# International Journal of Environmental Research

*International Journal of Environmental Research* is a multidisciplinary journal concerned with all aspects of environment. In pursuit of these, environmentalist disciplines are invited to contribute their knowledge and experience. *International Journal of Environmental Research* publishes original research papers, research notes and reviews across the broad field of environment. These include but are not limited to environmental science, environmental engineering, environmental management and planning and environmental design, urban and regional landscape design and natural disaster management. Thus high quality research papers or reviews dealing with any aspect of environment are welcomed. Papers may be theoretical, interpretative or experimental.

## CONTENTS

### Volume 1, Number 3, Summer 2007

## SAMPLE COVERING LETTER

**International Journal of Environmental Research (IJER)**
Graduate Faculty of Environment,
University of Tehran
P. O. Box: 14155-6135
Tehran, Iran

Subject: **Submission of manuscript**

Dear Editor,

I would like to submit the following manuscript for possible evaluation

| |
|---|
| Manuscript Title: |

| |
|---|
| Name and address of corresponding author: |

| | |
|---|---|
| Telephone # | Fax # |

| |
|---|
| Email: |

I affirm that the manuscript has been prepared in accordance with IJER Notes for Authors.

I have read the manuscript and I hereby affirm that the content of this manuscript or a major portion thereof has not been published in a refereed journal, and it is not being submitted for publication elsewhere.

Type of Manuscript (check one):

- ☐ Research original paper
- ☐ Review Article
- ☐ Short Communication
- ☐ Research Note

**Signature of Corresponding Author**

*Int. J. Environ. Res., 1(3): 198-203, Summer 2007*
*ISSN: 1735-6865*

# Statistical and Dynamic Modelling of Algea in Stream Systems

**Mirbagheri, S. A.[1*] and Tanji, K. K.[2]**

[1]Department of Civil Eng., Khajeh Nasir University, Tehran, Iran

[2]Department of Land, Air and Water Resources, University of California, California, USA

Received 15 Jan. 2007; Revised 20 May 2007; Accepted 30 May 2007

**ABSTRACT:** Algal growth and the water quality effects were studied and modeled in the lower reaches of the Colusa Basin Drain as a stream system. Statistical Techniques such as the correlation matrix and the stepwise multiple regression are performed on such variables as algal biomass, ammonia, nitrate, orthophosphate, temperature, and the solar radiation intensity in deriving an algae statistical model. Orthophosphate is shown as the limiting nutrient controlling the growth kinetics of algae. .A one-dimensional dynamic mathematical and computer model is formulated to simulate suspended algae and water quality parameters. The mathematical solution is obtained by a finite-difference implicit method. The model is calibrated and confirmed with the data collected from the lower 30 km reaches of the Colusa Basin Drain. The simulation results for both the statistical and the dynamic models are in good agreement with measured values. The model can be used to evaluate water quality in stream systems.

**Key words:** Algae, Statistical, Dynamic, Modeling, Water Quality, Streams, Limiting Factors

*Corresponding author: Email-drmirbagheri@yahoo.com

## INTRODUCTION

Analysis of suspended algae in response to limiting factors has been useful in understanding algal growth dynamics, because it has frequently revealed causes for change in population density (Colterman, 1975; Droop 1974; Rhee, 1978.) Population density is controlled by: 1) physical factors such as light intensity, temperature, turbidity, and turbulence; 2) biochemical factors such as inorganic nutrients, organic nutrients, growth-promoting and inhibiting substances, toxic materials, and heavy metals; and 3) biological factors such as parasitism, predation, and competition. In the ideal situation one factor is so rate limiting that it controls the algal biomass while all other factors may be at optimal levels.

This paper attempts to relate suspended algal biomass to changes in limiting nutrients and physical factors. Because population changes in nature can rarely be explained by only one factor, it is necessary to use methods of analysis that permit evaluation of several factors simultaneously. Statistical techniques such as multiple regression analysis make possible the simultaneous consideration of several suspected factors and the evaluation of relative importance of each factor. In addition to the empirical-statistical techniques, a dynamic simulation approach can be developed on the basis of conservation of mass to describe and predict the behavior of suspended algae and nutrient in the system.

Although excellent references are available in discussions of algae and nutrient in lakes (Chen, 1970 and Ditoro *et al*., 1970), less is known about algae and nutrient in stream systems. The objectives of this study are:

a) To determine to what extent the algal biomass abundance and growth kinetics could be correlated with limiting nutrient concentrations and physical factors; and b) to develop and compare the statistical and dynamic models which approximate the suspended algal biomass and water quality parameters in the prototype.

## MATERIALS & METHODS

The study area is the Colusa Basin Drain (CBD)that is located on the west side of the Sacramento Valley. The CBD conveys flood runoffs and irrigation waters from about 4,050 km 2 of watershed and agricultural lands into the Sacramento River. Water samples for biological and chemical analysis were obtained from CBD and two tributaries; Stone Corral at Two Mile Road and Glenn-Colusa Irrigation District (GCID) main canal. Samples were taken at the surface, one secchi-disc depth and two secchi-disc depth with a Van Dorn bottle cast. Chemical parameters measured were: total organic carbon (carbon analyzer), dissolved oxygen (membrane electrode), ammonia nitrogen (calorimetric phenolate), nitrate nitrogen (calorimetric), organic nitrogen (total kjeldahl), and orthophosphate phosphorus (calorimetric). Temperature was determined with a bucket thermometer. Light availability for photosynthetic organisms was measured in the water column using a LI- 185 quantum/radiometer/photometer; algal biomass was determined by measuring chlorophyll- a. Assuming 1.5 percent of the dry weight of organic matter (ash-free weight) of the algae is chlorophyll-a, algal biomass may be estimated by multiplying the chlorophyll-a content by a factor of 67. Chlorophyll-was measured using the fluorometric technique suggested by Vollenweider (1963). Magnesium carbonate ($MgCO_3$) was added as a preservative to prevent acidification of the acetone. Under acidic conditions chlorophyll can degrade into phaeophytin and other physiologically inactive products. These products have absorption peaks in the same regions of the spectrum as the chlorophyll and produce errors in chlorophyll determination. These potential errors were minimized by addition of $MgCO_3$, but some error may still exist as a result of the presence of phaeophytin and other chlorophyll degradation products among the living cells. In addition to the above, hydraulic parameters of the flow regime were also determined. The correlation matrix on the data revealed that except for solar radiation intensity and temperature, other variables were not correlated significantly. The solar radiation and temperature were correlated, with $r^2$-values greater than 0.70. Generally, if $r^2 = 0.7$ for two variables, the variable that shows greater correlation should be considered for further analysis. In the present study, the solar radiation showed a negative correlation $r^2 = -0.1$ with algal biomass, so temperature, with a $r^2$ value of 0.060, was used as independent variable for further analysis. The results of the stepwise multiple regression analysis on algal biomass and on variables such as orthophosphate, nitrate, ammonia, and temperature revealed the order of importance of the variable. These variables accounted for 99 percent of the variation of suspended algae in the study area. Orthophosphate accounted for 70 percent, and the other two variables for 29 percent. The results of multiple regression analysis led to the development of regression model given as:

$$G_{SA} = 12.34\,PO_4 - 0.015\,T + 1.06\,NO_3 + 0.12\,NH_3 - 0.046$$

In which $G_{SA}$ =suspended algal biomass (mg/L), $PO_4$ =orthophosphate concentration (mg/L), $NO_3$=nitrate concentration (mg/L), $NH_3$ = ammonia concentration (mg/L), and T=Temperature (° C).Phosphorus in the Colusa Basin Drain water appears to be the limiting nutrient controlling algal biomass productivity. The phosphorus concentration was low, ranging from 0.01 to 0.10 Mg/L, and the sources of phosphorus are most probably form the chemical weathering of primary minerals and decomposition of soil organic matter and vegetation. Phosphorus compounds in soils in the form of calcium, aluminum, or iron. Phosphates usually have very low solubility and hence phosphorus concentration levels in water are typically low. Phosphorus is also adsorbed by clay and organic particles and these particulate forms dominated in CBD. Since the current velocity of the CBD dropped from upstream to downstream, CBD-3 (Colusa Basin Drain at Tule Road) to CBD-1 (Colusa Basin Drain at Road 99E and 108), the suspended particle settled out. Therefore, a decrease in phosphate concentration in this region of the CBD was due to phosphate adsorption by suspended particles (Tanji *et al.*, 1980).

The results of this analysis between algae and orthophosphate indicate that the algal biomass is exponentially related to the orthophosphate concentration, as shown in Fig. 1. A strong correlation coefficient $r^2 = 0.91$ indicates that the orthophosphate is the most important factor controlling algal growth in the study area. To develop a relation between algal biomass and the limiting factor a simple regression analysis was performed.

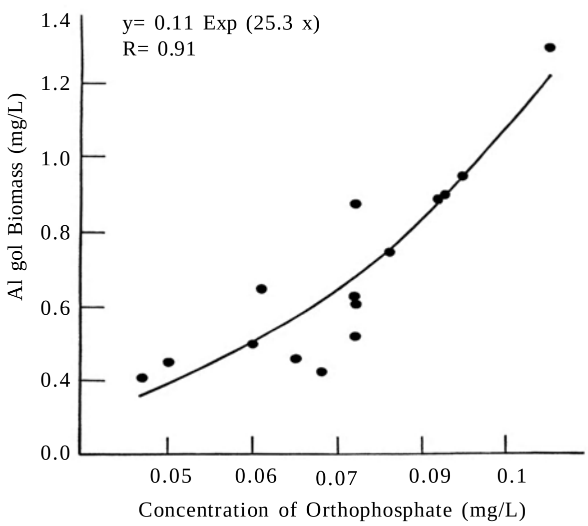



**Fig.1. Relationship between algal biomass and orthophosphate**

level $t_J$ Statistical methods were used to relate the algal biomass to factors controlling its growth kinetics. These methods are described below:

1. Correlation Matrix Method- This method was performed to determine which of the variables (ammonia, nitrate, orthophosphate, temperature and solar radiation intensity) are related to algal biomass. This method singles out the highly correlated variables. Algal biomass was treated as a dependent variable, and all other factors were treated as independent variables.

2. Stepwise Multiple Regression Method- After determining a correlation matrix, stepwise multiple regressions was performed to evaluate which independent variables explained the variation in the dependent variable, the dependent variable was algal biomass, and independent variables were orthophosphate, nitrate, ammonia, and temperature. For this analysis, an updated version of the statistical package for the social sciences (SPSS) was used. Two main criteria were applied at each step as a basis for selecting the best equation describing the algal biomass productivity in the system.

a) The F-test was used to determine the significance of the regression and to evaluate whether the amount of variation in the algal biomass described by the regression equation was statistically significant.

b) The square of the multiple correlation coefficients $(r^2)$ was compared with the standard error of the estimate before and after each new independent variable was added to the equation.

3. Simple Regression- After the correlation matrix and multiple regression analysis were performed on the dependent and independent variables, simple regression analysis was carried out to develop a functional relation between the algal biomass and its limiting factor.

### *Dynamic Simulation Approach*

In general, dynamic simulation modeling of phytoplankton and nutrients is at an advance stage of development. These models are based on conservation of mass and they take into account the hydrodynamic transport and the internal sources and sinks (Chen *et al.,* 1976, Contractor *et al.,* 1980, Ditoro *et al.,* 1973 and Toerien *et al.*, 1973). The majority of these models have been applied to real systems with satisfactory results. The major differences between the various models are the form of internal sources and sinks. Some models include predation of phytoplankton by zooplankton (Chen *et al* 1970 and Ditoro *et al.,* 1973) and such factors as temperature, light intensity and nutrient.

A dynamic simulation model was developed to describe and predict the behavior of suspended algae and nutrient. The model calculates the growth and decay of algae in the drain or river system in response to flow rate, water temperature, solar radiation intensity, and nutrient concentration.

