Ni and Mn, seems to have been mostly originated from natural sources mostly the erosion of barren agricultural and desert soils in the area. To reduce the risk of air pollution in populated urban areas in Kerman, it is necessary to establish less contaminating industries. Besides, more attention has to be paid to control wind erosion of barren soils in the region.

Keywords: air pollution, dust, heavy metals, Kerman.

Spatial-Temporal Analysis of Dust Storm Occurrence in West of IRAN

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Introduction

Earth has ever been exposed to environmental hazards. The hazards are continually occurring in the world in the recent years. Among them, atmospheric elements have created many human and financial losses in different regions.

One of the hazards is dust events and in its severe case is dust storm. It happens more frequently in arid and semiarid regions in deserts and their surrounding areas. Dust events is a natural phenomenon occurring in regions that have large parts of arid and desert regions, devoid of vegetation cover and other surface coatings areas. Lengthy periods of drought and principle of non-interference in nature may be the cause of this phenomenon. In addition to reducing the horizontal sight and ist effects, e.g., traffic issues, it has also many environmental impacts especially on human health. Dust storms can cause transport accidents. Perhaps more importantly, dust emissions from dried lake basins introduce fine particles, salts, and chemicals into the atmosphere, with a suite of health impacts, including not only respiratory complaints, but also other serious illnesses. They can also lead to particulate levels that exceed internationally recommended levels and transport allergens including bacteria and fungi.

In the recent years, dust storms in western part of Iran have caused various problems for people. The main objectives of this study are to monitor and assess the spatial and temporal distribution of the storms over the western of Iran during the last two decades.

Data and case study area: The data for the analysis are including statistical data of dust (taken from Meteorological Organization) in daily basis during the 8-hour observation in period of twenty years (1989-2008). Up to 26 stations in the western portion of Iran with appropriate distribution have been selected (Arak, Ardebil, Oroomieh, Western Islamabad, Omidiyeh, Ahvaz, Ilam, Abadan, ParsAbad, Tabriz, KhorramAbad, Khorramdareh, Khoy, Dezful, Dehloran, Zanjan, Saghez, Sanandaj, Shahrekord, Qazvin, Kermanshah, Makoo, Mianeh, Hamadan, Hamadan Nozheh, Yasooj).

Materials and methods

Reviewing the existence trend in the data has been studied in two forms of spatial and temporal. To investigate the spatial trend in data Trend Analysis in ArcMap10 application has been used. To achieve this, annual and monthly frequency and dust mean in all studied stations have been examined in relation to latitude and longitude.

Several methods have been proposed for the study of time trend in the panel data. It can be classified into parametric (t, trend analysis) and nonparametric (Mann-Kendall, *Kendall's Tau* Spearman coefficient and Sen's trend Tests) methods. Accordingly, the first step to choose an appropriate parametric and nonparametric method is awareness of the normal distribution of data. In this regard, the normality of the data is investigated based on Kolmogorov - Smirnov test (K-S test).

Kendall's Tau correlation coefficients for all pairs, i=1,2,…n,(x_i,y_i), can be calculated using the following algorithm. In comparison pairs (x_i,y_i) with (x_i,y_i) hold for every i and j, if $x_i > x_{j \text{ and } yi > yj}$. So, $y_i < y_j$ and $x_i < x_j$, are called isotones pairs, otherwise called no isotones. Then, the number of isotones pairs (n_{dis}) and no isotones pairs (n_{con}) are counted for all paired comparisons and Kendall's tau correlation coefficient is calculated from the following equation:

$$r_{kt} = \frac{n_{con} - n_{dis}}{\frac{1}{2}n(n-1)}$$

Mann Kendall theoretical basis according to the logic of Kendall's tau was recommended for reviewing the existence of the linear and nonlinear trends in the most technical reports. For this test, the comparison is limited

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to the desired time series. The first step is a ranking of the time series. It is assumed y_t are values of the time series rank. In the first step, regarding to the first observation, it is compared with x_tt= 2,3, …, n sequence comparison. In other words, comparison is done n-1 times that it can be displayed with n_1. In the next step, y_2 is compared with all x_t, t=3,4,…,n sequences . In other words, it is compared, n-2 times, showing this time with n_2, that continue one times to comparison of y_{n-1} to y_n. In comparison for each i<j, then $y_{i>}y_j$, is added one unit to n_i.

Then, Kendall statistic is calculated from the following equation:

$$T_{mk} = \sum_{k=1}^{n-1} n_k$$

For n larger than 40, the central limit theorem can be used. Expected value and variance T_{mk} are calculated using the following equations:

$$E(T_{mk}) = \frac{n(n-1)}{4}$$

$$Var(T_{mk}) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{i=1}^{ne} e_i(e_i-1)(2e_i+5) \right]$$

Where the n, is the group number which have the same rank and e_i is the same level of data in each group.

The U_{mk} statistic obtain statistic as the following equation, with a normal distribution.

$$U_{mk} = \frac{T_{mk} - E(T_{mk})}{\sqrt{Var}(T_{mk})}$$

If the relation $|U_{mk}| > Z_{(1-\frac{a}{2})}$ is satisfied, ascending and descending trend is rejected at the significant level α, in which $Z_{(1-a/2)}$obtains from normal destribution table and relates to $\propto$ Significant level. Also if $U_{mx} > 0$ or $U_{mk} < 0$, the trend is ascending or descending, respectively.

Results

The spatial trend in data analysis was examined using the frequency and mean of dust in all examined stations annually and monthly because of the similarity of graphs. Fixing the spatial trend in the data (annual, seasonal and monthly) can indicate that the sources of dust which enter to west part of the country are constant. Dust events have increasing trend from north to south and from West to East, increases primarily and then decreases again.

Normality of data was evaluated based on Kolmogorov - Smirnov test (KS test). Because the significant rate in the raw data is less than 005/0, so we can assume H0 (the data have normal distribution) with the maximum reliability 995/0 is rejected versus H1 (data have no normal distribution).

This can be concluded that there is not available sufficient evidence to accept the normality of the data and it can be accepted that the data were not normally distributed. The trends of significance in dust data were investigated by Mann Kendall test for existing stations in annual, seasonal, and monthly periods and determined that some of the stations have descending trend and others ascending. Comparison of the P-Value obtained from the tests with a critical level of 05/0 and 01/0 revealed significant at a confidence level of 95% and 99%.

In this study, time displacements of the dust events in the studied stations were to be analyzed. To achieve this goal, for each station dust events were gathered monthly and then the month with the most occurrence of the events was determined for every year. For example, the Arak station, illustrated the most dust occurrence in 1989 in the fifth and seventh months (May-July) or the most incidence has been recorded in sixth month (June) in 2008 for Yasouj station. For revealing the months with the peak occurrence of dust in each station, time series for each station were created during the period 1989 to 2008. Plotting the corresponding number for each month against the time of occurrence for each station created scatter plot. In this plot, line fitting with equation of the first degree revealed how is the change trend of dust occurrence. Significant results of this research, for determining the temporal changes for each station showed thatthe month with the maximum dust occurrence has been shifted towards warm or cold months over time. The review divided the studied stations into three groups. The first group indicates the maximum displacement of maximum dust to the warm months, The second group represents the displacement less than a month for the maximum dust.Finally, the third group represents displacement to the colder months.

Conclusion

Analyzing the spatial data trend indicates that the dust data in the studied stations have a north - south trend with linear increase while along the west to east it follows second degree polynomial function (curve with an arc). This indicates that frequency of dust is increasing from west to east and then it has been observedto reduce in the east of the region. It seems that the altitude exposure along the north to south particularly, Zagros Mountains on the path of dust progress has been caused this situation. Constant behavior of the spatial trend for dust frequency in monthly, seasonal and annual scales indicate no change in the dust source entry to the studied region. In other words, the origin and time arrival of dust to studied region have particular order.

Time trend of the dust frequency was reviewed in three monthly, quarterly, and annual scales. Significant ascending trend (with 95% confidence level) were observed at Arak, Oroomieh, Western Islamabad, Omidiyeh, Tabriz, Khorramabad, and Sanandaj stations in both monthly and seasonal time scales. However, only two stations (Arak and Khorramabad) have significant ascending trend in an annual scale. In the two stations, Khorramdareh and Qazvinwere also observed in descending trend in dust occurrence frequency with a confidence level of 95% in all time scales.

It was found that the maximum frequency of dust occurrence in some stations (Yasooj, Qazvin, Sanandaj, Khorram Abad and Arak) have been shifted to the warm months and in others (Ardebil, Oroomieh, Abadan, Ahvaz, ParsAbad, Tabriz, Khorramdareh, Khoy, Dezful, Dehloran, Zanjan, Saghez, Shahrekord, Kermanshah, and Hamadan) to cold months. In some stations (Ilam, Omidiyeh, Makoo, Western Islamabad, and Mianeh) there was no significant movement.

Keywords: dust storm, Mann-Kendall, spatial analysis, trend analysis, west of Iran.

Investigation of Flooding and Causative Factors in Balegli Chay Watershed by GIS, RS, and AHP Techniques

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Introduction

Floods are major disasters worldwide that causes serious damage to agriculture, fisheries, housing and infrastructure. They can also disrupt socio-economic activities. As the severity and frequency of flood events have considerably increased, there is a growing global concern about the need to decrease flood related fatalities and associated economic losses. Just in 2010, 178 million people were affected by floods and the total financial losses in the exceptional years such as 1998 and 2010 exceeded $40 billion. This study has presented an exhaustive methodology of using Geographical Information System (GIS), Satellite imagery interpretation, Rain gauge station data and Analytical Hierarchy Process (AHP) method of flood hazard mapping for surveying flood hazard in Balegli Chay Watershed and sub-basins. The study area is located in the northwest of Iran, in the west of Ardabil and east of Azerbaijan Sharghi provinces where the Balegli Chay is located**.** This river is one of the most important rivers in the Azerbaijan, because its sub-watershed is one of the vulnerable areas to flood damages. Also this river passes through the middle of the Ardabil City where there are many communication lines, infrastructure, and recreation areas next to this river. The Balegli Chay Watershed is one of Garasu sub-basins, which is drained from Alborz mountain range. This basin has an area about 1036 km2 in the upstream of PolehAlmas hydrometer station. High Mountain ranges and harsh slope changes at the foot of mountains create special hydro-geomorphical characteristics for the watershed and due to these characteristics, risk of flooding is high. The Savalan Mountain with 4811 meters elevation is located in the northwest. A flat plain that called Ardabil plain with 1432 meters elevation is located in the middle parts and downstream of the Balegli Chay Basin. The average elevation of the study area is 2014 meters above mean sea level (M.S.L) and ranging from 1424 to 4811 meters above M.S.L.

In this study, flood hazard map was created based on the integrated effects of physical and climatic factors. First, eight physical factors including size of sub-basin, slope, aspect, time of concentration, drainage density, bifurcation ratio, Miller Coefficient, curve number and two climatic factors including annual rainfall and the maximum daily rainfall were used to produce the flood hazard map. ArcGIS application was used to produce layers of the factors, along with the spatial conditions of the study area obtained by field investigation and satellite images.