### *Model Formulation*

The formulation is based on the mass balance for a particular substance. The statement of the mass balance can be given as:

Accumulation = Inflow - outflow + sources or sinks

The mass-balance statement yields the equations for the suspended algae, ammonia, nitrate, and orthophosphate. These equations take into account advective transport, diffusive transport, growth and respiration, chemical reactions, and lateral inflow of point and non-point sources. The equations are written in one dimensional form, assuming steady-state, non-uniform, spatially varied stream flow, as follows:

1. Mass Balance Equation for Suspended Algae:

$$\frac{\partial S_a}{\partial t} = -\frac{1}{A}\frac{\partial}{\partial X}(AuS_a) + \frac{1}{A}\frac{\partial}{\partial X}[AD_X \frac{\partial S_a}{\partial X} + \frac{1}{A}\frac{dS_a}{dX} + (\mu - r - S)S_a] \quad (2)$$

In which $S_a$ =concentration of suspended algae (mg/L), A=cross-sectional area of flow $(m^2)$, u=average current velocity (m/sec), t=Time (sec), $\mu$ = local specific growth rate of algae (L/day), r=local respiration rate of algae (L/day), and S=local settling rate (m/day). The third term in equation 2 takes into account the lateral inflow or outflow $Q_X S_a$ in which $Q_X$ = flow rate $(m^3/\mathrm{sec})$.

2. Mass-Balance Equation for Nitrogen

$$\frac{\partial N_1}{\partial t} = -\frac{1}{A}\frac{\partial}{\partial X}(AUN_1) + \frac{1}{A}\frac{\partial}{\partial X}[AD_X \frac{\partial N_1}{\partial X} + \frac{1}{A}\frac{dN_1}{dX} + (\alpha_1 r S_a - \beta_a N_1 + \alpha_a / A) - \alpha_3 S_a \quad (3)$$

In which $N_1$ = concentration of ammonia nitrogen (mg/L), $\alpha_1$ = fraction of respired algae re-solubilized as ammonia nitrogen (mg/L), $\alpha_2$ = benthos source rate for ammonia nitrogen (mg/L.day), $\alpha_3$ = fraction of algal biomass that is ammonia (mg/L), $\beta_1$ = rate constant for the biological oxidation of ammonia. The third term in equation 3 takes into account the lateral inflow $(Q_X N_1)$.

$$\frac{\partial N_2}{\partial t} = -\frac{1}{A}\frac{\partial}{\partial X}(AUN_2) + \frac{1}{A}\frac{\partial}{\partial X}(AD_X \frac{\partial N_2}{\partial X}) + \frac{1}{A}\frac{dN_2}{dX} + (\beta_1 N_1 - \alpha_1 US_a) - \beta_2 S_a \quad (4)$$

In which $N_2$ = concentration of nitrate nitrogen (mg/L) and 2=fraction of algal biomass i.e. nitrate (mg/L).

3. Mass Balance Equation for phosphorus

$$\frac{\partial P}{\partial t} = -\frac{1}{A}\frac{\partial}{\partial X}(AUP) + \frac{1}{A}\frac{\partial}{\partial z}(AD_X \frac{\partial P}{\partial X}) + \frac{1}{A}\frac{dP}{dX} + (\alpha_4 r S_a - \alpha_4 \mu S_a - \alpha_4 \mu S_a + r / a) \quad (5)$$

In which P=concentration of orthophosphate ion (mg/L), $\alpha_4$ = fraction of algal biomass that is phosphorus and r=benthos source rate for phosphorus (mg/L.day). The third term in equation 5 takes into account the lateral inflow $(Q_X P)$.

### *Method of Solution*

An implicit finite difference scheme was used to solve the above partial differential equations numerically. This scheme has the advantages of being stable even when large time intervals are chosen, which, in turn, provides considerable savings for long-term simulation of large-scale problems. To apply the solution procedure, equations 2 through 5 were written in the following generalized form:

$$\frac{\partial S}{\partial t} = -\frac{1}{A}\frac{\partial}{\partial X}(QS) + \frac{1}{A}\frac{\partial}{\partial X}(AD_X \frac{\partial S}{\partial X}) + \phi \quad (6)$$

In which S=concentration of constituent to be simulated, Q=flow rate, and $\phi$ = sources and sinks. The equation was written in an implicit finite difference form for reach length x and grid points I-1, I+1, as shown in Fig. 2a.

The temporal derivative was approximated for a finite set of coordinates X and t. the spatial derivatives were approximated along three points, I-1, I, and I+1 at time J+1 as shown in Fig. 3b. All variables were known for all computationalelements of the network at the time level t. The known values of the variables at time were found by solving the system of linear algebraic equations formulated from tridiagonal matrix which resulted from substitution of the finite-difference approximations. The special technique used for solving such matrix equations was the modified Gaussian elimination algorithm. The equations were solved by taking proper boundary and initial conditions. Details of the solution procedure are found in documentation (Mirbagheri *et al.*, 1981).

### *Initialand Boundary Condition*

The concentration of suspended algae and nutrients along the CBD was not known at the beginning of the simulation period. Therefore, in the present study, the initial conditions are said to be zero. Since the transport is unidirectional in most freshwater streams, i. e., there is no significant transport upstream, the concentration in the flow entering the CBD-3 was taken as the upstream boundary condition, $S_0^{J+1}$.

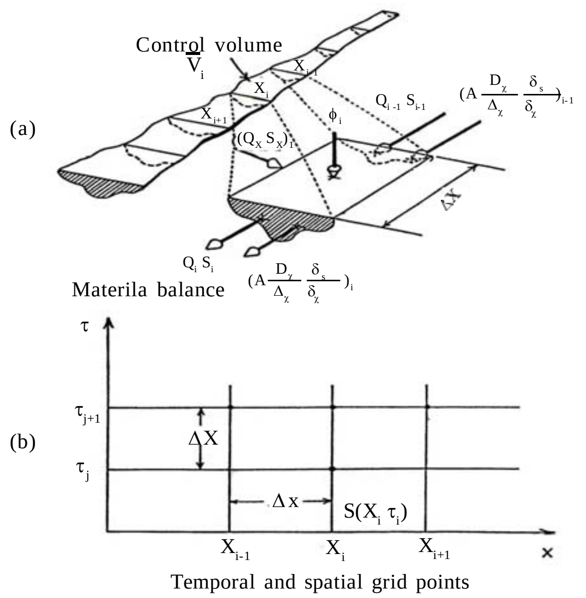



**Fig. 2. Discretized Stream System (After Water Resources Engineers, Inc., 1976)**

Since the ration x/uT in the numerical scheme should be approximately equal to the current velocity of water in the prototype, suspended algae and nutrient will travel a distance x in a time interval t. Thus if only advection operates, the downstream boundary condition can be given approximately by $S_{N+1}^{J+1} = S_N^J$ where $S_{N+1}^{J+1}$ is the concentration just downstream from the end of the system i.e., CBD-1.

### *Smulation Results*

Measured and simulated concentration profiles along the Colusa Basin Drain were compared to determine the accuracy of the models. The suspended algae concentration was simulated by both the regression analysis and the dynamic models as shown in Fig. 3. Both models followed basically the same pattern as the measured value of suspended algae. Such behavior was expected, because phosphorus was considered to be a limiting nutrient. In the regression model, the concentration of orthophosphate controls algal biomass and light has no effect, whereas the dynamic model considers the effect of both light intensity in the water and the concentration of orthophosphate.The algae concentration simulated by the regression model is closer to the measured value than is the value simulated by the dynamic model. The regression model over estimates the value of suspended algae from CBD-1A (km 24) to CBD-1 (km 30), as shown in Fig. 4 possibly because of a high concentration of nitrate.

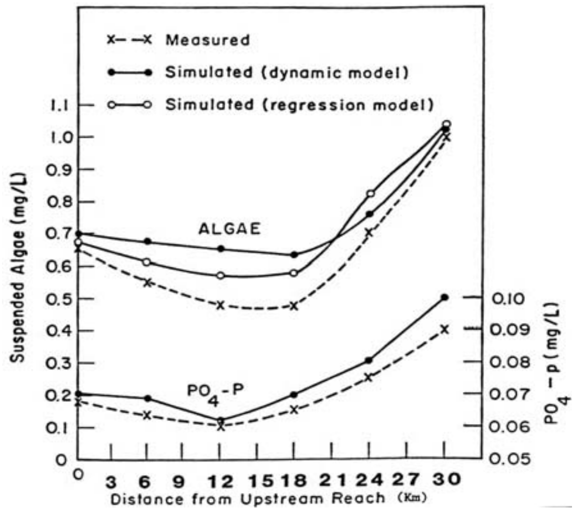



**Fig. 3. Algal and Phosphorus Simulation Results**

Generally, the algal biomass should increase with time and distance, but it decrease between CBD-2A (6 km) and CBD-1B (18 km) and then increased. This may be done to endogenous respiration and to the settling rate of algae. The lateral inflow of algae form the rice fields between CBD-1B and CBD-1 is another possible explanation. Orthophosphate, ammonia, and nitrate were simulated by the dynamic model, as shown in Fig. 3 and 4. Since the concentration of phosphorus and algae are interrelated, the concentration profile for phosphorus followed the same pattern as algae. Figure 4 shows that the agreement between simulated and measured values of phosphorus is satisfactory. The simulation results of ammonia followed the same pattern as the measured one within 80% agreement, as shown in Fig.4. Simulated data on nitrate overprotected the concentration of nitrate form CBD1A to CBD-1, as shown in Fig. 4. A large population of terrestrial and aquatic plants grow on the bank and in the water, but nitrate uptake by there plants is not considered in the model, for no data are available on the biomass of these plants. In general, the simulated results for suspended algae and nutrients agreed well with the measured values, the overall behavior of this system is reasonably well represented by the model output.

## CONCLUSION

The principal objective of this research was to obtain a more clear understanding of algal rowth and limiting nutrients as well as transport mechanisms in fully mixed stream systems. A regression model was developed based on the correlation matrix and stepwise multiple-regression analysis on such variables as algal biomass, ammonia, nitrate, orthophosphate, temperature, and solar radiation intensity. The specific growth, endogenous respiration, settling rate of algae, and half-saturation constant of phosphorus were evaluated. The rating curves for the current velocity, discharge, and water depth were established. The functional relation were developed and used as a flow model to generate hydraulic data for the dynamic model. Based on the model formulation, a computer code was developed to simulate suspended algae and nutrient in the one-dimensional fully mixed Colusa Basin Drain. The model was calibrated and validated based on the data collected along the Colusa Basin Drain.

Finally from the study of algae and the limiting nutrient we conclude that:

1. Phosphorus is the most important limiting nutrient.
2. Nitrate and temperature are of secondary importance.
3. Photo inhibition is significant at the water surface at high light intensity.
4. A simple statistical model agrees somewhat with kinetic models on algal growth mainly controlled by phosphorus.
5. The statistical model simulates closer to measured values than the dynamic model but it is site-specific.

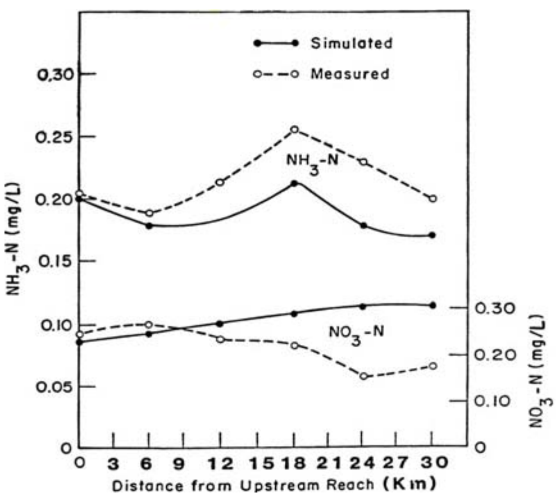



**Fig. 4. Ammonia and Nitrate Simulation Results**

6. The simulated dynamic model agrees well with the measured values.
7. The dynamic model can be applied to other systems and other locations if provided the necessary input information.
8. Both models can be applied to stream systems to evaluate water quality parameters.

## REFERENCES


Chen, C. W., (1970). Concepts and Utilities of Ecologic Model. J. Sanit, Eng. Div., ASCE, **96**, (SA5), 1086-1097.

Chen, C. W. and Wells, J. T. Jr., (1976). Bise River Ecological Modeling. Modeling Biochemical Process in Aquatic Ecosystem, in R. P. Canales, Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan, 171-203.

Colterman, H. L., (1975). Physiological Limnology. Development in Water Science, 215-247.

Contractor, D. N. and King, P. H., (1980). Water Quality Modeling in the Upper Reaches of the Chowan. Water Resources Bulletin, Am. Water Res. Assoc., **16**(1), 118-126.

DiToro, D. M., O’Connor, D. J. and Thomann, R. V. (1970). A Dynamic Model of the Phytoplankton Population in the Sacramento-San Joaquin Delta. Nonequlibirium System in Natural Water Chemistry, in R.E. Gould, Am. Chem. Soc., Washington D.C., 131-180.

Ditoro, D. M., O’Connor, D. J. and Thomann, R. V. (1973). Phytoplankton-Zooplankton-Nutrient Model of Western Lake Erie. *Environmental Engineering and Science Program,* Manhattan College, New York.

Droop, M. R., (1974). The Nutrient Status of Algal Cells in Continuous Culture. J. Marine Bio. Assoc., U.K., **54**, 825-855.

Mirbagheri, S. A. and Tanji, K. K., (1981). Sediment Characterization and Transport Modeling in Colusa Basin Drain. University of California, Davis, Water Science and Engineering Paper 4021, 259.

Rhee, G. Y., (1978). A Continues Culture- Study of Phosphate Uptake, Grout Rate and Polyphosphate in Schenedesmus. J. Phycology, **9**, 495-506.

Tanji, K. K., Singer, M. J., Henderson, D. W., Whittig, L. D. and Biggar, J. W., (1980). Non-point Sediment Production in the Colusa Basin Drainage Area. 1978-79 Annual EPA-Report, Grant No. R805462, University of California, Davis, Water Science and Engineering (4019), 1980, 157.

*Int. J. Environ. Res., 1(3): 204-213, Summer 2007*
*ISSN: 1735-6865*

# River-Valleys as an Intra-city Natural Feature

**Micarelli, R.[1], Irani Behbahani, H.[2*] and Shafie, B.[2]**

[1] Department of Environmental Design, University of Politechnico di Milano, Italy
[2] Department of Environmental Design, Faculty of Environment, University of Tehran, Tehran, Iran

Received 20 Jan. 2007; Revised 25 April 2007; Accepted 15 May 2007

**ABSTRACT:** Intra-city natural structures have always had a key role in creating sustainable urban greenspaces. Adapting to natural features and relating the intra-city greenspaces to such natural structures as river-valleys, hillsides, lakes and forests, guarantee the endurance, sustainability and longevity of the natural quality of city. This paper looks at intra-city natural structures which have undergone wholesale changes and been ruined, and considers the lives of these invaluable natural structures which have been endangered due to gross human interference and pressure, regardless of physical and biological features. River-valleys in Tehran have always had a significant role in offering valuable bio-environmental services to the city. From the time of Qadjar era, villages enjoying favorable climate were built outside the city, and the villa of the governors and affluent people were built near hillsides across river-valleys because of the abundance of running water, cool weather in the summer and natural plant life. Little by little green corridors of Shemiranat were built near river-valleys, which formed the axes of the development of the city at the time Pahlavi dynasty. From then, the development of the city towards hillsides, regardless of these natural structures, increased and the destruction of these urban natural spaces have posed serious problems nowadays. Familiarity with these natural structures, their preservation and organization, and making the optimum use of them seem to be a very critical issue. Taking an ecological approach in this paper, is an attempt to look at the intra-city river-valleys. To do so, the data collected from a natural river-valley is used as evidence to back up any claims made in this regard.

**Key words:** River-valleys, Ecological Restoration, Jajrood, Darband

* Corresponding Author: Email-hirani@ut.ac.ir

## INTRODUCTION

The human interference in rivers has been far from a success. River-valleys and floodplains have always been regarded as suitable places of residence. Changing and straightening the course of rivers by means of simple Euclidean geometry figures have caused occasional floods whose prediction is not easy. Another problem which often arises at local levels is the effect of canalization systems in areas leveled for residence and road making. The leveling of these areas speeds up the flow of flood and rain. This issue is a stumbling block in the way of storing water and prevents the natural drainage. Likewise, it exacerbates the impacts of flooding (Bell, 1999).

Therefore, getting to know the natural structures of this system and riparian plants patterns can enormously help protect river-valleys within the city and avoid dreadful disasters.

Owing to the sharp increase in construction work in Tehran, the ecological structure of the city has undergone sweeping changes, so creating ample greenspaces as the main bio-environmental balancing factor is a must At present, although Tehran river-valleys are regarded as the most favorable areas of the city enjoying great climate due to the existence of private gardens and old trees near the hillsides, unfortunately they do not lie in the urban landscape and most of them have been either covered or changed into sewage canals (Behbahani, *et al.,* 2002).

Taking into account different dimensions and combining art and science, environmental and landscape design has opened up a new window towards sustainable design of landscape. The scientific basis of the issue can be landscape ecology which focuses on the structures and patterns of landscapes and horizontal relationship between elements. Considering aesthetic factors, visual variables, the way they are organized, and also using natural forms and materials account for the artistic dimension of the designing. As a result, the structures and the interior relationship between different parts of the environment are understood, the hidden patterns are revealed and the change of spatial arrangement of the structures which is the result of natural processes, is interpreted (Shafie, 2003).

The spatial-temporal data (in terms of place and time) about a given case, helps us make a sound decision on the restoration of a ruined river-valley. The data can also be used as a reference in the future. This will lead to putting forward principles and approaches which, once adopted, will preserve the riverbed, riparian plants and its connection to the urban greenspaces. As a result, the preservation of the natural and man-maid ecosystems is guaranteed. A river or river-valley system is a continuum one which usually exists in natural connection with the flow of water, the movement of alluvium, temperature and other variables which are called dynamic equilibrium (NTIS, 2000). These ecological corridors are complex ecosystems consisting of the earth, plant lives, animals and the fluvial network between them. They offer ecological services like balancing the fluvial flow, saving and purifying water and providing a residence for aquatic and terrestrial animals and plants. Moreover, they are quite different features and characteristics from the neighboring areas and uplands, in terms of the type of soil and plants (NTIS, 2000).

The plant life structure of river-valleys ensures the success of fluvial systems. The movement and the flow of the river and the increase in the number of twists at the end of the river course bring about topographical varieties. The flow of water and even flooding often have greater impacts on lower areas than higher ones and the preservation of alluvium depends very much on the relative slope of the lands (Bell, 1999). Some areas are inundated much more than others and the trees and bushes which grow on the dykes level the river banks and gather the detritus while flooding. Therefore, the existence of various and plentiful plant patterns, are in close relation with such processes as flooding, erosion and sedimentation (Fig. 1). The protracted and curvilinear patterns of the river-valleys are also reflected in the plants patterns and configuration. The intensive growth of plants on the dykes across the old bends, contributes to the continuum of the pattern (Bell, 1999). From an ecological point of view, landscape is a heterogeneous land consisting of groups of ecosystems or spatial units which influence each other and has similar form all over it and its three basic and fundamental features are structure, function and change or dynamism (Forman and Gordon, 1986). Therefore, landscape is a highly complicated system which reflects different patterns according to its scale and parts (Farina, 1998). These natural and structural patterns have been transformed due to human destruction and interference.

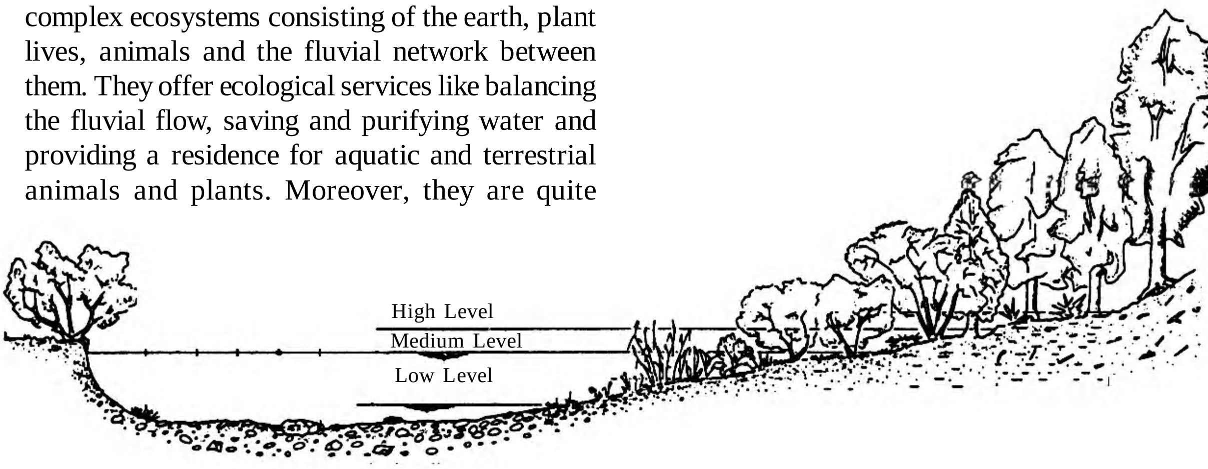



**Fig. 1. A common plants configuration in river-valley**
Source: Di Fidio, M. (1995) Icorci D'acqua. Pirola

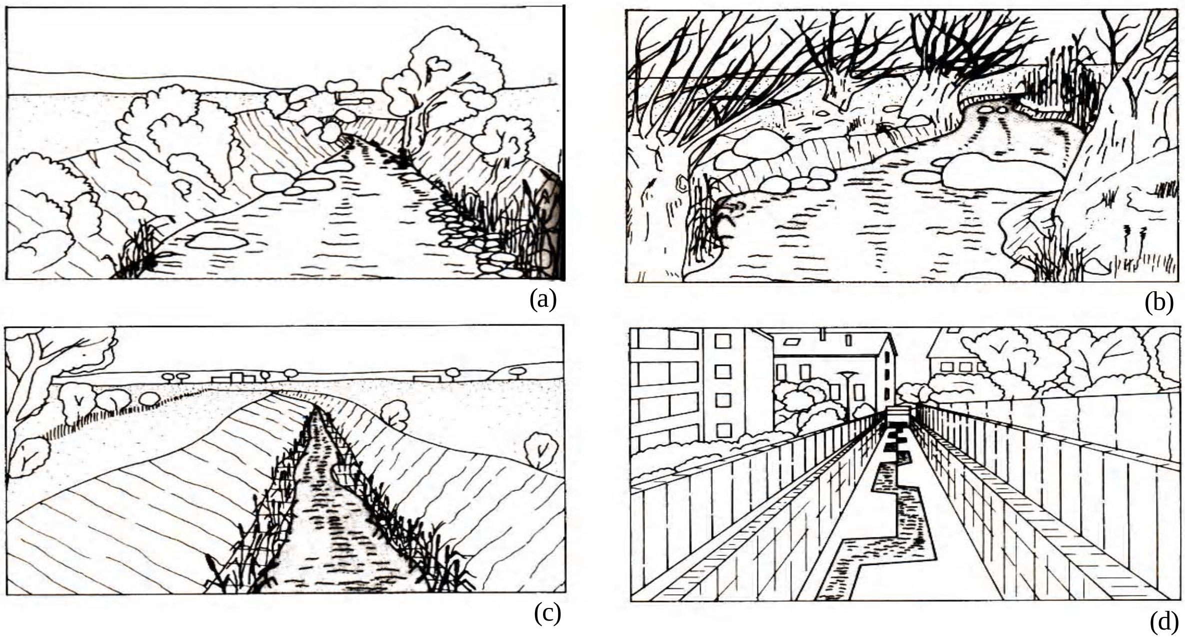


**Fig. 2. Degradation of river-valley due to human disturbance**
Source: Di Fidio, M. (1995)Icorci D'acqua. Pirola

As a result, the natural performance of the river system has been thrown into disorder after the destruction of plant life of the river-valley because of the leveling and canalization of the river and its transformation into a canal (Fig. 2).