Materials and methods

In order to determine weights of causative factors, AHP method based on the data collected from expert responses by questionnaire has been adopted in this research to quantify the weights given to each component and subcomponent. The pairwise comparison matrix makes pairwise comparisons of the criteria. This method applies basic scale with 1 to 9 values to determine the extent of relative priorities of two criteria. Weighted linear combination method (WLC) is the most common technique in analyzing the multi-scale evaluation. In this method, decision making principle calculated the value of each A_i option by equation 1:

$$A_i = \sum_{j=1}^{n} W_j \times X_{ij} \quad (1)$$

where, W_j is weight of j criterion; X_{ij} is a value asigned in place i in relation to j criterion. In other words, this

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value can indicate appropriate degree of i in relation to j criterion; n is total number of criteria and A_j is a value which finally will attach to i location.

Saaty considered consistency tests for pair evaluation, including Consistency Index (C.I.) and Consistency Ratio (C.R.) (Eq. 2 and 3).

$$C.I. = \frac{\lambda_{max} - n}{n - 1} \quad (2)$$

$$C.R. = \frac{C.I.}{R.I.} \quad (3)$$

Where, λ_{max} is the maximum eigenvalue of the matrix, n is the matrix rank, and R.I. (Random Index) is the consistency index of the random matrix.

Saaty regarded the comparison being randomly generated when the C.R. approached 1 and the consistency being higher when C.R. approached 0. In general, C.R. ≤ 0.1 was considered acceptable, while C.R. > 0.1 showed the inconsistency and they had to be re-compared. Expert Choice software was used to analyze the numerical values of inundation factors. With the input values in pairwise comparison and weights calculated, consistency ratio (CR) was found as 0.08. This indicated a reasonable level of consistency in the pairwise comparison of the factors. After calculating the weight among factors in the hierarchies, the weight of the overall hierarchy should also be calculated. The weights acquired by AHP were linked to the shacks as attribute data in the ArcGIS.

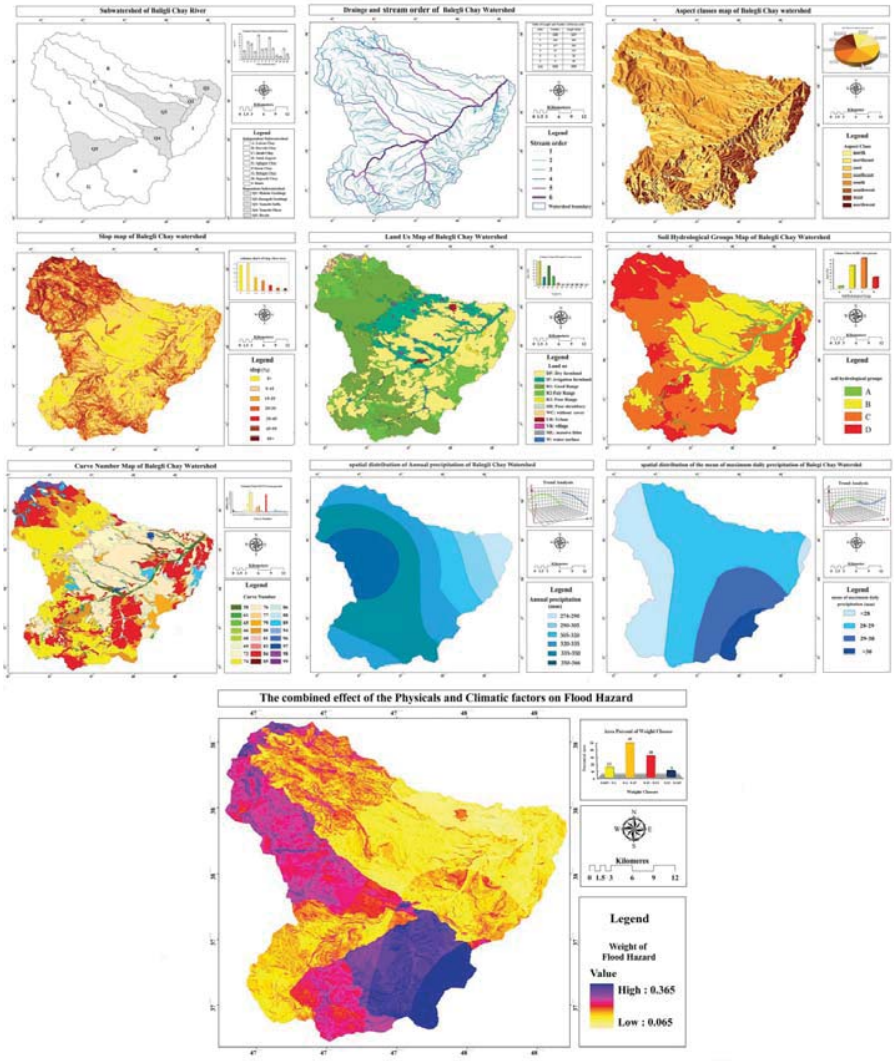

Figure 1. Produced layers in ArcGIS and flooding Weight map of Balegli Chay Watershed

The total weights of every contributing factor were calculated by AHP. The maps of all factors were overlaid in ArcGIS to create raster maps of flood vulnerable areas with 10*10 meters cell size. The pixels with the highest weights in each raster indicate high flood hazard risk areas. Finally, the combined map shows that the areas with higher pixel values are more susceptible to flooding.

Results and discussion

The produced layers of flooding factors in ArcGIS and flooding weight map of Balegli Chay Watershed are shown in Figure1. The results show that in south and northeast of the study area, influence of these factors are very high whereas, in the middle and outlet parts of the watershed it is slight.

Conclusion

According to the results it can be indicated that the Sagezchi Chay (H) sub-basins in the south of the watershed is in the first rank in term of flood occurrence. In contrast, sub-watershed of Latran Chay (A) in the east of the watershed is in the lowest rank of flooding. These results are greatly dependent on combined and integrated effectiveness of physical and climatic factors on flood production. The results of such studies are quite helpful in flood control projects and assessment of the causative factors on flooding in the watershed for more efficient management practices.

Keywords: AHP, Balegli Chay, curve number, flooding, GIS.

Green Tax: a Factor which Has Been Neglected in Industrial Planning of Iran

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Introduction

The environmental issues have been considered in all development plans of Iran. For example, the forty-fifth, forty-seventh, and fiftieth principles of "Iran Constitution" directly refer to environmental issues. According to the future outlook of the Islamic Republic of Iran "having the favorable living environment" is regarded as the characteristics of the Iranian society in the horizon of the next two decades. The environmental issues have also been considered in the economic development plans of Iran. In the thirteenth waver of the First Development Plan Act, factories and workshops are required to provide the necessary equipments and facilities to prevent the environmental pollution. In the Second Development Plan Act, the eighty-one, eighty-two, and eighty-three wavers are explicitly dedicated to environmental issues. The Third Development Plan Act has a new approach to the environmental issues. This Act can be considered as a turning point in the environmental policy because in this plan a separate section is allocated to the environmental issues. Also, the second part of the Fourth Development Plan Act is allocated to the environment issues which include four articles. In the Fifth Development Plan Act, a separate part is allocated to the environment which includes seven articles. Summily, the importance of environmental issues has increased in documents and laws of Iran.

Despite the importance of the environment in the documents and laws of the Islamic Republic of Iran, emphasis on the production and creating the added value is considered in the first place but, the effect of additional products or added value on the environment is a factor that has been almost forgotten. The expansion of pollution in the industrial areas is important evidence to this claim. In fact, the added value resulted in pollution due to increased industrial production cannot be considered as a true value because the share of the imposed costs to the environment due to the created value added is ignored. Accordingly, the employment, added value and profitability alone are not a factor for determining investment priorities.Therefore, it is also necessary to consider the costs of environmental degradation in the industrial planning and to obtain green tax for reconstruction of environment. Accordingly, this paper attempts to examine the relationship between profitability and industrial air pollution in Iran to introduce a tax base for environmental taxes.

Materials and methods

To determine the relationship between emissions and profitability of manufacturing industries we used two different methods. In the first approach, the industrial pollution and profitability are calculated. To calculate the industrial pollution, the data on six fuels consumption in the industrial sector include Kerosene, Natural Gas, Liquid Petroleum Gas (LPG), Diesel, Gasoline and Fuel Oil. Data for this consumption were collected from the statistical center of Iran for 2005. The results of the calculation showed that the highest consumption of fossil fuels in Iranian manufacturing industries was related to Natural Gas, Fuel Oil, and Gasoline, in order. Then, the emission coefficients for these three major pollutant fuels were obtained from the Iranian Department of Environment. Emission coefficients are collected based on six pollutants caused by combustion of fossil fuels. These are including Sulfur oxides (SOx), nitrogen oxides (NOx), carbon monoxide (CO), carbon dioxide (CO2), suspended particulate materials (SPM), and hydrocarbons (HC). Thus, the emissions from fossil fuels have been calculated using the amount of consumptions and emission coefficients of the fossil fuels. To determine the profitability of manufacturing industries, many indices were introduced in the literature in this area. In this study, the price cost margin index is used to calculate profitability. After evaluation of industrial pollution and profitability, the manufacturing industries are ranked into two groups using numerical taxonomy method and

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based on the degree of emission: clean, highly clean and, highly polluting and polluting groups. Then, the average profitability for each group is calculated separately. According to the second approach, the relationship between industrial pollution and the profitability will be examined using panel data regression model. Therefore, the following equation is used to investigate the relationship between air pollution and profitability:

$$PCMi,t = ai + \beta\ Polli,t + \varepsilon i,t$$

where, i and t represent the number of industries and the research period (2000-2005), respectively. ai is intercept, β indicates model coefficient and εi, t is residual term.

Results

In the first stage, the industries were divided into two groups. Hence, the average of profitability was calculated for each group. The results show that there is a significant difference between the levels of pollution and profitability between the two groups, so that these differences are more apparent in the final years of the period. According to the second approach, there is a significant positive relationship between the amounts of industrial pollutions and profitability of manufacturing industries during 2000-2005.

Conclusions

The environmental protection, especially in the recent decades has been considered as an important issue. The green tax can be used as a control instrument by governments to perform this task. Thus introducing a tax base is important for green tax. This study attempts to identify the relationship between industrial pollution and profitability of manufacturing industries to provide a basis for determining green tax. To do this, two approaches were used. In the first approach to determine the relationship between air pollution and profitability of manufacturing industries, the levels of pollution were calculated based on the emission coefficients of three major industrial pollutant fuels. PThen, the industries were ranked into highly clean-clean and highly polluting-polluting groups using numerical taxonomy method. Then, the profitability of manufacturing industries was evaluated using the PCM index. The average of profitability was also determined for each group. The results show that there are significant differences of profitability between the two groups, so the average profitability for highly polluting and polluting group is more than that in the other group.

The second approach is based on the relationship between industrial air pollution and profitability using panel data method. This confirms the results of the first approach. The results show that there is a significant positive relationship between the degree of polluting and profitability, the coefficient model is equal to 0.0638. It means that one percent increase in industrial pollution leads to increase in the profitability by 6.38 percent. Therefore, the results of the two approaches confirm the existence of a positive relationship between profitability and industrial pollution during 2000-2005. Hence, it can be expected that a portion of the profitability is achieved by more pollution, not due to better performance of the industries. Therefore, according to the results of this study, the profitability of manufacturing industries can be considered as a basis to determine the green tax rate.The results of this study can also be used as a key issue for future studies.

Keywords: environment, green tax, industrial emission, Iranian manufacturing industries.

Impact of Carbon Tax and Fossil Fuel Price on Long-term Develeopment of Iranian Electricity Supply System

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Introduction

Despite the abundant renewable energy sources, the Iranian energy sector relies almost entirely on fossil fuel energy resources. Power sector is dominant source of CO_2 emissions and responsible for about 35% of total CO_2 emissions in the country. Additionally, long-term electricity demand of Iran is expected to grow quickly, which in turn requires extensive investment to meet the growing demand over the next decades. On the other hand, increasing domestic fossil fuel consumption had been a serious challenge due to high costs of oil and gas. Current study pays particular attention to the possible penetration rates of renewable electricity technologies and their implications for fossil fuel consumption and CO_2 emissions. The analysis is performed by using an energy supply optimization model. Different scenarios are defined to evaluate the impact of fossil fuel prices and carbon tax on utilization of renewable resources.

Materials and methods

Model for Energy Supply Strategy Alternatives and their General Environmental Impacts (MESSAGE) is applied in this study as a mathematical programming tool. MESSAGE is a multi-objective optimization model used for energy system planning, energy policy analysis, and scenario development over medium to long-term periods. MESSAGE was originally developed at International Institute for Applied Systems Analysis (IIASA) and the International Atomic Energy Agency (IAEA) added a user-interface to facilitate its application. In this methodology, the performance of a special technology is compared with its alternatives on a life cycle basis to identify how much of the available technologies should be expanded to meet the future energy demands.

Reference energy system for Iranian power sector

Reference energy system represents the structure of power system depicting energy chains, electricity generation technologies, resources required to meet electricity demand, and energy levels. At the resource level, natural gas, petroleum products, hydrogen, nuclear fuel, thermal coal and different renewable energy resources including hydropower, wind, solar, geothermal, and biomass can be mentioned. Conversion level consists of various conventional and advanced thermal power plants and different renewable electricity technologies for centralized power generation. In addition, some distributed generation (DG) technologies are also considered for on-site generation of electricity. Imports and exports of electricity are modeled at the transmission level.

Data and Scenarios

The required data and the main assumptions for the Iranian power sector are presented in this section. Different scenarios are then defined to determine the appropriate technology options and to quantify the implications of renewables' contribution to fuel consumption and CO_2 emissions. The main assumptions of the different scenarios are as follows:

- **Reference Scenario:** This scenario refers to business-as-usual situation describing the development of power sector with constant fuel price level over the projected period.

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- **High fuel price scenario:** we assume a rising trend for fossil fuel prices which are consistent with those developed by U.S. Energy Information Administration**.**
- **Carbon tax scenario:** Fuel price is assumed to be the same as high fuel price scenario and a rising trend for carbon tax is used in this scenario from 8 $/tonne carbon at the base year to 50 $/tonne at the end of the study period.

Results

Natural gas combined cycle power plant holds the largest contribution almost in all conditions over the period of study, as it may reduce the investment cost of electricity supply system and benefit from the higher energy efficiency. Hydropower is one of the leading power generation technologies of the future. The total amount of hydropower generation will increase continuously until the limit of its exploitation is reached. Operation of gas turbines will also be attractive due to the technical possibilities of plants in terms of adjusting power level to meet the peak load demand. However, in a longer term perspective, the maximum potential of generation from pumped-storage hydropower is fully exploited and the share of gas turbine may be reduced.

A gradual change is seen in the power system structure over a short to medium-term period in the high fuel price scenario. Combined cycle power plants increases at a descending rate. In the long-term, the generation is characterized with the application of wind turbines and solar photovoltaic systems. Carbon price in carbon tax scenario accelerate the employment of renewable energies. The contribution of renewables to electricity generation in 2045 will reach to 10%, 20%, and 35% of total generation in the reference, high fuel price, and carbon tax scenarios, respectively. When there is no carbon tax, advanced coal power plants will be competitive, due to the assumed coal-to-gas fuel price ratio and their costs applied.

The fuel consumption is slowed down in the alternative scenarios by deployment of renewable energies (24-42% reduction compared to the reference case in 2045). In the reference scenario, total emission reaches 217 million tonnes in 2045. In the alternative scenarios, between 38 to 93 million tonnes of carbon dioxide per year could be avoided compared with the reference case by 2045. This is as a result of renewable energy deployment. Total amount of CO_2 emissions and carbon intensity are shown in Figure 1.

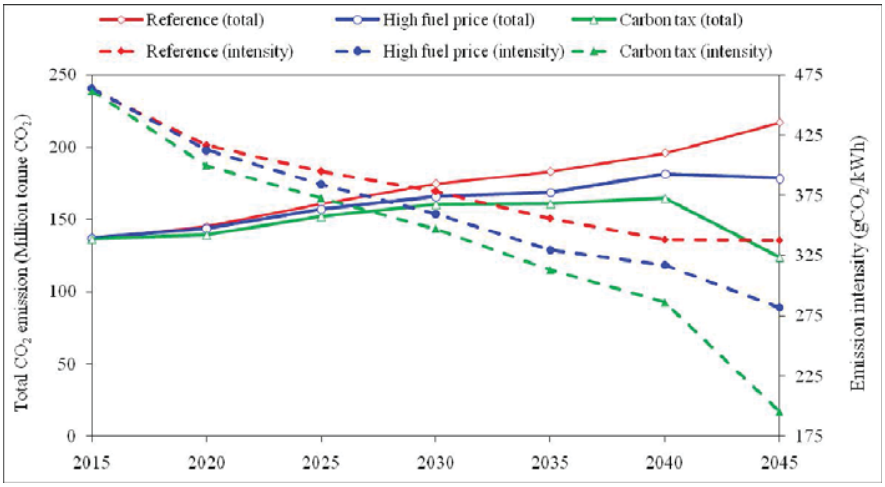

Figure 1. Total CO_2 emissions and carbon intensity in different scenarios

Conclusion

This paper mainly focuses on the future development of electricity supply system in Iran. It also explores the prospects for development of renewable electricity technologies and their implications for fossil fuel consumption and CO_2 emissions over the next three decades. Different scenarios are investigated to evaluate how renewable energy utilization can be affected by technology development, fossil fuel prices, and carbon tax. The assessment of new energy technologies are provided by using MESSAGE, a cost minimizing mixed-integer programming model. Results of the model reveal that renewable energy technologies will contribute to supply 10-35% of total electricity demand by 2045. The average CO_2 emissions per unit of electricity generated can be reduced by 30-70%.

Keywords: CO_2 emissions, electricity supply system, fuel consumption, MESSAGE, renewable energy technologies.

Estimation of Cost Curve to Control Sulfur Dioxide Gas (SO_2) Emissions from Sarcheshmeh Copper Complex

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Introduction

Sarcheshmeh Copper Mine is regarded as the second largest copper deposit in the world. This is one of the largest industrial-mining complexes in the world and the largest producer of copper in Iran. This complex plays an important role in Iran's economy. In 2012, this complex created employment for about 8000 people in Iran and produced 203065 tons of copper cathodes.

However, high amounts of pollutants are being produced and emitting into the environment from this complex. SO_2 is the main type of air pollutant emitted from its smelter factory. This complex emits about 789.9 tons of SO_2 per day.

The necessity to protect the environment is an indisputable principle which has been accepted by everyone in today's world. Therefore, pollutant emissions from manufacturing firms are regulated to protect human and environment health. Although the potential benefits of industrial pollution control are clear, policy makers worry about the costs. The development of pollution abatement policies and technologies require information on emission control potentials and their costs. Abatement cost curves (ACCs) are powerful management tools. These tools greatly improve the transparency of pollution-reduction information. Therefore, the SO_2 ACC is constructed in this study for Sarcheshmeh Copper Complex to determine the potentials and costs of SO_2 abatement.

Material and methods

Abatement cost curve shows the annual abatement cost per unit of avoided emissions of pollution. The Marginal Abatement Cost Curve (MACC) links a firm's emission levels and the cost of additional units of pollution reduction.

There are a number of methods available at varying levels of complexity and scale to create ACCs. Methods which focus on technological details and the impact on individual enterprise are classified as bottom-up measures. The economy wide impact of abatement costs are investigated by top-down measures. Due to the small spatial scale of this study, the most suitable approach is a bottom-up study.

A stepwise methodology was applied. There are four steps to the methodology:

1. Identification of the available abatement techniques;

2. Calculation of total cost and abatement potential for all techniques, and identification of possible combinations and incompatibilities;

In an analysis of the industrial processes, investment and operation and maintenance (O&M) costs must be taken into consideration. In this study, energy, labor, insurance, depreciation, overheads, materials, maintenance, and repair were considered as O&M costs. Various methods can be employed for estimating investment costs. In this study, the power factor applied to plant-capacity ratio method was used for estimating investment costs. This method for studying or order-of-magnitude estimates relates the capital investment of a new process plant to the capital investment of similar previously constructed plants by an exponential power ratio. That is, for certain similar process plant configurations, the capital investment of the new facility (C_n) is equal to the capital investment of the constructed facility C multiplied by the ratio R. This is defined as the capacity of the new

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facility divided by the capacity of the old, raised to a power x (Eq. 1). This power has been found to average between 0.6 and 0.7 for many process facilities.

$$C_n = C(R)^x \quad (1)$$

Several studies have estimated investment and O&M costs of SO_2 abatement. This study used Islas and Shafizadeh's studies for estimating costs.

3. Manipulation and standardization of data;
4. Derivation of the abatement cost curves.

Results and conclusions

Five SO_2 abatement technologies were assumed. The costs of the five techniques were estimated for Sarcheshmeh Copper Complex. The cost data were divided into investment and O&M costs. SO_2 abatement costs were calculated using a discount rate of 20%, a time horizon of 15 years (2012-2027). Fig. 1 shows the calculated SO_2 abatement cost curve for the complex. This curve shows the annual SO_2 abatement cost per tons of avoided SO_2 emissions. The SO_2 abatement cost varies from US$4 to US$604/ton of SO_2.