Therefore, intra-city river-valleys are seen as minor elements beside urban patches and corridors. In fact, the form of the river follows of urban structure and man-maid patches. The river structure is a natural corridor which usually flows in a rubble bed, and the plants around it and their configuration, follow the natural form of the river and this pattern continues for several kilometers in the same way. When the natural patterns are not repeated in the river-valleys, warns of an event or disturbance,which has given rise to a structural change in the river-valley in the city. In fact, the landscape of the river-valley inside the city has deteriorated and degraded. It is a clear indication of the fact that they are in dire, need for restoration so that, they can take on their original patterns prior to disturbance (Shafie, 2003). Ecological restoration is, in fact, bringing an ecosystem back to its original conditions and performances prior to disturbance as much as possible (Harker,1999). As far as river-valleys are concerned, this issue goes beyond growing various plants with the express purpose of leveling the soil, preventing erosion or creating landscapes by growing indigenous plants. In fact, it is an attempt to make nature produce a reaction (S.E.R., 2000).

In this regard, the physical and biological features of a river-valley that still flowing in a natural bed outside a city, are explored as evidences for intra-city river-valleys , in order to comparative study. In order to understand the physical and biological changes of the intra-city river-valleys, the natural structure of an extra-city river-valley (i.e. a part of the Jajrood river in the Khojir national park) and the Darband river-valley, from the Sarband square up to the Shahid Hemmat is examined. Then with a comparative study of the cross-sections of the Jajrood river-valley and the Darband river-valley, an intimate knowledge of the changes of this natural structure in the city is acquired, and on the basis of that acquired knowledge, some suggestions are put forward regarding ecological planning and programming (Fig. 3). The main branch of the Jajrood river, as long as 140 km, rises in the heights of the Kharsang mountain in the southern part of central Alborz heights in the north-east of Tehran and continues southwards.The water supply of this river is provided by some tributaries, springs, underground waters and precipitation. Having passed the Latyan dam, this river flows only through the Khojir national park. However, its branches flow outside the national park.

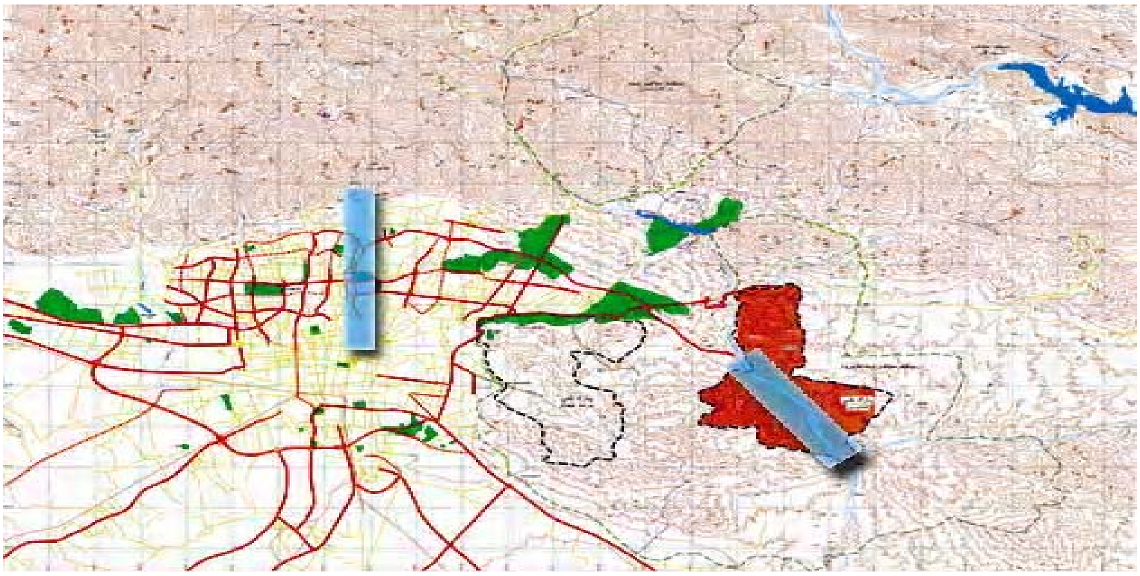


**Fig. 3. The scope of study in Darband and Jajrood river-valley**

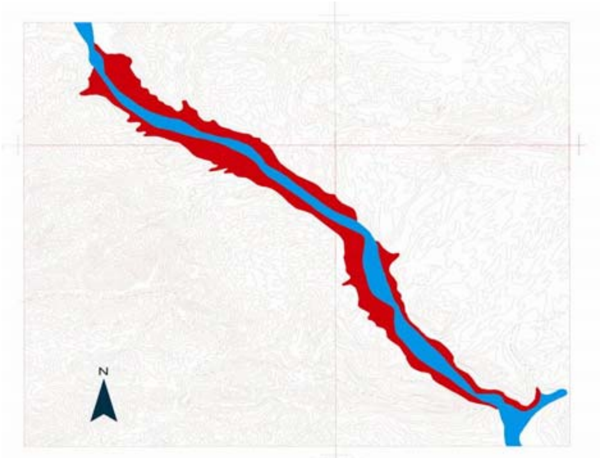


**Fig. 4. The area of study in Khoir (Jajrood river-valley)**

**Fig. 5. Plants configuration in Jajrood river-valley**

Having passed the Khojir national park, this river joins the Damavand river in Mamlo and flows towards Varamin and the plains in the south of Tehran. The waterways of the Jajrood river in the Khojr national park are mostly used for agricultural purposes. Also some wells have been dug alongside.

The area of study has 300 m width, according to park management comprehensive plan in Khojir and Sorkhehessar national parks (Makhdoum, *et al.*, 1987). Then, it was corrected by contours and land form (Shafie, 2003). So, width of the area varies from 50 to 500 m (Fig. 4). The dry and cold climate of the area has givenrise to the woody and herbaceous plants. The woody types of trees and shrubs include Populus nigra, Salix sp. and Tamarix sp. (Fig. 5).

Among the main communities of bushy plants, *Rubus sp*. is outstanding. *Rubus sp*. increases considerably as one approach the southern areas of the park. *Salix sp* and *Populus nigra* are indigenous to the region and there are various communities of them alongside the river-valley. *Tamarix sp* is the main indigenous shrubs alongside this river-valley. *Tamarix sp,* along with *Salix sp,* has formed unique riparian communities. The spatial arrangement of these plant communities shows the most important structural pattern in this river-valley (Shafie, 2003). The plantation of *Ailanthus sp*.and *Pinus eldarica* in this region proved a total success. However, they are not among its indigenous and riparian communities.The plantation of *Ailanthus sp*.and *Pinus eldarica* in this region proved a total success. However, they are not among its indigenous and riparian communities.

*Phragmites australis, Bromus sp.* ,*Achillea sp., Reseda lutea, Ajuga chamacitus* , *Hypericum sp., Allium sp.,* and *Artemisia sieberi* are among the other herbaceous and bushy plants which grow alongside or far from the river.

The Darband river rises in the Toochal heights. It has some branches on top, the most important of which flow downwards near the Shirpala castle and from the Doqolou (twin) waterfall. Another branch is the Oosan river. These two branches converge into one to form the Darband river. The Darband river is 4723 meters long and 7 meters wide on average. This river has water all the time and its mountainous area is measured to be about 2200 hectares. The Darband river has a steep slope which decreases in gravity as it approaches the castle. This part up to the Sarband square is 1500 meters long, 9 meters wide and 6 meters deep on average. The bed of the river in this part is stony (Baft-e shar consulting eng. , 2003).

From the Sarband square, the presence of the river is felt in the urban area since those regions whose heights are higher than 1800 meters are excluded from urban planning and programming. From the Sarband square up to the northern angle of the Saad Abad palace, a concrete canal, which is about 1000 meters long, has been built. From this area onwards, the river enters the complex of the Saad Abad palace (which is also Jafar Abad). This part is about 500 meters long. Most of the stream is natural except for 70 meters which have a stone wall. This river enters the Shahid Jafari street from the south of the palace and flows alongside it. Then under the Tajrish bridge, it joins the Golab Dareh stream to form the Maqsoud Bak stream. Alongside the Dr. Shariati street, this stream continues to flow through the Elahiyeh, Zargandeh, Davoudiyeh districts and the Mother square to reach the junction of Pasdaran, Shariati and the Shahid Hemmat highway. In the end, having irrigated farmlands, it narrows down in the Band Ali Khan lagoon and disappears in a salt desert. The green space of this river-valley is not noticeable and most of it is in the southern part. Moreover, the construction work in the middle or the southern part of the stream is relatively sparse.

## MATERIALS & METHODS

The reasons for choosing Jajrood and Darband river-valleys as subjects of the study are as follows:

- Being in the same climatic range (mountainous cold and dry to moderate)
- Both river-valleys rise in the southern heights of the central Alborz. Furthermore, both have rubble beds.
- Jajrood river-valley is one of those river-valleys outside Tehran which are used as outdoor recreation areas by Tehran citizens.
- That part of Jajrood river-valley which flows through the Khojir national park enjoys a rather virgin nature since, in accordance with the laws of the fourfold districts of the environment department, the natural entity and being of national parks should be kept intact and natural as much as possible. Therefore, it is a very appropriate case for study as a river-valley having remained intact in structure and entity. However, there are some parts which have been slightly damaged in this park.
- The Darband river-valley is one of those intra-city river-valleys in Tehran which are regarded as recreation areas by Tehran citizens from the old times. Because of its passing the Saad Abad museum-palace and some districts which mainly had gardens, garden-villas, residential places and the gardensof the embassies, its preservation as a natural and precious feature, has always been of tremendous importance.

However, its natural and genuine face has changed due to the construction development and an increase in the price of the lands.In order to gain a thorough knowledge of the structure of river-valleys, all the study sections of the Jajrood and Darband river-valleys were categorized into five continuous sequences. This categorization has been based on geomorphologic features which take into account land form, plant life, landscape grains, the flow of the river water and the way it is handled. The sequencing of the Jajrood river-valley in the Khojir national park mostly has been in accordance with present land use (Fig. 6). So that from the north to the south, the district allocated for plantation, agriculture and green houses were put in the first sequence; the Khojir forest park and the Khojir village were put in the second sequence; burnt areas were put in the third sequence, cultivation areas were put in the fourth sequence and finally those lands close to warmer and drier districts were put in the fifth sequence.