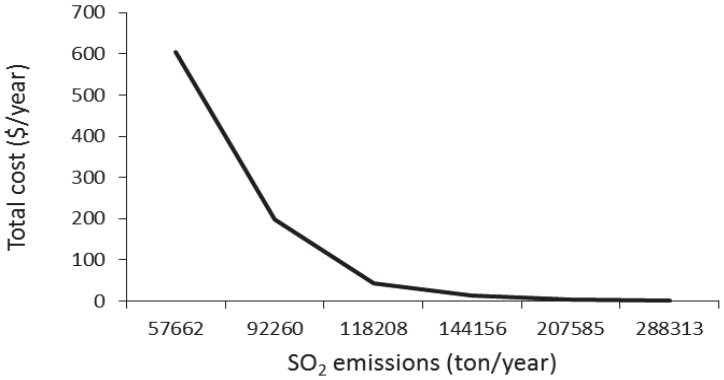

Figure 1. The SO_2 abatement cost curve for Sarcheshmeh Copper Complex

Figure 2 shows the calculated SO_2 marginal abatement cost curve for the complex. The calculated MACC provides the cost of reduction in additional ton of SO_2 from a given emission level.

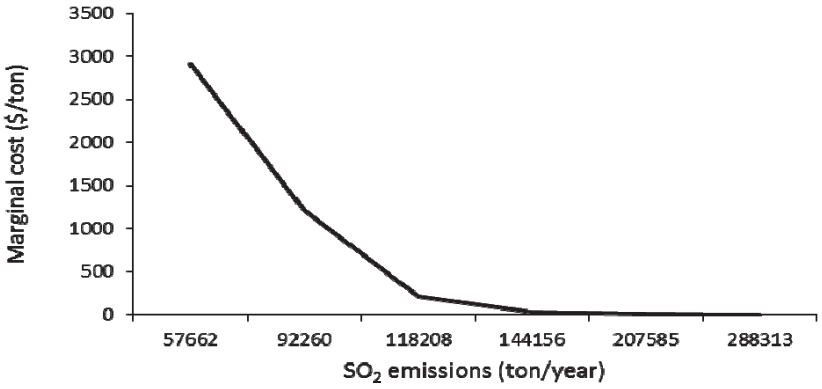

Figure 2. The SO_2 marginal abatement cost curve for Sarcheshmeh Copper Complex

The shape of the two curves was consistent with the theory and previous studies. Estimated ACC provides useful information for managers or decision-makers in the complex to determine the potentials and costs of SO_2 abatement. The MAC curve is also a useful tool for policy makers to assess policy instruments.

Keywords: abatement cost curve, engineering-economic method, marginal abatement cost curve, Sarcheshmeh copper complex, SO_2.

The Application of One and One-Half Bound (OOHB) Choices in the Contingent Valuation to Determine Tourists Consumer Surplus of Sisangan Forest Park

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Introduction

Forest for biodiversity and ecological functions is the main natural habitats. The most important function of forest is zonal and global climate regulation, recreation and ecotourism, water saving, regulation of hydrological cycle, flood control, and prevention of soil erosion. Valuation of public goods was noticeably widespread in the last decades. An understanding of the relationship between environmental economics and business economics is essential for policy makers. The influence of environmental resources functions increase vitality and joy of spirit and community development feasibility assessments of these areas. Today, a country that thinks more about economic development has seen tourism as a necessary. To ecotourism as an important branch of tourism has been paid serious attentionis. Even though there is no market for many ecosystem services where they could be traded by supply and demand, they do have value and are not really ‘free of charge’ or ‘cost-free’ in that there are almost always opportunity costs involved. For instance, their current use is at the expense of their future use as is the case for non-renewable energy resources such as oil and gas. Additionally, their use by one particular group is at the expense of another group of people as is the case when we have overcrowded common pool resources like natural parks or beaches, or discharge wastewater in a river impairing recreational fishing opportunities. Understanding the economic value for local, national and global policy is very important.

According to the influential role of environmental resource functions to increase the vitality and mental joy of individuals and to assess the feasibility of developing these regions, it is essential to determine the value of these resources functions. The purpose of this study is to identify factors influencing Willingness to pay of tourists in Sisangan Forest Park in Mazandaran province for recreationand to determine quantity of willingness to pay with One and One-Half Bounded (OOHB) choice in the Contingent Value.

Material & Methods

The study area for this research is Sisangan Forest Park located in the Mazandaran Province, about 30 km from Noushahr City and 20 km West of Nour city. The forest park area is 625 hectares with 200 meter width and 3 kilometer length on coastline of the Caspian Sea. It has very pleasant and attractive places for recreation and leisure for travelers to Mazandaran Province.

According to the internal and external studies in valuation non-market functions of environmental resources, the widely expressed Willingness to Pay method (contingent valuation method (CVM)) has been used to determine the value of ecotourism of environmental resources. Contingent valuation method is an established survey-based methodology that can be used to determine the value of non-market goods which are derived from natural and environmental resources, such as recreational function. The CVM attempts to determine willingness to pay (WTP) of individuals under certain hypothetical market scenarios.

According to economic theory, a rational person maximizes utility with respect to the expenditure limitation due to an incomplete understanding of optimization.As, an analyst is unable to accurately measure all relevant variables there are many errors in the maximization. Therefore, it is assumed that each respondent has a random utility function.

This theory is based on probability choice and it is assumed that individuals make choices that will maximize their utility, from the set of Frequently Asked Questions. In this context, indirect utility function for respondent i in equation 1 can be divided into two parts. Deterministic component (Observed by the researcher) is typically as an index of specific features of individual and effective option. It ischosen as option j in the proposed fees for

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use of special functions. Other section is random components (imperceptible by the researcher) that indicate invisible effects on the person choice:

$U_i=V_i\ (X_i) + e_i = \beta X_i + e_i$ (1)

Where, U_i represents indirect utility of person, V_i is deterministic component, e_i stochastic component, X_i individual specific features and effective option to accept the proposed amount, and i is number of responders.

Random utility theory posits that the person i choose c choice from C_n range of choices that indirect utility of C is larger than any other choice, such as O. It is shown in equation 2:

$$U_{iC} > U_{iO} \Rightarrow\gg V_{iC} + e_{iC} > V_{iO} + e_{iO} \quad (2)$$

Now, the probability that a particular respondentprefer C choice from a chosen range relative to any choice like O, can be said a probability that the utility associated with option C is the most desirable options stated.

$$prob((U_{iC}>U_{iO})\ \forall\ C\neq O) = prob((V_{iC} - V_{iO}) > (e_{iC} - e_{iO})\ ;\ C, O \in Cn \quad (3)$$

Now, we proposed One-One Half Bounded (OOHB) questionnaire to determine recreational willingness to pay by Sisangan visitors. One-One Half Bounded (OOHB) questionnaire is presented with a range (B_i^-, B_i^+), where $B_i^- < B_i^+$. One of these two prices is selected in random, and the respondent is asked whether she/he would be willing to pay that amount. She/he is asked about the second price only if that is compatible with her/his response to the first price. If the lower price, B_i^- is randomly drawn as the starting bid, the three possible response outcomes are (no), (yes, no), and (yes, yes); we denote the corresponding response probabilities by π_i^N, π_i^{YN}, π_i^{YY}. If the higher price, B_i^+ is randomly drawn as the starting bid, the possible response outcomes are (yes), (no, yes) and (no, no). We denote the corresponding response probabilities by π_i^Y, π_i^{NY}, π_i^{NN}. Observe that:

$$\pi_i^N = \pi_i^{NN} = P(C_i \le B_i^D) = G(B_i^D;\theta) \quad (4)$$

$$\pi_i^{YN} = \pi_i^{NY} = P(B_i^D \le C_i \le B_i^U) = G(B_i^u;\theta) - G(B_i^D;\theta) \quad (5)$$

$$\pi_i^{YY} = \pi_i^Y = P(C_i \ge B_i^U) = 1 - G(B_i^U;\theta) \quad (6)$$

Let d_i^N= 1 if either the starting bid is B_i^- and the response is (no) or the starting bid is $B_i^+$and the response is (no, no), and 0 otherwise; let d_i^{YN} = 1 if either the starting bid is B_i^- and the response is (yes, no) or the starting bid is B_i^+ and the response is (no, yes), and 0 otherwise; and let d_i^{YY} =1 if either the starting bid is B_i^- and the response is (yes, yes) or the starting bid is B_i^+ and the response is (yes), and 0 otherwise. Then, the log likelihood function for the response to a CV survey is using the OOHB format:

This study is assayed to calculate separately willingness to pay of persons who have Lexicographic and Consequentialist tendencies.

$$\ln L^{OOHB}(\theta) = \sum_{i=1}^{N} (d_i^Y \ln\left[1 - G(B_i^U;\theta)\right] + d_i^{YN} \ln\left[G(B_i^U;\theta) - G(B_i^D;\theta)\right] + d_i^N \ln\left[G(B_i^D;\theta)\right]) \quad (7)$$

Results and conclusions

Based on the extracted data from the General Administration of Cultural Heritage and Tourism Organization of Mazandaran Province, Iran, about 700,000 people visited the park in 2012. Accordingly, in the pre-questionnaire, respondents were asked a question that is: “Do you have willingness to pay for visit and recreational use of Sisangan Park or not”. This is a question to determine the sample size based on the trait variance of the answers. Variance of the responses in the 40 pre-questionnaires were 0.341 that using the Cochran's sampling formula, the required sample size is 180 cases.

From Logit model estimated in this study, it was clear that variables such as bid price amount, size of household, numbers of annual visits, Lexicographic, and monthly income of household have significant effects on person’s willingness to pay. Percentage of Right Predictions in this estimated model is equal to 0.88 and Cragg-Uhler R-Square equal to 0.69772. Likelihood Ratio Test is also equal to 239 with 8 degree of freedom in model. This shows that the model is significant in 99 percentage of confidence interval.

Willing to pay among households that have Consequentialist tendencies is 11,751 Rials per household in

average, and among those who had Lexicographic tendencies is equivalent to 13,409 Rials (1Rial is nearly equal to about $3.333*10^{-5}$ USD$). Finally, Based on the Result of the present study by calculating the weighted average, Consequentialist households and Lexicographic (0.77 and 0.23), the average willingness to pay (WTP) of households is estimated to be 12,201 Rials annually. The total recreation value of this park with using OOHB choice on the contingent value method is also estimated about 11.32 Billion Rials and 377 million Rials per hectare in the 2012.

According to the results it seems inevitable that more attention by the relevant authorities must be paid to extend the recreational functions of Sisangan Forest Park for more general welfare of tourists.People who believe it their duty to protect the environment have more WTP (equivalent to 14.1 percent) than those who beleive the support of the Environmental Protection has huge benefits that they can get from protecting the the park. So, if it does not benefit them, they may be reluctant to protect the environment. Therefore, we can providemany additional costs for maintenance, utilization, and development of environmental resources if household educations that have Lexicographic tendencies are strengthened to accept protection of environment as a task.

Keywords: One and One-Half Bound choice (OOHB), Sisangan Forest Park, valuation.

PCA Method in Landscape Visual Quality Assessment, Case study: Ziarat Watershed of Golestan Province

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Introduction

Conservation and management of landscapes and beautiful sceneries is one of the necessities of establishing and maintaining the protected areas. Analysis of landscape visual quality has an important place in landscape planning and designing. In this way, reviewing effective criteria and discovering the simple patterns which affect the landscapes is the most important step of modeling and problem solving. Principal Component Analysis (PCA) is a way of identifying patterns in data, and expressing the data to highlight their similarities and differences. Since it is hard to find patterns in high dimension data, where the luxury of graphical representation is not available, PCA is a powerful tool for their analysis. The other main advantage of PCA is reducing the number of dimensions, without much loss of information. This study shows the application of this method in environmental sciences especially in landscape visual quality assessment. This study has tried to identify the most important subjective and objective criteria which are effective on scenic value in order to evaluate visual quality of landscape more accurate and fast using the lower volume of data. In this study by reviewing the different references and according to expert opinions and geographic location of the study area, 8 objective and 15 subjective criteria have been selected. The objective criteria are including: tree types, vegetation density, diversity of vegetation density, ecoton of tree type, water falls viewshed, peaks viewshed, river viewshed along walking tracks and visibility of high diversity points. The subjective criteria are including color diversity, texture variety, cleanliness of environment, dynamism, sequence, complexity, singularity, density, closed view landscapes, open view landscapes, landscapes with moderate visibility, front view landscape of visitors, overhead view landscape of visitors, and bottom view landscape of visitors. These were distinguished as effective criteria in PCA analysis to reduce the number of criteria and select more important variables.

Material and methods

In this research, walking tracks of Ziarat Basin of Golestan Province in Iran were investigated to assess the visual quality of landscape. After the determination of subjective and objective criteria which are effective on aesthetic value of landscapes, a questionnaire in two parts including a table of subjective criteria and a table of objective criteria was distributed between the 150 visitors. The visitors were asked to rate the amount of effect of each criterion on the preference of landscape in four categories including: very high, high, medium and low. Finally, the results of questionnaire were analyzed using PCA method in SPSS at five steps as following:

- ✓ Collecting data and preparing a list of effective criteria on aesthetic value of landscape.
- ✓ Check the pre assumption of factor analysis by KMO and Bartlett indices, setting the data and reviewing subscriptions table.
- ✓ Calculate the covariance matrix.
- ✓ Compute eigenvalues and reviewing the scree plot.
- ✓ Extraction of principal components.

In PCA method KMO and Bartlett's indices and the tables of total variance and rotated component matrixes are more important tables for better analysis of variables.

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Results and discussion

After running the PCA method in SPSS, KMO and Bartlett's table should be checked at first. If KMO index was more than 1, then the volume of data would be acceptable. And "if the probability of Bartlett index was lower than 0.05 (chi-square is significant), correlation matrix would be appropriate for factor analysis. Thus, multi linear pre assumption is respected and use of this statistical method doesn't hinder. Tables 1 and 2 show these indices.

Table 1. KMO and Bartlett indexes for Subjective Components

KMO index	0.671
Bartlett index	**0.000**

Table 2. KMO and Bartlett indexes for Objective Components

KMO index	0.718
Bartlett index	**0.0000**

The other important table is rotated component matrix, this table by categorizing the component made it possible for us to extract the criteria which has the highest value in each column as the representative of group, because these criteria would cover the other criteria which are in its group to a large extent. In this table, the criteria which allocate the maximum number of values in each column are considered as the main criteria. Table 3 and 4 shows the main subjective and objective criteria.

Table 3. Rotated Component Matrix of subjective criteria

Criteria	Component				
	1	2	3	4	5
Complexity	**.794**	.248	.225	.007	-.223
Dynamism	.694	-.132	-.026	.248	.303
Sequence	.690	-.040	.012	.152	.153
Colour	.016	.782	-.200	-.110	.135
Bottom view landscape	-.335	.766	.184	.297	-.049
Landscapes with moderate visibility	.340	.697	.287	.064	-.092
Overhead view landscape	-.059	-.024	**.832**	.018	-.106
Open view landscapes	.393	**.086**	.699	-.168	-.041
Cleanliness of environment	.054	.072	-.119	**.877**	-.158
Singularity	.330	.024	.107	.802	.147
Front view landscape	-.103	.205	.223	.154	-.691
Texture variety	.098	.452	.037	.031	**.648**
Density	.021	.159	.562	.276	.567

As the Scree plot graphs show, there are 5 components from subjective criteria and 3 components from objective criteria which have the eigenvalue more than 1. They were separated as the principal components (Fig. 1 & 2).

Table 4. Rotated Component Matrix of objective criteria

Criteria	Component		
	1	2	3
Diversity of vegetation density	**.797**	.360	.002
Ecoton of tree type	.723	.262	.251
River viewshed	.691	-.502	.043
Tree types	.676	.419	-.107
Vegetation density	.523	.375	-.304
Peak viewshed	-.249	**.809**	.261
Waterfall viewshed	.560	-.608	-.226
Diversepoint viewshed	.245	-.272	**.862**

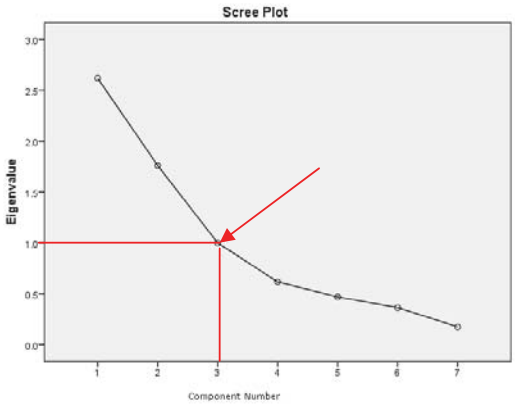

Figure 1. Scree plot of objective components

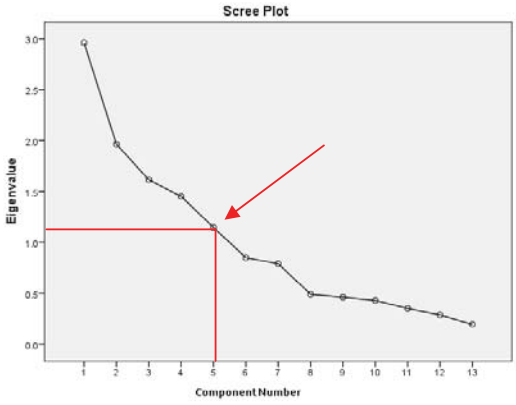

Figure 2. Scree plot of subjective components

Conclusion

Since conservation and management of landscapes and beautiful sceneries are necessary for establishing and maintaining the protected areas, so analysis of visual quality assessment has an important place in landscape planning. There are three different approaches in visual quality assessment including subjective approach, objective approach and comprehensive approach. In this research, we have tried to extract more important subjective and objective criteria which are effective on landscape visual quality assessment using PCA method. The results of this research show that from the fifteen subjective components, 5 components including color diversity, texture, complexity, front view landscape of visitors, and cleanness of the environment were chosen as more important subjective criteria. From the eight objective components, 3 components including the diversity of vegetation density, waterfalls viewshed, and visibility of high diversity points were chosen as the more important objective criteria. These components are actually the representative of other components. This research shows that PCA method could also have a widespread application in environmental sciences. We can use this method in different places according to the specific environmental situation of the region and extract more important effective criteria. Using the results of this study made it possible to form questionnaires with fewer questions, so the managers of tourist areas can achive the perception of visual quality of the area of interest by spending less time and cost.

Keywords: landscape visual quality assessment, objective and subjective criteria, Principal Component Analysis (PCA), Ziarat Watershed.

Multi Criteria Decision Making Based on DEMATEL and ANP Techniques to Select the Optimum Location for Cemeteries, Isfahan City, Iran

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Introduction

One of the major tasks of urban and regional planners is allocation of land to various urban utilizations according to the role and function of the city, urban economy, and also cross-effect of the land-uses with each other. This is the quantitative aspect of the subject, but what is more important is the qualitative aspect which means appropriate distribution and deployment of land-uses or applications on a physical level (optimal location of land-use). A planning in this way by appropriate land-uses help citizens enjoy the services and facilities offered in different parts of the city. This competent planning requires no additional commuting and will reduce environmental pollution, help to create safe urban space and acceptable environment, and provides peaceful, convenient living. Cemeteries are the places where are considered as the essential services in urban areas. Unfortunately, it is predicted that fullness and replenishment of cemeteries will leads to urban crisis in the next decade and finding other places for cemeteries will be unavoidable. Necessity of having the second or third cemetery in urban areas is not only because of their replenishment or fullness but also it is due to their distance from the cities. This can be problematic for the citizens and make difficulties for the citizens to visit the graves. It seems that the idea of cemeteries development in different directions of the cities would makes the access to them easier for the citizens. Nevertheless, urban planners still do not pay attention to establishment of new cemeteries in the cities according to the facts. Due to the importance finding a suitable place for construction of cemetery in one hand and the complexity of the problem because of different effective factors on the other hand, selection of a suitable environment to model and solve the problem is very important to find the solution. According to studies and surveys conducted in Geographical Information System (GIS) it was found that this system has excellent features and capabilities in collection, storage, retrieval, detection, integration, analysis, modeling, and displaying of geographic data. Having these functionalities, GIS can be used in site selection of urban centers such as cemeteries by involvement of qualitative and quantitative variables. Moreover, GIS can also be used as a strong decision support system in urban planning and management. Therefore, to model and solve the optimization problem of finding a suitable place for a cemetery, the techniques in the MCDM is utilized in GIS environment.

Materials

In this study, environmental, social, and economic standards have been considered for finding a suitable place for constructing a new cemetery. Effective criteria in locating the cemetery were identified using expert opinions and resources. Included criteria are distance from city, distance from river, access to main road, slope, geology, soil, and land-use. After the criteria were identified, due to the lack of sufficient information about the amount of effectiveness and interaction of the factors with each other it was tried to make a weighting of the factors based on their relationships.

Distance from city: there are different reasons that the cemetery should be located away from the urban main structure. From the jurisprudential view, the maximum distance of cemetery from the city shall be such that not to break the prayer and revocation of fasting. On the other hand, given that the Muslims are going to pilgrimage of the graves periodically (roughly every week), thus distance of cemetery should not be such that the citizens have access difficulties. It should not also cause transmission in many types of contaminations. However, for the favour of urbanism principles, distance between cemetery and the city is necessary, otherwise several problems

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such as the following will occurs:

- Transmission of different types of pollutions including air pollutions due to burning of the dead costumes, interactions resulting from decomposition of corpses, contamination caused by burial in soil, noise pollution induced mourning and wailing voices of the survivors.
- Psychological effects and depression of people, particularly for children who living around the cemetery, they are facing harrowing scenes of wailing every day.
- Traffic due to mass movement of the participants in funeral ceremony.

Road access criteria: due to funeral ceremony and the events afterwards, commuting to the cemetery takes place in collective and group form. At specific days such as Friday nights and some national religious occasions many people turn to the cemeteries. Therefore, proper and safe access to these palces are very significant. It is to mention that sometimes funeral participants do not act rationally due to mental disorders. Hence, if access way to cemetery is out of the town and if it consists of many intersections it may have safety issues.

Soil: In chemical interactions on corpse the soil type and material is highly effective. Compounds that are high absorbent of water and or their absorption are very low, cause that the corpse remains in the soil for a long time. Therefore, the soil material and its compounds should be such that not cause disorder in corpse decomposition.