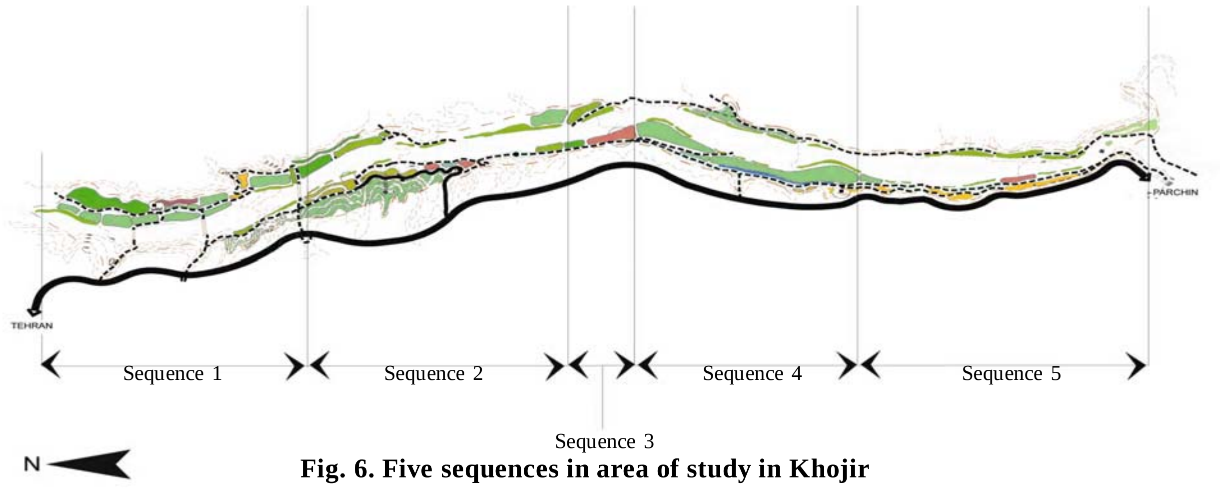



**Fig. 6. Five sequences in area of study in Khojir**

In the Darband river-valley, relatively virgin lands up to the very top were put in the first sequence. The Saad Abad palace and the areas upto the Tajrish square were put in the second sequence; areas from the Tajrish square up to the Elahiyeh district were put in the third sequence; the Elahiyeh district and the areas up to the north of the Shahid Ayatollah Sadr highway were put in the fourth sequence; and finally the Zargandeh, Davoudiyeh, and Mirdamad districts which are more populated residential areas were put in the fifth sequence.

In every one of these sequences, a section of the river-valleys and nearby areas has been drawn.

` The comparison of these sections from the north to the south in each river-valley and the comparison of the sections of the Jajrood river-valley with that of the Darband river-valley reveal the changes and disturbances brought by human interference in the structure of the intra-city river-valley (Figs. 7 & 8).

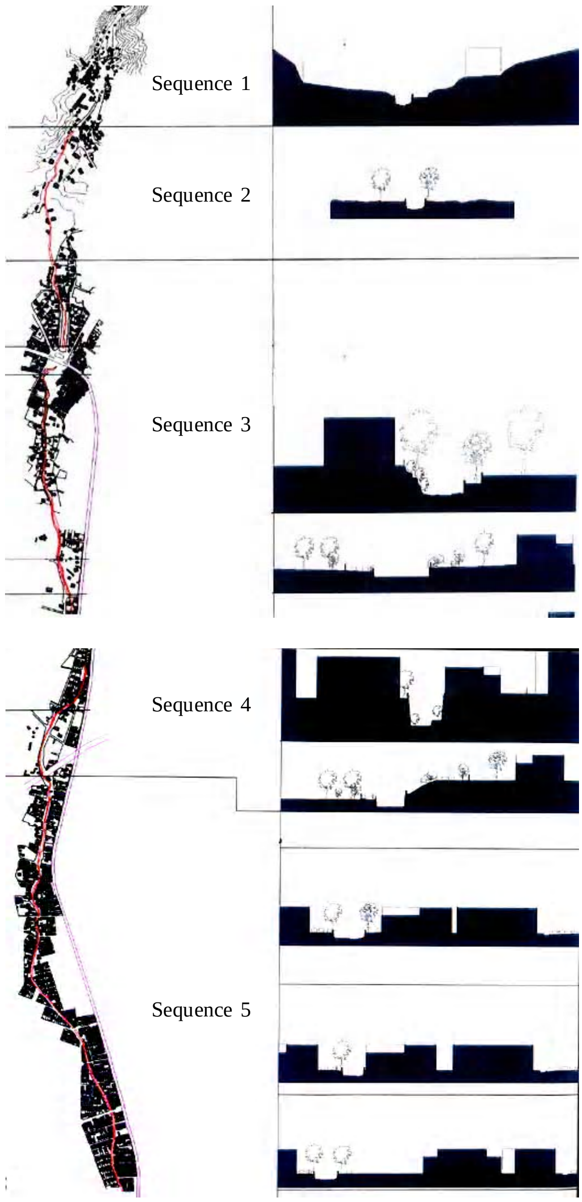
**A. Darband River-Valley**

**First Sequence (Uplands)**

The first sequence has retained its natural and integrity state. Landscape units are much wider and the structure of the landscape is coarse grain. Due to some masonry retaining walls, the riparian plants, especially herbaceous species, has almost been destroyed.

**Second Sequence (Hillside Lands)**

The majority of this sequence lies in the Saad Abad palace. The river-valley has retained its original and natural state in most its parts.




**Figs. 7 & 8. Five sequences in area of study in Darband**

Source: Hessamfar, M. Verons, J. (2002).

Landscape units are wide and the structure of the landscape is coarse grain. The riparian plants mostly include cultivated trees, and indigenous species, especially herbaceous ones, have decreased in number or disappeared. Outside the Saad Abad palace, the river has fully turned into a canal and has become more of a place for piling rubbish.

**Third Sequence (End of Hillside Lands)**

In this sequence, the Darband river-valley and Golab Dareh river have joined to form the Maqsood Bak canal, and the river-valley has been totally ruined.

The construction development has obscured the boundary of the river-valley. Also the landscape units are not wide and its structure is fine grain. In some parts, the presence of parks and urban green spaces has made the structure of the landscape coarse grain.

The plant life mainly includes cultivated trees and shrubs. Indigenous species, especially herbaceous species, either have disappeared or are in a poor condition.

**Fourth Sequence (Middle lands)**

The development of high-rise construction has made the structure of the landscape very fine grain and changed the river-valley completely into a canal, except some parts in Elahieh .

**Fifth Sequence (Beginning of low lands)**

According to the passage of the canal from residential areas or parks and green spaces, the structure of the landscape ranges from middle to fine in terms of grain.

**B. Jajrood River-Valley**

**First Sequence (Hillside Lands)**

The natural bed of the river has been retained. riparian plants, especially *Salix sp.* and *Tamarix sp.* communities, have been retained as well. And in addition to the indigenous *Populus nigra*, cultivated poplars serve the function of hedges in the farms (Fig. 9).

**Second Sequence (End of Hillside Lands)**

The natural bed of the river has been retained.Herbaceous riparian plants have been destroyed or become sparse due to human interference in this part. The riparian plant life, including trees and shrubs, ranges from average to high in quality. *Salix sp.* and *Tamarix sp.* Communities mainly account for the plant life in this part.

The Khojir forest park has cultivated with *Pinus eldarica* and their rapid and strong growth has made the coarse grain landscape unit (Fig. 10).

**Third Sequence (Middle lands)**

The natural bed of the river has been retained. The riparian plants, especially *Salix sp.* and *Tamarix sp.* communities, have been destroyed or weakened by human interference and the fire started by arsonists. Herbaceous plant life enjoys steady and strong growth around the river (Fig. 11).

**Fourth Sequence (Beginning of low lands)**

Aside from minor changes in the bank due to human interference, the natural bed of the river has been retained on the whole. Fertile soil and great width from the river frontage to the road, have set agricultural lands. Riparian plants, especially *Salix sp.* and *Tamarix sp.* communities, has been retained and even cultivated *Salix sp.* and *Populus nigra*, being used as hedges for the farms, have increased in number. The most coarse grain landscape unit in this sequence is the agricultural lands (Fig. 12).

**Fifth Sequence (low lands)**

The natural bed of the river has been retained. Due to its great width, getting close to the plain and the gentle slope of the lands, the river is broad and landscape unit is coarse grain in this sequence. The riparian plants have been changed and *Salix sp.* and *Tamarix sp.* communities have been replaced by *Rubus sp.* community (Fig. 13). Comparing the higher parts and lower ones in both of the river-valley, one can easily find out the process of formation, human interference and destruction. Comparing intra-city river-valleys with extra-city river-valleys from a structural and littoral plant life point of view, one can easily explore the differences between a destroyed river-valley and a natural one.A brief look at the cross-sections of this river-valley makes it clear that the destruction of the littoral plant lives has had a dramatic impact on the structure of the river-valley and its transformation into a stream. The plant life of the Jajrood river-valley in the Khojir national park mainly includes *Salix sp.* and *Tamarix sp.* communities.

The spatial arrangement of these communities is after the fashion of the pattern of the river and it continues for several kilometers nonstop. In addition to their contribution to the beauty of the landscape, these plant communities control most of the hydraulic processes, and even flooding or the overflowing of the river. The presence of *Rubus sp*. community is a clear indication of getting close to another microclimate and getting through to another landscape. Therefore, the climate and the pattern of the riverbed are in close relation with the riparian plants and the plant life plays a key role in the performance of the ecosystem of the river. The landscape units, which are the ecosystems, enjoy coarser grain in the Jajrood river-valley. As the components of these units around the river mostly include plant lives (like riparian plants, forests and farmlands), building up a horizontal relationship between the ecosystem of the river and the ecosystems of the plants around the river and building up a vertical relationship between every one of these ecosystems contribute to the stability of the riverbed, the components and the units of the landscape. On the other hand, due to gross human interference, the Darband river-valley has lost its natural plant life, and the natural bed of the river has lost its natural and rubble form and turned into a stream with masonry or concrete walls in most parts. As a result, the ecosystem of the river has changed in form and not only is building up a vertical relationship inside it is in danger, but also building up a horizontal relationship between the ecosystems is impossible due to the destruction of the riparian plants. As the patches near the canal are urban patches with fine grain, the destruction of the riparian plants has led to a breakdown in the relationship between the ecosystem of the river and the ecosystem of the city. It should be noted that the landscape in the Darband river-valley is mostly fine grain and this greatly threatens the sustainability of system. In fact, whatever we face today is the result of a structure established yesterday and what is waiting for us depends on the structure which is being established today (Yavari, 2006).

## RESULTS &DISCUSSION

Considering the analysis based on landscape ecology and the comparative approach of this study, these river-valleys can be used as reference sites and the findings of the study, which originates from the landscape ecology knowledge, can be applicable in similar cases.