Geology: In terms of permeability, the bedrock could be considered as primary necessities in selection of cemetery location. Because very high permeability leads to groundwater pollution and in contrast low permeability leads to contamination of surface water.

Surface waters: Cemetery should not be adjacent to river, fountain, and subterranean, because cemetery sewage and specially mortuary wastewater is highly contaminated and by no means should not contact the water for human, livestock, and farming consumption.

Land's slope: topography of cemetery location should have suitable slope to rapid depletion of flowing surface waters, so that the water from rain and snow should not remain on the cemetery surface. The topography of the burial place should also be considered to determine the extent of required excavations and embankments for land leveling

Methods

Since finding a place for new cemetery requires criteria identification and weighting them as well, spatial multi-criteria decision making techniques in combination with GIS capabilities in resolving such problems can play a key role in achieving the goal. In multi-criteria decision making there are several techniques in regards to site selection. In the current study and in order to select suitable location, ANP, DEMATEL, were used along with GIS. In order to execute the site selection, fuzzy membership values determined for each phase and their corresponding fuzzy maps are prepared in ArcGIS software environment. In addition, for geological and soil criteria based on their types, discrete fuzzy values were devoted. In the final step, the obtained weights in network analysis process for each criterion were multiplied by the obtained fuzzy map for that criterion.

Results and discussion

To determine an optimal location for construction of a new cemetery, after generation of the weighted fuzzy maps in ArcGIS environment, all proportional maps were combined in ArcGIS using gamma operator with the value of 0.7. The difference between suitable and unsuitable location are discerned in the operators. Gamma value of 0.9 allocates greater areas to suitable location, and gamma 0.8 is also high percentage of suitable location. The results obtained from gamma value of 0.7 indicate that the area of unsuitable location is high and area of suitable location is low. As a result, the operator will assist us to determine the most suitable location. Gamma operator has adjusted very high sensitivity of multiplication in fuzzy operator of fuzzy sum. The results obtained from this operator were used to execute the model for constructing cemetery. The selected locations from combination of all the effective factors give us a suitable location qualified all the hygiene and environment principles for places of the cemeteries.

Conclusions

Based on previous researches and the results of the current study, it can be argued that using spatial decision support system through DEMATEL and ANP techniques in GIS environment by gamma fuzzy operators helps to execute an appropriate evaluation and the results close to the real world. DEMATEL technique, by enjoyment of graph theory principles, can be applied to extract the relationships of cross-effectiveness and influence of the elements in the graph of the present study. Thus, it can determine intense effects of the cited relations in the form of numerical scores. One of the advantages of this method compared with other decision making methods is use of feedback relationship. This means that in the structure of this technique each element can affect the same level

of elements, upper and lower level elements as well, and in contrast takes effects from each of them. Utilization of DEMATEL for ANP method is effective not only for calculation of influence level between different groups of factors but for matrix normalization. Construction of cemetery in these places can avoid pollution emission in the city. The research suggests also the places for cemeteries in order to avoid traffic in the city.

Keywords: ANP, cemetery, DEMATEL technique, fuzzy, Multi Criteria Decision Making (MCDM).

Impact of ZayandehRud Drought on Social Interactions and Populated Spaces in Isfahan City

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Introduction

There is a special competition among many metropolitans for improving physical and semantic quality of urban landscape to upgrade their positions in global level and attract more tourists. Based on such characteristics, one of the important goals of metropolitan management planners of the society is to develop open populated spaces and make leisure centers. Urban spaces development in the present era without sufficient knowledge of urban rivers characteristics and taking advantage of their potentials has had many problems for the cities. Zayandeh Rud is one of the largest rivers in Iran. It is flowing on the center of the country and from west to east. Many tourists visit Zayandeh Rud each year, because several historic bridges are remained from Safavid Majesty and before over this river and it is also located in historical city of Isfahan. But it is a few years that this large river has been exposed to drought; this issue, in addition to the effects on the rate of tourism of the city, encounters the farmers of this area with irrigation problems. Zayandeh Rud River as one of the largest rivers of central plateau of Iran is located in Gavkhooni area. Zayandeh Rud originates from Zard Kooh Bakhtiari, Haft Tanan in the area of Shourab Tang-e-Gazi in Chaharmahal Bakhtiari Province. After absorbing running waters in some parts of Faridan and Fereydoon Shahr it flows towards Isfahan city. The length of this river is 405 km and the average slope of the channel bed 15 percent. Eventually, this river terminates in Gavkhooni Swamp, about 120 km in southeast of Isfahan. Average annual rainfall along the river is 450 mm and the extent of catchment area is about 27,100 km^2. Isfahan city's share of the river water that used to be distributed in the city through 9 major streams and their sub-branches is so high that in the recent eras it converted this city as a garden city (existence of 158 gardens and farms) and its passages as garden alleys. The main reason of Zayandeh Rud nomination to this name is that it revives and reclaims many villages, gardens, and farms. From ancient times, this river has been named as Zayandeh Rud, Zendehrud, Zand Rud, Zarin Rud, Zarinehrud, Zarnrud, and Zandak Rud. On one side, this river as artery and vital vein itself has had an important role in residents' leisure. Beside other cultural and economic profits for Isfahan city, Zayandeh Rud River has made a public area to develop humans' social interactions with each other. In addition a place for entertainment and leisure, the river provided a special position for urban identity of Isfahan citizens. This river shapes influential in the main identity of Isfahan city. This can be felt due to different signs and symbols that are visible in culture of Isfahan city and each has a sign of Zayandeh Rud.

Materials and Methods

The present study in terms of time is a longitudinal research with asurvey methodology. Questionnaire tool has been employed to gather information. The present study is considered longitudinal because it was done in two stages before and after drying of Zayandeh Rud River; Because of the lack of access to the respondents who can answer the questions before drought, in the second stage it was tried to select the respondents with the same age and gender characteristics as the first stage. In the present research two types of survey method have been used: documentation method of study by which conceptual and theoretical review have been conducted on this topic; this make it possible for the researcher to present conceptual and theoretical definitions for variables and use the previous methods and findings in the research. Statistical population of this study contains all citizens of Isfahan city that attended in this place for comfort and leisure or crossing of Zayandeh Rud. Sample volume of this study

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is 325 people that were selected in form of simple random sampling. In the present study a researcher made questionnaire tool was used to gather information. Its validity was confirmed using structural validity and through confirmatory factor analysis (CFA) method. According to the results of this method, factorial loads of each of indicators on the related variables are in acceptable level. Cronbach's alpha test was used to assess reliability of the research tool. The rate of Cronbach's alpha is obtained 0.73 for social interactions variable and 0.81 for environmental quality variable which both of them indicate optimal reliability of the research tool.

Results and discussion

The role Zayandeh Rud has played in the creation of social interaction is different before and after drought. The respondents' evaluation of the quality of public spaces around the river affects the rate of their interactions. Average exercise and entertainment around Zayandeh Rud is 2.54 hours a week among men which is significantly more than women with 1.94 hours a week. Null hypothesis was rejected in the index of sport and entertainment and in terms of gender, and opposite hypothesis was confirmed. In age of respondents, there is no significant difference among average sport and entertainment around Zayandeh Rud and all age groups are almost similar in exercise and recreation in these spaces. Average friendly appointments in the spaces around Zayandeh Rud with 2.98 hours a week among men is significantly more than women with 2.55 hours a week. Also, average friendly appointments in the spaces around Zayandeh Rud before river water drought, with 2.98 hours a week, are significantly more than those after river water drought, with 2.57 hours a week. In terms of age of the respondents, there is no significant difference among average friendly appointments in the spaces around Zayandeh Rud and almost all age groups have similar friendly appointments in these spaces. Average talk with others in the spaces among men, with 3.32 hours a week, is significantly more than women, with 3.01 hours a week. In terms of age the respondents, average talk with others in the spaces around Zayandeh Rud shows no significant difference and almost all age groups talk with others similarly in these spaces. The results of structural equations modeling show that the respondents' evaluation on the quality (access quality, services, aesthetic elements and comfort and security) of the spaces around Zayandeh Rud River has positive and significant effect on the rate of their interactions. Also, comparison testing of the averages shows that the role of these spaces in social interactions of men is more than women, but no significant difference was observed in terms of age. Moreover, the results of this study show that Zayandeh Rud River drought has significantly reduced the rate of social interactions among citizens that visit this place.

Conclusions

It was always thought that natural ecosystem in various forms can be involved in improving life of people. One of the most important aspects of natural ecosystem is its social functions. Natural ecosystem is effective on social elements in three aspects. The first aspect is that it can create an environment for human recreation and leisure. The second aspect is that being in natural environments makes humans familiar with cultural and social values. The third is that people become familiar with the nature and learn more about it. Natural environments such as the park around Zayandeh Rud have this capability that provides places for human regular and ongoing activities. Recreation can improve the possibility of social interactions as the important aspect of social health. Providing a public space that is aesthetically attractive, natural environments are able to attract people and increase human interactions and random communications with one another. Random face to face communications provide an opportunity for social interactions and familiarity and thus connecting with each other. Social ties also provide for the people with social health. The results of this study show that social interactions of citizens around Zayandeh Rud River have also been significantly reduced by river water drought Thus, it is obvious that the viability and survival of an environmental element such as Zayandeh Rud can play an important role on the continuity and dynamism of social life. Another important achievement of the present research is that addition to water flow in Zayandeh Rud River channel, evaluation of the citizens about the environment quality around this river such as easy and rapid access, services for citizens like appropriate spaces for sitting and shopping, and visual and welfare elements can also play a significant role in social interactions of citizens near the river. Effective attempts can be made to increase a set of scientific capacities to solve the problems arising from the river drought. It can be recommended to consider environmental demands of researchers, citizens, and managers at national and provincial levels, and increasing public awareness in Isfahan and the entire country of Zayandeh Rud drought and the possible hazards, planning for citizen participation and social cohesion in restoration of Zayandeh Rud flow, and taking advantage of new research findings and successful executive experiences. Generally, due to the findings of this study, it can be said that expanding, maintaining, and enhancing public spaces can provide for the public with social interactions such as visiting, talking, doing group and common activities, exercise and playing games; and promote the social vitality.

Keywords: drought, Isfahan, social interaction, urban rivers, Zayandeh Rud.

Environmental Impacts of Ardakan Pelletizing Plant Using TOPSIS Fuzzy Method

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Introduction

With increasing attention about environmental issues, especially in the recent century, and some problems like population growth, poverty, natural resources exhaustion, and widespread pollution it is needed to form an environmental management system. Environment is a complicated combination of various factors which is appeared from evolution of organisms and component of the earth. Thus, it affects human activities and also affected by them. Connection between human and environment result in organizations and communications that require a program compatible with the environment.

Ardakan Pelletizing Plant with 3.4 ton capacity of production per year and 780 hectare area is located in 32°,22′ North latitude and 53°,47′ East longitude, 25th Kilometers of Naeen, Yazd, Iran. Raw materials that are iron ore concentrates are produced from Chadormalu iron ore. Then, iron ore concentrates are changed into pellet during a process. Through this method pellet can be reclaimed and changed into steel. The area is not suitable for agriculture and is just suitable for industrial activities. Job positions here prevent migration of local people to big cities. Gas emissions from chimnies cause pollutions including Sox, NOx and dust. Fortunately, the area has potential of refinement.

Materials and methods

This study aims to investigate environmental impacts of the industrial activities. Thus, some methods can be used in this survey. These methods are case study, questionnaire, interviewing, internet searching, and library studies. For data analysis, some software such as SPSS 17, GIS 9.3 and Excel were used.

Questionnaires with up to 33 questions were designed to gather the required data. Statistical population of this research is the managers and experts of the plant and central office (55 persons). For determining sample size, simple random sampling and Cochran formula was used. Finally, sample size was estimated about 42 persons. In the next step, to make a ranking of pollutants in the questionnaire, TOPSIS method was applied. TOPSIS method, as a multi criteria decision making method, is our main technique that is employed in this research. Since this method is designed based upon intellectual deductions of specialists, our model would lead to more realistic results. This method includes 6 steps. Its basic concept is that the best selected alternative from a finite set of alternatives should have the shortest distance from the ideal solution and the most distance from the negative ideal solution in a geometrical sense. Thus, contaminative alternatives and criteria of functional procedures are categorized by means of a TOSIS method.

Results

Environmental management plan is suggested to evaluate and monitor all of the impacts resulted from the activities in the plant. This plan can cause coordination and conformity between all factors of environment system. Environmental management includes many methods and policies to improve condition of the environment. This action makes reduction in the environmental impacts and promotion of quality level for environmental parameters. Moreover, it is necessary to monitor and control changes of quantity and quality of environmental parameters according to standards.

Results indicate that among air pollutants Electrostatic Precipitator (with importance of 0.817), among water pollutants lab (with importance of 0.971), among noise pollutants Roller Mill and in soil contaminants function of pan conveyor and rotation of rolls in Rollers (with importance of 0.988 and 1) have the highest priority. In

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habitats and vegetation, wastes and for socio-cultural and economical environment, residential villages both with importance of 1 got the highest rank. Furthermore, harmful environmental factors and occupational accidents respectively with importance of 0.542, 0.993 obtained the highest priority among health and industrial safety criteria. According to these results, establishing environmental management plan is a good suggestion to assess, monitor, and survey the impacts of Ardakan Pelletizing Plant activities on the environment. In this plan location of sampling, kinds of pollutant emissions, measure indicators, and time frequency of sampling were determined. Execution of this plan helps mitigate harmful environmental impacts. Moreover, corrective actions lead to better reduction and control.

Below table (Table 1) shows a monitoring plan in both constructional and operational phases. Parameters that are monitored include particles, SOx, NOx, CO, and noise. Moreover, sampling points in constructional phase include the areas where produce pollutants like soil operations. Persons in charge of monitoring are Environment Experts or HSE inspectors with cooperation of reliable observers.

Moreover, some of management solutions for controlling environmental impacts are mentioned here. In production process, pollutants are in 2 forms of gas and particles. In steel industry storing and removing of materials and raw material productions are the main factor for air pollution and wind help them to spread more. Moreover, in result of bag filters operation, particles are emitted into the air. Another unit that makes air pollution is gravity collector. Wet scrubbers in mixing, cooling and screening can also be a cause for air pollution.

These are some of methods for controlling particles dispersion: planting trees, using ceiling fans in workplace for aerification of air and reduction of particles, using stores for controlling dust dispersion, using waste gases for producing heat and steam, using electrostatic filters for dust refinement, cleaning units and manufactory with vacuum cleaner, sealing doors and windows of control room to prevent dust penetration, allocating %25 of plant area to vegetation, using central bag filters to reduce dust of fusion chimney.

For reducing noise in the plant these ways are suggested: using the fans and engines with lower noise, installation of silencers in input air system of compressors, lubrication of equipment with grease and oils, tightening of pieces and equipment, reduction of time of noise confrontation among persons, using suitable foundation, noise insulation equipment, protection hats to prevent noise transfering, vibration control, and health and safety education to employees to care about their hearing.

In production cycle of Ardakan Pelletizing Plant there is not any waste in that the plant has waste reclamation system. This system follows a direction that all of the waste and under size and over size productions are mixed with water and conducted to clarifier in the form of slurry. After water refinement, the precipitated materials by slurry pump go into thikner and after another precipitation and filtering operation go back to cycle production. The waste water from irrigation and raining in the form of runoff enter into some canals arranged in all of the plant. The canal ways at the end are connected to evaporation pound. Base of this pound is covered with plastic as an isolator. Thus, there isn't any leakage to lower levels and the pollutants can't leak to the nature. The evaporation takes place from the top of the pound.

Some solutions for reduction of water pollutions are: using water waste for irrigation of plants in yard of the factory, construction of a pond for sedimentation of iron oxide, construction of waste water treatment system to prevent mixing sewage with other sources of water, and washing of filters based on standards.

For waste management some solutions are also suggested: reduction of waste from the source of production, separation of waste, refinery and recycling, prevention of mixing hazard wastes with other wastes, and storing all of the wastes in one place for sale.

For reducing energy consumption these solutions are proposed: optimization of fuel consumption, identifying the areas of energy dissipation, increasing the resources for promotion of energy management, identifying potentials of energy economy, identifying points of energy loss, reducing energy consumption in chimney.

Solutions for reduction of health impacts in place of work are: application of masks with filters for employees, using of dust filter for chimney, using sprinkler to moist and reduce dust, use of noise isolation with doghouses in chimney, and using protective caps to prevent transfer of the noise.

In conclusion, this can be argued that as this plant is built 5 years ago, application of modern technologies such as online monitoring systems and filters for controlling air pollution can put it in a desirable condition.

Table 1. Monitor Indicators and plans for constructional and operational phases

Monitor Indicator	Parameters	Monitoring Frequency	Sampling points in constructional phase	Sampling points in operational phase	Monitoring person
Air quality with equipped system and online	particles	Without using of online system, monthly	Areas that produce pollutants like soil operations	Outside and inside area of plant	Environment Expert or HSE inspector with cooperation of reliable observer
	SOx				
	NOx				
	CO		Areas that produce pollutants	"	"
			"	"	"
			"	"	"
Sound quality	Noise level	Seasonal	"	"	"

Keywords: air pollution, Ardakan Pelletizing Plant, environmental impact, Multi Criteria Decision Making Methods (MCDM), TOPSIS Method.

Analysis of Mega-landforms in Desert Environment Using Artificial Neural Network, Iran's Lut and China's Qaidam Deserts

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Introduction

Morphological segmentation of land surface is commonly used for land surface allocation in management and environmental sciences. The first step in assigning a piece of land to a specific application is to divide it into homogeneous morphological segments. Traditional field-based geomorphological mapping can be time consuming, costly, and challenging when large areas, particularly in remote areas where terrain is difficult to access and where the topography and landforms can be highly variable over short distances. Like other geomorphometric studies DEM is used as the basic input and SRTM DEM with 90 m resolution is actually suitable for mega landforms analysis. That is one of the most reliable elevation models worldwide.

Yardangs and ergs (sand dune fields) are exclusive landforms resulted from intensive wind erosion and deposition. They cover a large area in hyper-arid and arid regions near each other. Two typical examples of both these landforms can be found in Lut Desert of Iran and Qaidam Desert in China. This paper presents a new approach using Self Organizing Map (SOM) as unsupervised algorithm of artificial neural networks for analysis and characterization and finally comparison of yardangs and ergs in these two different and interesting deserts of Asia.

Material and methods

Lut Desert of Iran with an area about 80,000 $km^2$is a lowland area of several large basins separated by low ridges located in provinces of Kerman, Khorasan, and Sistan. This desert depression contains several hundred meters of upper Pliocene to Pleistocene lacustrine silts over a basement of flat-lying Paleogene and esitic lavas and tuffs. Several Quaternary basalt flows occur near the Nayband fault on the western edge of the Lut. The eastern part of Dasht-e Lut is a low plateau covered with salt flats. This area consists of sand and it contains also some of the highest dunes of the world', about300 m high. Western part of Lut desert is covered with strong diagonal lines resulting from wind erosion and episodic floods acting on the Neogene silts. Surface slope is ranged from 0 to 19°. The desert is characterized by a hyper-arid climate with an annual rainfall less than 10 mm mainly falling in winter. The prevailing wind known as "wind of 120 days" or Bad-i-sad-o-bist roz Systan blows from NNW–SSE direction and corresponds exactly to the direction of elongated yardangs.

Qaidam Basin, the third largest basin in China, is located in Qinghai Province, northeast of Qinghai-Tibet Plateru. The average altitude of the bottom of the basin is about 2,600 - 3,000 m. It is the highest basin in China. The wind regimes are characterized by a narrow range of wind directions and dominant wind directions of gradual change, changing from near northerly to northwesterly in the NW sector to near westerly in the SE sector. Longitudinal dunes occur in all major sand areas in the world. The yardangs of Qaidam are enormous, reaching up to 50 m high, and can clearly be observed on satellite images and often camouflage the trend of bedding in the sedimentary rocks on which they are carved.

Kohonen's Self Organizing Map (SOM) is an unsupervised artificial neural network for clustering and visualization of the information that preserve the topological relationship of the input. It converts the nonlinear statistical relationships of high dimensional input data to low dimensional (usually two-dimensional) output grid. The SOM characteristics perform like learning ability, abstraction with topology preservation and visualization can be utilized in complex tasks such as morphometric analysis and landform classification. Digital Elevation Model (DEM) is the basic input of all geomorphometric analysis. We have used the latest version of SRTM/X with 90 m resolution. The data are displayed in a geographic (Lat/Long) projection, with the WGS84 horizontal datum and the EGM96 vertical datum (figure 1). The SRTM 3 arc seconds data were re-projected to a 90 m

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UTM grid. Bivariate quadratic surfaces with moving window size of 5×5 were fitted to this DEM. The first derivative, slope steepness and the second derivatives minimum and maximum curvature and also cross-sectional curvatures were calculated as geomorphometric parameters used as input to the SOM. Final landform maps are evaluated using minimum quantization error and topography map.

Discussion of results and conclusion

All four areas (Lut Yardang region, Lut erg, Qaidam Yardang region, Qaidam erg) have been classified separately by 4 basic geomorphometric parameters (Slope, minimal curvature, maximal curvature, and cross sectional curvature) with the most precise SOM classification of IDRISI application. We have also used a special Davies Bouldin Index (DBI) to find out the best number of classes in each area and for each set of landforms.