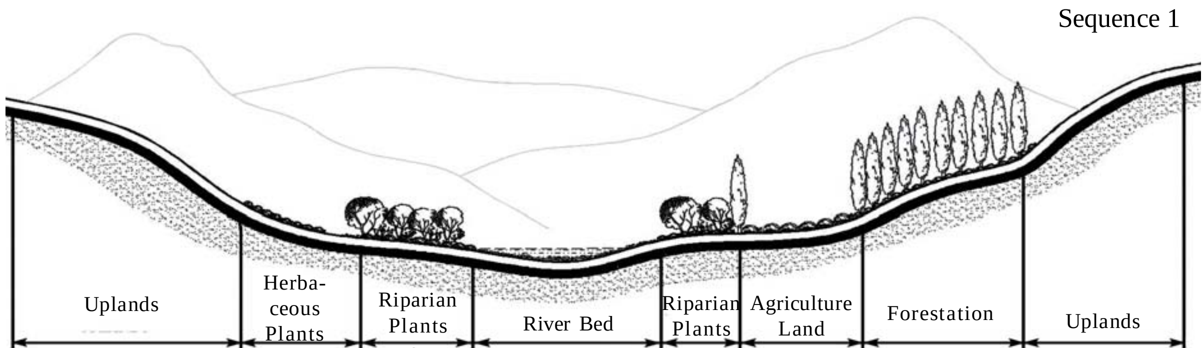



**Fig. 9. first Sequence in Jajrood river- walley**

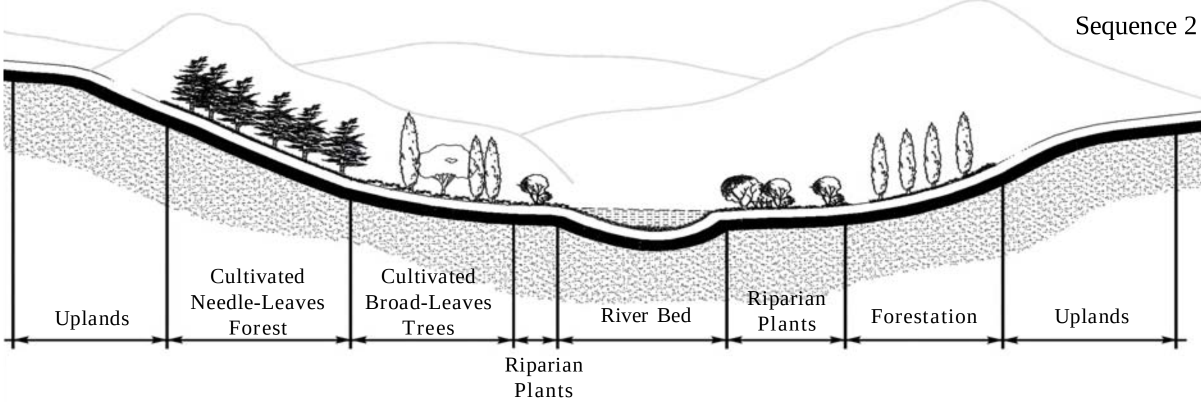



**Fig. 10. Landscpe elements in Second Sequence in Jajrood river- walley**

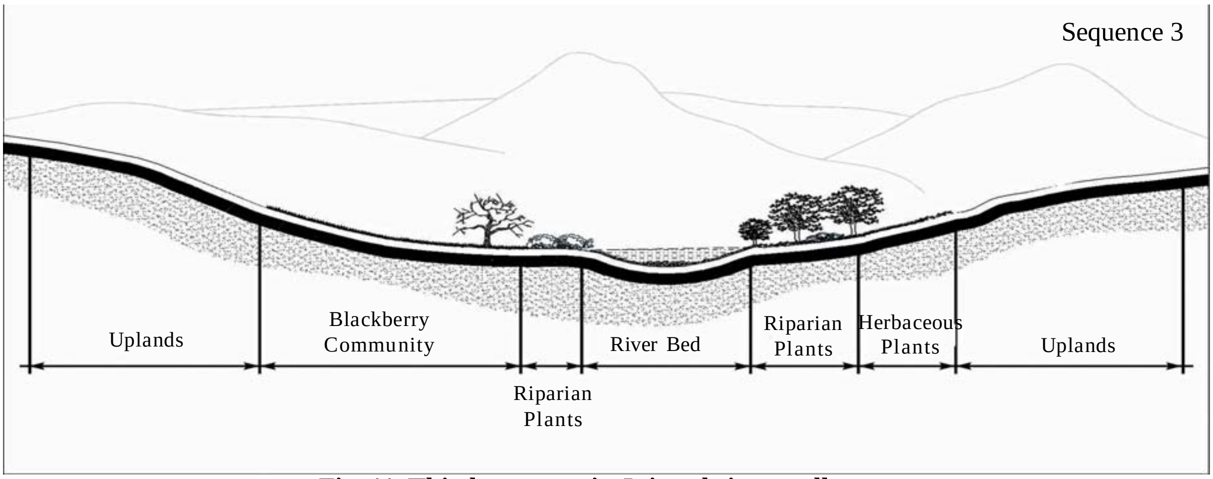



**Fig. 11. Third sequence in Jajrood river-walley**

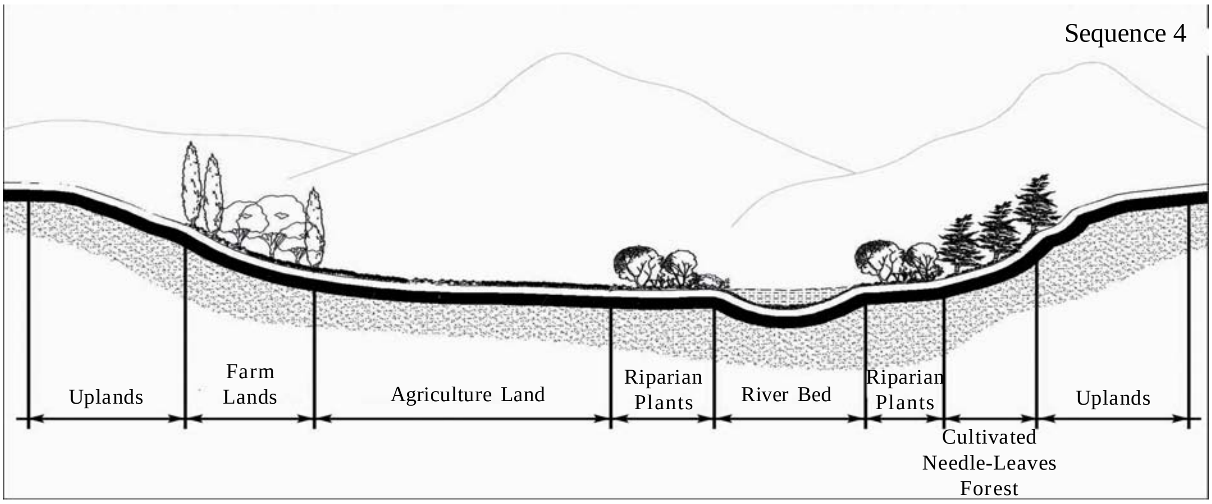



**Fig. 12. Landscape elements in forth sequence in Jajrood river-walley**

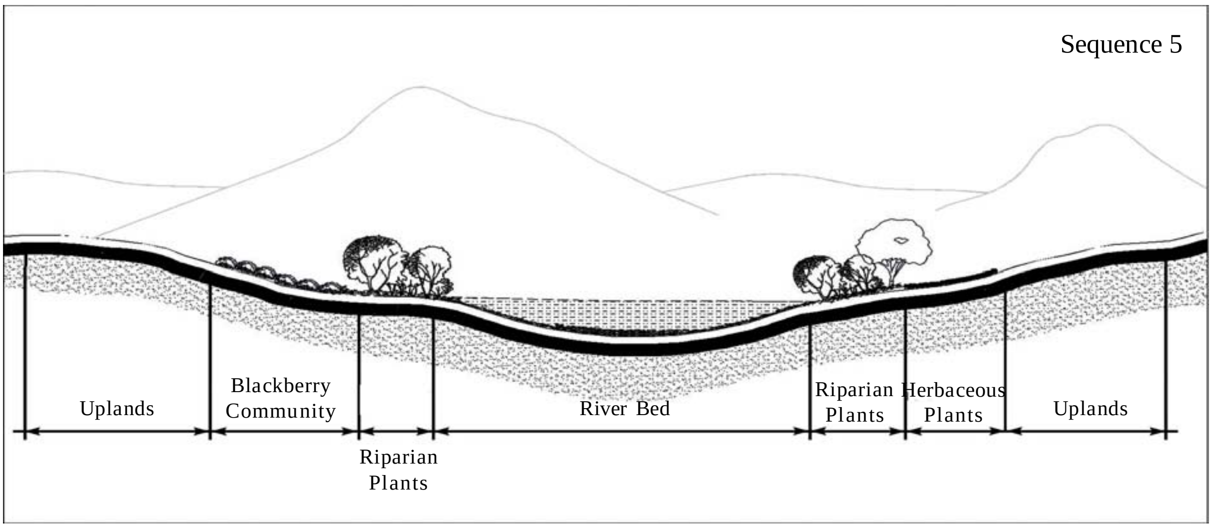



**Fig. 13. Fifth sequence shows different grains**

In this study, the river-valleys were explored and the approaches to find out the landscape patterns, the causes of destruction and scientific approaches to restoration were scrutinized. Therefore, a couple of suggestions and objectives based on landscape ecology and ecological design are put forward for river conservation and utilization inside the city as follows:

- Being heedful of the boundary of the river and providing bufferes in the fragile areas.
- Protecting the natural features of the rivers such as the twists and turns of the rivers and trying to restore them, once damaged.
- Controlling floodwaters and setting up artificial lagoons and wetlands for refining waters and purifying them from added pollutants (they can be set up either in the higher or lower parts).
- Examining the physiology and morphology of the riparian plants as elements related to the hydraulic pattern of the river , and restoration and planting trees according to their orientation to rivers.
- Mimicing nature, selecting native species, paying attention to key stones and using pioneer species.
- Creating balance between outdoor recreational goals and the protection and restoration of river-valleys.
- Establishing an ecological connectivity between natural and green patches in the city by connecting greenspaces, parks, and cultivated plants to riparian plants in order to set up sustainable green urban networks.

## CONCLUSION

Comparative study between disturbed river-valley and original one, shall clear what is lost, and what and how shall be done. Restoration is based on bioengineering approaches according to which materials found in nature are used as much as possible. Sticking to the above-mentioned operational principles and approaches has led to the ecological restoration of the higher areas of the Darband river-valley. Also around beginning of low lands, which mostly accommodates intensively populated residential and commercial areas of Tehran, the transference of pollution to the lower areas has been prevented by building linear parks around the river-valley and by sticking to the above-mentioned principles. Moreover, a relationship between ecological processes in the environment has been built up by establishing green urban networks. Connecting green urban networks to open and green lands around city, which is possible through river valleys, leads to the continuum and sustainable matrices of the city. Also, utilization of water and land resources, with protecting, enjoying and improving the environment goals, shall be possible by process approach with use of the past structures for future plans as invaluable reference.

## REFERENCES

Behbahani, H. Zandi, Sh., Abarkar, M., (2002). Natural Intra-city Environment Surviving. J. Environ. Stud., **28** (30). 43-54.

Bell, S., (1999). Landscape (pattern, perception and process). London, F& FN SPON. 197.

Baft-eShahr Consulting Eng., (2003). District 1 Comprehensive plan of Tehran municipality. Environmental Studies.Internal report, Tehran-Iran.

Di Fidio, M., (1995). I corsi D’acqua. Pirola, Milano. 42,64.

Farina, A., (1998). Principles and Methods in Landscape Ecology. Chapman & Hall. 21.

Forman, R. and Gordon, M., (1986). Landscape Ecology. John Wiley & son, Inc. 1-2.

Harker, D. and Evans, L., (1999). Landscape Restoration. (Hand Book). 2nd. Ed., Lewis Publisher. 63.

Hessamfar, M. and Verons, J., (2002). Un Joob au paradise. Diploma de fin d’etude. E’Cole d’architecture et de pay sage de Bordeaux. 71-72.

Makhdoum, M. Majnoonian, B., Mahdavi, M., Bayat, H., Jazebizadeh, K., Javanshir, K., Riazi, B., Habbibbi, H., Sisstani, D., Khallili, A., Dayanni, A., Behrouzirad, B., Karami, M., Mehrabbi,A., Nakhjavani, F., (1987). Park Management Comprehensive Plan of Khojir and Sorkh-e-hesar National Parks. Environmental Protection Organization, Tehran-Iran. 342-345,366-390.

NTIS Gov. Products, (2000). Stream corridor restoration. Principles, processes, practices. USA. 1-3.

Shafie, B., Behbahani, H., Makhdoum, M., Yavari, A., Karimi, K., (2003). Design Recommendations and Restoration in Riparian Zones, Based on Landscape Ecology. J. Environ. Stud. **29**. ( 32).1-14.

Soiety for ecological restoration News, (SER), (2000). SER Reports, B.C., Canada, 1-5.

Yavari, A., (1385). Ecological Structure Rectification. 2nd. Seminar on Construction in Tehran, Khordad 1-3. 247-264.

*Int. J. Environ. Res., 1(3): 214-217, Summer 2007*
*ISSN: 1735-6865*

# A Study on Risk Assessment of Benzene as one of the VOCs Air Pollution

**Jafari, H. R.* and Ebrahimi, S.**

Graduate Faculty of Environment, University of Tehran, P. O. Box 14155-6135
Tehran, Iran

Received 20 Jan. 2007; Revised 28 April 2007; Accepted 29 May 2007

**ABSTRACT:** Weather and climate have considerable influence on the concentration of air pollutants such as particles and gases. The range and concentration of these particles and gases are very dependent on prevailing weather conditions and air currents. This research concentrates on health effects of benzene, one of the air pollutants of Tehran, as a major city. The concentration of benzene emission to air due to deficient oxidation of fuel in vehicles or evaporation of gasoline at gas stations and the gas tanks of the automobiles, at market station in Tehran shows significantly high values than EPA guidelines that is used in Iran. The result of calculation of risk assessment was $3.6 \times 10^{-5}$ (3.6 cancers per 100000).

**Key words:** Benzene, Air Pollution, Risk Assessment, Tehran, Iran.

* Corresponding Author: Email-hjafari@ut.ac.ir

## INTRODUCTION

Information and its management are moving towards the centre of development thinking and development action. Nowhere this is truer than in the environmental sector. Policy-makers, planners, managers, and activists are calling for greater investment in the generation of data and information, and its subsequent use (Ballantyne, 1995). Despite legal or moral requirements to manage the environment sustainably, human is now changing the environment at such a rate scale that risks to society from ignorance, inappropriate policy directives and action are more pervasive, costly and potentially catastrophic than ever before (Vitousek, *et al.*, 1997). Given the increasing speed and breadth of human interactions with the environment, it is of little surprise that processes that allow us to understand and manage these are becoming increasingly information intensive (Carley, 1994). As problems become more complex involving spatially and temporally dynamic environmental, social and economic systems, gathering and analyzing more and better quality information in order to identify problems and create knowledge basis from which strategies, policies, programmes and projects can be developed and implemented is becoming a complicated imperative (Russell and Powell, 1996; Vitoseuk, *et al.*, 1997). While not a panacea in itself, since political agendas, governance mechanisms and individual and institutional capacities play a large part in public policy processes, access to the right sort of information and the ability to comprehend it are critical in the development of policy to manage the effects of human activities (Crewe and Young, 2002). Knowledge and information are now widely recognized and promoted as key features of economic growth, economic competitiveness and sustainable development (Lundvall and Johnson, 1994; French, 200). Indeed, throughout the world considerable effort is being directed toward the development of institutional and individual capacity and expertise for generating, managing and utilizing economically, socially and environmentally valuable information and knowledge. An important feature of the emerging discourse on sustainable development and the knowledge society is the emphasis on data quality and the development of procedures and processes to quantify data accuracy (Zoller and Scholz, 2004). Regardingless of the data type, if its quality is unknown then the accuracy of the data is in question and its usefulness compromised. For example, to have confidence in data that shows spatial or temporal variability in air quality, instrument or processing errors must identified and quantified and where possible reduced. It is for reasons of data quality and interpretation that there is increasing emphasis among decision-makers, interest groups and citizens alike for science-based environmental policy and more direct involvement of scientists in the policy arena (Steel, *et al.*, 2004). Vehicle emissions contain chemicals and particulate matter that are toxic to most life forms, including humans, at certain exposure concentrations and frequencies. Air pollution and its impacts on human health and natural ecosystems is a major environmental problem worldwide (Seinfeld, 1986) and in Iran. Emissions of main atmospheric pollutants result from anthropogenic and natural activities and have short and long-term effects on the environment. These include the acidification problem, air quality degradation, global warming, climate change, damage and soiling of buildings and other structures, stratospheric ozone depletion, human and ecosystem exposure to hazardous substances.

We can now say with a very high degree of certainty that as this century proceeds, climate change will have an increasing impact on human society. Also it is known that there is a very strong trend towards an increasing proportion of the world's population living in cities. Thus many of the impacts of climate change will be experienced through the ways in which they affect the lives of our urban population. There are at least three good reasons why it is useful to think about the issue of climate change specifically in terms of how it relates to cities: 1) Over 75%of energy consumption is directly related to cities, 2) In many cases cities are highly vulnerable to the impacts of climate change, 3) Cities have a great potential to instigate novel and easily replicable solutions.

Population Growth and industry development leads to different environmental pollutions which is the main problem of most societies. Most countries established special legislations as a standard for permitted amount of pollutant emotions, and tried to reduce the pollutions so that in an amount below the permitted, there would be no harm for human health and environment.

Worldwide, the increasing deterioration in urban air quality due to emissions of air pollutants has created the need for greater capacity in air quality management and more comprehensive knowledge about the sources and spatial and temporal distribution of vehicle emissions, without which impact studies and subsequent mitigation policy cannot be formulated. In recent years, one area that has been increasingly highlighted in the international air quality literature, as a critical to air quality policy decisions is validated emissions data. Understanding and qualifying emissions of air pollutant is the first, essential step in understanding, controlling and mitigating air pollution. Source emissions data (i.e., chemical and physical data) is a key pre-requisite to accurate impact analyses, forecasting, and the development of effective abatement strategies.

## MATERIALS & METHODS

According to NIOSH (National Institution of Occupation on Safety and Health) and OSHA (Occupational Exposure Limit), one of the best methods for sampling of organic compounds is the use of absorbents. In order to sample the benzene concentration as one of VOCs, 226-01 activated carbon absorbent was used. Sampling was done in different steps. Air passing through SIBATA mini sampler was set on 200 mL/min. The end sides of absorbent tube were broken so that the air enter and exit easily and were connected to pomp. In order to have regular air flow, electricity was used in place of battery. Once the sampling was over the end sides of absorbent tube were closed using a plastic cap. Absorbent tube was kept in the refrigerator for later tests. CS2 dissolver was used to separate aromatic compounds from the surface of active carbon, and then was injected to gas chromatograph instrument. The data used in this research were obtained from Tehran Air Quality Control Company.

## RESULTS & DISCUSSIONS

Average benzene concentration was 0.1 mg/m$^3$ in ambient air at some stations of Tehran, which is high comparing to the United States Environmental Protection Agency (U.S.EPA) standard. EPA has documented Reference Concentration for Chronic Inhalation Exposure (RFCs) and Reference Dose for Chronic Oral

Exposures (RFDs) at Integrated Risk Information System (IRIS). Since this research was done on adverse effect of benzene inhalation, so RFD was not applicable. Last revised in 2003 the Inhalation Reference Concentration of benzene is 0.03 $mg/m^3$ (U.S. EPA, 2003). A review of the relevant literature suggests absorption efficiencies of 50% and 100% for inhalation and oral routes of exposure, respectively. Adverse effects of benzene on human's health depend on its concentration and exposure time. In order to determine adverse effects of benzene, cancer induced risk of benzene inhalation were determined for some stations habitant and compared to U.S EPA RFC standard. Benzene is classified as a "known" human carcinogen (Category A) under the Risk Assessment Guidelines of 1986. Under the proposed revised Carcinogen Risk Assessment Guidelines (U.S. EPA, 1992), it is characterized as a known human carcinogen for all routes of exposure based upon convincing human evidences as well as supporting evidence from animal studies (U.S. EPA, 1998; ATSDR, 1997) which indicates there are adequate epidemiologic evidence to prove the relation of exposure to benzene and cause cancer both on human health studies and laboratory animals. In this paper, average life time of a male adult was considered as 70 years. Also Potency Factor of benzene for inhalation is 0.029. The formula of calculation for lifetime risk is:

**Table1: Benzene Concentration in the Air of some stations ($mg/m^3$)**

| Stations | Concentration |
|---|---|
| 1 | 0.143 |
| 2 | 0.536 |
| 3 | 0.104 |
| 4 | 0.035 |
| 5 | 0.084 |
| 6 | 0.051 |
| 7 | 0.016 |
| 8 | 0.018 |
| 9 | 0.018 |
| 10 | 0.011 |

Figure 1 illustrates the difference among benzene concentration measurements at Various stations.

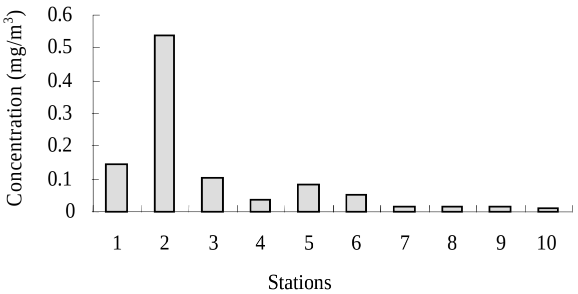



**Fig.1. Air Benzene Concentration at various Stations ($mg/m^3$)**

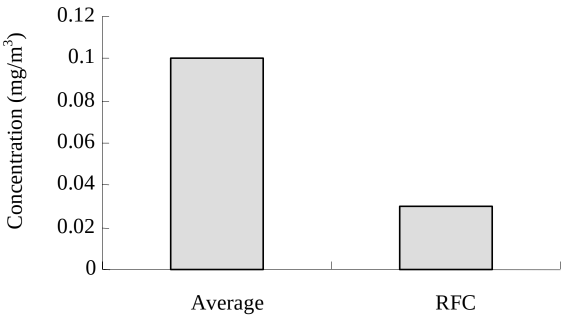



**Fig.2. Average Air Benzene concentration compared with RFC**

Life time Risk = Average daily Dose × Potency Factor

Then, in order to determine Chronic Daily Intake (CDI) following formula was used:

CDI (mg/kg/day) = Total dose (mg) / [(Body weigh (kg) × Lifetime (days)]
Total dose=Pollutant concentration×Intake rate Exposure time×Absorbent rate of toxic substance

According to measurements at some stations, benzene concentrations of the air were determined and are summarized in Table 1.

Average benzene concentration in the air at stations was 0.1$mg/m^3$ that shows considerable difference to United States Environmental Protection Agency RFC and is shown in Fig. 2.

In order to calculate the risk of benzene inhalation by station habitants and workers around the stations, whom work some part of a day and breathe polluted air, following conditions were considered:

Body Weigh (of a male adult worker): 70 kg
Exposure time: 5 days per week, 50 weeks per year for 20 years
The worker breaths deep 2 hours (1.5 $m^3$ air per hour) and in other 6 hours (1$m^3$ air per hour)
Potency Factor of Benzene (inhalation): 0.029 $(mg/kg/day)^{-1}$
Benzene Absorption Rate (of inhalation): 50%
Average Benzene Concentration rate of stations: 0.1$mg/m^3$
Risk Calculation:

Daily Intake Rate:
1.5 $m^3$/hr × 2 hr × 1 $m^3$/hr × 6 hr = 9 $m^3$/hr
Total Dose:
9 $m^3$/day × 5 day/week × 50 week/year × 20 year × 0.1mg/$m^3$ × 0.5 = 2250 mg
Chronic Daily Intake (CDI):
2250 mg / (70kg × 70year × 365day/year) = 0.001258 mg/kg/day
Risk = CDI × PF
Risk = 0.001258 mg/kg/day × 0.029 $(mg/kg/day)^{-1}$ = 0.000036482 = $3.6 \times 10^{-5}$
Thus, risk for the workers is 3.6 people per 100000 people.
And RFC calculations:
Total Dose: 675 mg
Chronic daily Intake: 0.000377 mg/kg/day
Risk = 0.000011
In other word, risk for the workers must not exceed 1.1 people per 100000 people.