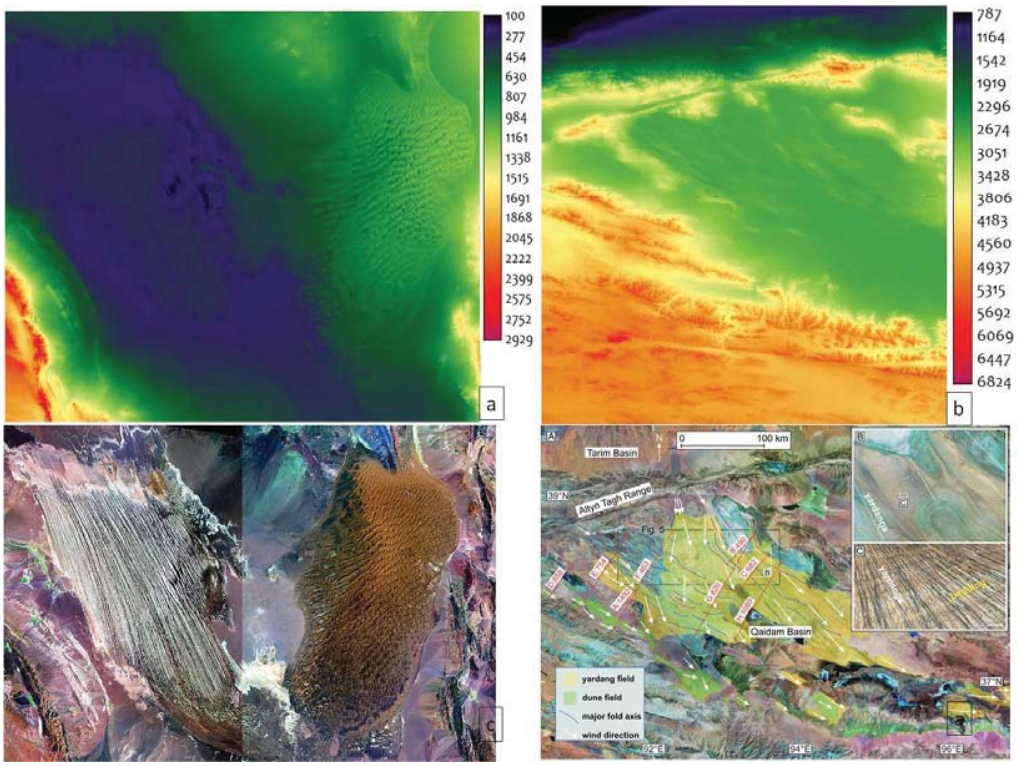

Figure 3. SRTM DEM of Lut Desert of Iran (a), Qaidam Desert of China (b) Landsat 7 image of Lut (c) and Qaidam.

Comparison between the classes shows that the number of classes in yardangs of Qaidam Desert is more than those of Lut. This is because of whale shape of yardangs in Qaidam and active geology and also two different levels of micro and mega yardangs . Another reason can be the existence of semi-strong winds in other directions different from the strong winds in overall direction of yardangs. The lithology of structures can also be effective in their variation.

Nose slope in Qaidam yardangs is exactly in windward part of whale shape yardangs but because of Spindle shape form and the homogeneity of their width, it is not recognizable in Lut yardans. Thus, three classes in Qaidam are the same as just one class in Lut. Slow slope corridor class in Qaidam and slow slope corridor in Lut are different in shape and percentage in both regions.

Classification of ergs indicates that diversity in dune patterns and forms are much more in Lut desert in comparison with Qaidam. Nose slope class is about 30% in Lut and 12% in Qaidam. This shows much mature sand dunes in Lut. Erg classification has less quantization error relative to the errors in yardangs classification. This is indicative of a better classification (Table 1). More specific input data of geomorphometric parameters can lead to better classification in yardang regions but it seems that classification with these four parameters work well for the sand dune regions.

Table 1. comparison of yardages and ergs with differences in number of classes and quantization errors between Lut and Qaidam Deserts.

	Yardang region		Erg region	
	Lut	Qaidam	Lut	Qaidam
Best Number of Classes (DBI)	7	8	6	6
Quantization Error	0.0639	0.0424	0.033	0.0244

Results of this research show the same number of classes in the ergs of the two regions (6 classes). But yardang region in Qaidam with 8 classes shows more complexities in comparison with Lut yardang area with 7 classes. The area in Lut has more uniform distributed classes. In addition, more detailed yardangs in Qaidam relative to more homogeneous yardangs in Lut lead to more complex classification in Qaidam. Effect of aspect (slope direction) in final classification of Qaidam made it more specific. The most significant reason of huge differences in yardang area of these two deserts is the lithology and topography of their bed.

We can observe more similarities in erg area of the two regions. But more mature erg in Lut is the evidence of available sand source with different wind directions and it is a little bit more detailed than that in Qaidam. Percentage of Shoulder and Nose slope classes in the two regions is notable. These classes are related to wind direction and topography of bed rock. Finally, in this research Self Organizing Maps as an unsupervised algorithm proved effective and useful for semi-automatic analysis of desert landforms and comparison between same landforms in different regions.

Keywords: landform, Lut Desert, Qaidam in China, SOM, SRTM.

Evaluation and Comparison of the Sustainability Level of Agronomy Crops under Drought Condition by Using MCDA in the East of Zayandeh-Rud River Basin

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Introduction

Agricultural sustainability is regarded as a key factor for long term profitability of farming in rural areas. Researchers believe that an agricultural system is sustainable if it includes environmental quality, economic viability, and employment and social performance. Agricultural sustainability can be analyzed on diverse spatial scales, from the field to a regional, national or even an international scale. Regarding the natural environment the agro-technical and socio-economic conditions in every region have raised the need for more granular scales of assessment.

A recent drought in Zayandeh-Rud River Basin caused an increase in competition among water users in agriculture, industry, and drinking sectors. There is too much pressure on water resources. This competitiveness can increase agricultural water shortage and serious problems such as agricultural unsustainability.

The availability of water is an important factor for agricultural production in arid and semi-arid areas. Excessive use of water resources influences agricultural development and plays a key role in environmental degradation. However, evaluation of sustainability under drought condition will be used to help decision makers establish effective water exploitation and allocation policies, and thus facilitate the local agriculture sustainability.

In this paper to assess agricultural sustainability data are collected by using questionnaire and Expert Choice 11 application in the east of Zayandeh-Rud River Basin.

The partial goals are including assessment of:

- environmental sustainability in case study.
- economic sustainability in case study.
- social sustainability in case study.
- drought impact on crop sustainability in case study.

Material and methods

The Analytic Hierarchy Process (AHP) is one of the most commonly applied MCDA techniques based on value measurement models which proposed by Thomas L. Saaty. This states that transferability of a sustainability evaluation framework is not a strict requirement. Therefore, in this research a set of indicators were used to assess and compare the sustainability level of agronomy and orchard production systems.

Data collection

Data was obtained at the farm by a survey method and applying a structured questionnaire and face to face interviews with farmers in 2013. The questionnaire was divided into three parts consisting, (a) crop management practices, (b) farm structure and economic performance, and (c) individual, household and social characteristics of each farm manager.

Analytical Hierarchy Process (AHP)

AHP was performed by doing five following steps:

Step one: Development an attribute tree. In the attribute tree the agricultural sustainability was primarily divided hierarchically into the tree sustainability pillarsas final goal, then to the lower level criteria, and ultimately to measurable attributes.

Step two: Pairwise comparison of criteria.

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Step three: Pairwise comparison of alternatives (crops) with regard to criteria. At this stage, pairwise comparisons on the alternative crops with respect to the criteria were performed by rating of mean value of indicators. The value of the 22 indicators for each crop and farm was estimated at the farm level.

Step four: Calculating consistency. After each pairwise comparison of the criteria and alternatives, a consistency check must be applied. Priorities make sense if they are derived from consistent matrices.

Step five: Sensitivity analysis. The last step of the AHP is the sensitivity analysis to verify the results of decisions by changing the importance of the criteria. If the priority does not change, the results are robust.

Results and Discussion

Results of this research have indicated that alfalfa with 0.287 preference has a higher level of agricultural sustainability compared to other crops. According to the environmental assessment, barely (with 0.352) were the most sustainable crops. According to the social assessment alfalfa with 0.274 was sustainable crop. According to the results the higher scores are observed in farmers of alfalfa than in other farmers. Alfalfa farmers are highly educated and mainly occupied in off farm activities. In addition, employment rate is much higher in alfalfa. Wheat farmers are younger than other farmers.

According to the economic assessment the alfalfa has significantly higher scores than other crops (utility of about 0.5). The farmers have generally a better farm structure than farmers of other crops. In addition, farm financial indicator values are also much higher in these farms.

Based on performance sensitivity analysis, by changing the weights of the environmental criteria over 0.4, the priorities are reversed and alfalfa is being unsustainable. In this situation, barely is the most sustainable.

Conclusion

In this paper, a methodological approach was presented to assess and compare sustainability of agricultural products at the farm level under drought condition.

According to the environmental assessment, barely was the most sustainable crop. By increasing the use of fertilizer, agricultural sustainability level decreases. The use of fertilizer reflects the specialization and intensification of cropping practices. Barley had the lowest fertilizer usage among other crops. Furthermore, pesticides pose threats to human health and the environment that forage maize and barely have the lowest number of replications of herbicides, insecticides, and fungicides application per growing season. In addition, barely is the most sustainable crop based on water consumption indicator. By decreasing share of agriculture sector from surface water, pressure on groundwater resource increases and agricultural sustainability decreases in drought condition. In this way, sustainability of barely can increase because of low water requirement and resistance to salt.

According to the economic assessment, alfalfa was a sustainable crop. GM for alfalfa was 35 times greater than barely, 14 times greater than wheat and 3 times greater than forage maize. Holding size was larger than other crops for alfalfa that increases yield and may represent potentially higher sustainability efficiency. It is worth nothing that because the smallholders' farmers break the law of inheritance and land plots to carry out activities by machine and consequently the degree of mechanization is reduced. The multi-partitioning of agricultural lands results in higher yield variability along with more required energy and labor. Wheat and barley were the most sustainable among other crops.

According to the social assessment, alfalfa was sustainable crop. Age has been associated with farmer's education level, attitudes, managerial features, commitment to farming, and size of farming operation. In addition, a farmer's educational level and effective farm management as well as timely adoption of environmentally friendly management practices are positively correlated. Hence, barley and forage maize have respectively higher and lower social sustainability. Furthermore, agricultural employment represents the level of employment in the agricultural sector, illustrating its importance as a source of labor for the rural population. This criterion for alfalfa was 10 times greater than barely, 9.5 times greater than wheat and 6.5 times greater than forage maize. Furthermore, family size indicates that the family members may give significant information about the structure of agricultural household and it highlights the staying of farm population in the countryside.

In the east of Zayandeh-Rud river basin drought along with legal prohibition of land use change were caused to increase migration and decrease income. This can strongly affect the sustainability.

To increase sustainability under drought condition, increasing the efficiency of water use is necessary in agriculture sector in the case of study. But the level of adoption of sprinkler irrigation is low because of: high water PH, high water EC, smallholder's farmers, and high costs of equipment. Therefore, other methods such as intubation in the field can be recommended for better performance and efficiency of water use and allocation. This requires public accommodations to provide low-interest loans by the government.

Keywords: AHP, drought, sustainability, Zayandeh-Rud River.