As the Figures illustrate, it can be concluded that EPA standards is not adequate for the condition of Tehran air quality; so we suggest to modify the standards for air quality of Tehran and beside carry out more precise researches to over come the deficiencies of present work. Emissions of air pollutants especially from vehicles are still to be acknowledged as a serious economic concern primarily because data of sufficient quantity and quality are not available. The limited development of effective air quality policy is not surprising, since policy formulation and implementation always lags behind problem recognition. As is the case with environmental problems that result from incremental change and require specific and costly technologies to measure, developing policy to address their impacts is usually constrained by a lack of political attention, support and consensus, until the problem is well advanced and well defined. In the first instance this relies on the generation and distribution of trusted environmental information. In many places, policymakers are demanding access to better quality information resources, better integrative policy processes and assistance from information systems managers (Ballantyne, 1995; Fisher, 2002; Sliggers, 2004).

## REFRENCES


ATSDR (Agency for Toxic Substances and Disease Registry). (1997) Toxicological profile for benzene. Update. Public Health Service, U.S. Department of Health and Human Services, Atlanta, Ga.

Ballantyne. P., (1995). Information, capacity development and environmental policy making. European Centre of Development Policy Management. Working Paper No. 7, Maastricht.

Carley, M., (1994). Policy management systems and methods of analysis for sustainable agriculture and rural development. Food and Agriculture Organization of the United Nations, Rome.

Fisher, B., (2002). Fuzzy environmental decision-making: Application to air pollution. J. Atmos. Environ. (37), 1865-1877.

French, S., (2000). Re-scaling the economic geography of knowledge and information: Constructing life assurance makers. Geoforum. (31), 101-119.

Lundvall, B. and Johnson, B., (1994). The learning economy. J. Indus. Stud., **1**, (2), 23-42.

Russell, C. S. and Powell, P. T., (1996). Choosing environmental policy tools: Theoretical cautions & practical considerations. The Inter-American Development Bank, Washington D.C. (N ENV-102).

Sienfeld, J. H., (1986). Atmospheric Chemistry and Physics of Air Pollution, Willey Interscience, New York, 738.

Sliggers, J., (2004). The need for more integrated policy for air quality, acidification and climate change: Reactive nitrogen links them all. J. Environ. Sci. Policy, (7), 47-58.

Steel, B., List, P., Lach, D. and Shindler, B., (2004). The role of scientists in environmental policy process: A case study from American west. J. Environ. Sci. Policy, (7), 1-13.

U.S. Environmental Protection Agency (U.S.EPA), (1992). Integrated Risk Information System (IRIS). Substance file- benzene. Washington, DC: National Center for Environmental Assessment.

U.S. Environmental Protection Agency (U.S.EPA), (1998). Carcinogenic effects of benzene: an update. Prepared by the National Center for Environmental Health, Office of Research and Development. Washington, DC. EPA/600/P-97/001F.

U.S. Environmental Protection Agency (U.S.EPA), (2003). Reference Concentration for Chronic Inhalation Exposure (RFC). Substance file- benzene. Washington, DC: National Center for Environmental Assessment.

Vitousek, P., Monney, H., Lubchenko, J. and Melillo, J., (1997). Human domination of the earth’s ecosystems. Science, 277: 494-499.

Zoller, U. and Scholz, R., (2004). The HOCS paradigm shift from disciplinary knowledge (LOCS) to interdisciplinary evaluative, system thinking (HOCS): What should it take in science-technology-environment-society oriented courses, curricula and assessment? J. Wat. Sci. Tech., **46** (8), 27-36.

*Int. J. Environ. Res., 1(3): 218-230, Summer, 2007*
*ISSN: 1735-6865*

# Sustainable Urban Growth Management Using What-If?

**Asgary, A.[1*], Klosterman, R.[2] and Razani, A.[3]**

[1]Atkinson Faculty of Liberal and Professional Studies, York University, Toronto, Canada
[2]Department of Geography and Planning, University of Akron, USA
[3]Department of Urban & Regional Planning, Jahad Daneshgahi, Tehran, Iran

Received 20 Dec. 2006; Revised 20 March 2007; Accepted 15 May 2007

**ABSTRACT:** This paper examines the application of a GIS based planning support system, What If?™, to evaluate alternative growth policies for sustainable urban growth in a rapidly growing city of Iran. The paper describes the study area, Dorood city, and the What If? Model. It then explains the procedures that were used to obtain the required data and to run the model to Dorood city. The paper concludes by considering the results and implications, which the study has for urban growth management of the city to preserve farmland and accommodate growth in the city.

**Key Words**: Sustainable Urban Growth, What-If? Planning Support Systems, Dorood City,Iran

*Corresponding author: Email-asgary@yorku.ca

## INTRODUCTION

Population growth in urban areas increases the pressure for urban sprawl and this expansion usually happens in agricultural lands encircled the cities. It has increased the planners environmental and sustainability responsibilities to guide developments in a manner to reduce the pressure on agricultural lands. On the other hand allocation of scarce land resources to urban uses should follow certain roles to be able to satisfy different competing uses while creating a balanced and equitable use of these resources to achieve social goals of sustainability paradigm. In practice, land use planning is the fundamental part of physical planning and the success and failure of all future plans and policies depends on that. In such conditions, the conventional incremental planning tools are not sufficient for analyzing and responding the current complex situations. In other words, with increasing urban sprawl and the need for sustainable urban growth, it is clear that policy on its own is not enough and urban growth management using sustainability principles should be applied. The implementation of sustainable urban growth is viewed as the answer to reducing, or at least controlling, sprawled development. In addition to slowing the loss of farmland, open space and irreplaceable natural resources, sustainable urban growth policies direct development towards existing communities already served by roads, sewer systems and other infrastructure. Preventing low-density urban growth on the urban–rural fringe are thought to support sustainable urban growth through various ways. It results to more efficient use of land and less pressure to convert habitat and farmland to urban uses. It reduces car use and commuting distances through associated reductions in greenhouse gas emissions and air pollution) by bringing origins and destinations closer together and by making public transit more economically viable. This policy also reduces the consumption of water and energy, which is typically higher in low-density districts due to higher heating and cooling costs for single-family homes and excess water use on lawns, gardens and cars. More importantly, it provides greater efficiencies in the provision and use of infrastructure systems, which are costly and consume energy and raw materials through their manufacture and emplacement. Road infrastructure also reduces soil permeability and contributes to flooding (Alexander and Tomalty, 2002).

Five critical elements of an sustainable urban growth management strategy can be considered as 1) Collaboration, co-ordination and leadership among and between governments 2) The introduction of new tools and resources and the innovative application of existing tools to effectively guide growth; 3) The use of public investment and incentives to leverage market forces; 4) Thinking, planning and making investment decisions based on immediate needs and 50-year timeframes; and 5) The creation of a broad base of understanding and support for managing growth. Legislative requirements and popular concern with issues of unsustainable urban growth, the loss of open space, and environmental degradation are creating a demand for models that can consider the potential impacts of alternate growth management policies. And popular demand for direct involvement in the policy- making process is creating a need for easy-to-use and - understand models that will allow non-professionals to address issues of local concern. This paper will describe the use of What if? ™ , to consider alternative policies for preserving open space in a rapidly urbanizing city in the Lorestan province of Iran.

What-If is among the newly developed and progressive PSSs that is based on current knowledge of land use planning. While, its approach is promising, the software is in the first stages of development and so far only limited application of the software has been reported (Klosterman, 2000). This paper presents the first application of What-If GIS based PSS in Iran and probably developing countries. This application of What-If was conducted for Dorood city, a medium city with rapid population growth in western part of Iran. The aim of the study has been to use What-If for finding the future direction of city growth so as to minimize its impacts on agricultural lands surrounded the city according to sustainable urban growth principles. The rest of this paper is organized as follow. Section two briefly illustrates the What-If? model and software components. Section three provides some background information about Dorood city and its growth issues. In section four the data used in the study will be discussed. Section five shows the application of What-If for the study area and its basic findings on land suitability analysis. Section six shows the results of land demand analysis .

What-If is a GIS based planning support system which uses GIS data and analytical and map generation tools to produce different land use scenarios based on theoretically accepted planning methods. Although GIS by itself provides an adequate base for urban planning and management, but conventional GIS softwares hardly handle planning tasks. In other words, GIS mapping concepts are insufficient for building PSSs (Hopkins, 1999), but GIS have become a useful component and an integral part of PSSs, which tend to incorporate modelling procedures (Harris 1999; Kammeier, 1999), expert systems (Edamura and Tsuchida, 1999; Shi and Yeh 1999), databases, decision trees, computer aided design or CAD (Alley, 1993; Schuur, 1994; Ranzinger and Gleixner, 1997), hypertext (George, 1997), mapping (Singh, 1999), user interfaces for public participation (Shiffer, 1992), virtual reality, and World Wide Web (Doyle, *et al.*, 1998; Heikkila, 1998). Development of PSSs includes integration of GIS with other technologies (hypertext, groupware, audio/visuals, multimedia, models, simulations, expert systems, etc.). To enable prediction of urban phenomena and processes, GIS software must allow for modelling procedures to run within its environment. This is, incidentally, one of the most frequently cited deficiencies of GIS (Harris and Batty, 1993). Predictive modelling is usually performed outside GIS and loosely coupled to the system via programming procedures. Embedding of urban models within GIS has been attempted in advanced research projects (Batty and Xie, 1994), but has not become part of commercial GIS software. Esnard and MacDougall (1997) maintained that there is a common ground for integrating planning theory and GIS in data creation, analysis, and presentation. What-if has been developed using the above ground by realizing the relationship between planning theory and methods and geospatial technologies. What-if developers have tried to build and implement tools that are suitable to planning practice. Landis' (1994, 1995) California Urban Futures Model, Landis, *et al.*, (1998) California Urban and Biodiversity Analysis, and Klosterman's (1999) "What if?" are probably the three most comprehensive attempts to date in simulating land use scenarios resulting from given demographic and economic trends, environmental constraints, and urban development policies.

The progress in modelling land use change in particular is impressive (Matheny, *et al.,* 1999), but yet to gain usability and acceptance in planning agencies at various levels of government.

As its name suggests, What if? does not attempt to predict future conditions exactly. Instead, it is an explicitly policy-oriented planning tool that can be used to determine what would happen if policy choices are made and assumptions concerning the future prove to be correct. Policy choices that can be considered in the model include the staged expansion of public infrastructure, the implementation of land use plans or zoning ordinances, and the establishment of open space protection programs. Assumptions for the future that can be considered in the model include future population and employment trends and anticipated development densities (Klosterman, 1999; Klosterman, 2001). What if*?* projects future land use patterns by balancing the supply of, and demand for, land suitable for different uses at different locations, subject to user-specified policies for allocating the projected demand to suitable locations. Alternative visions for an area's future can be explored by defining alternative suitability, growth, and allocation scenarios. The assumptions underlying scenarios can be easily modified to incorporate the full range of alternative visions for an area's future.

Basically, What if? begins with homogeneous land units or uniform analysis zones (UAZs), applies alternative policy choices to these units, allocates projected land use demands to them, and then derives regional conditions (e.g., population and employment growth trends) by aggregating the values for these land units. UAZs are GIS-generated polygons which are homogeneous in all respects considered in the model. Therefore, all points within a UAZ have the same slope, are located in the same municipality, have the same zoning designation, are within the same distance of an existing or proposed highway, and so on.

UAZs are created using different GIS functions to generate adequate layers and combine all of the relevant layers of information on natural and man-made features to define the UAZs that are used in a study area. The map layers can contain information on natural conditions (slopes, soils, and scenic, …), existing and proposed infrastructure (the proximity to intersections or major roads and the availability of sewer and water service and land use controls (zoning districts and planned land uses). The UAZs contain information which was provided in each of the constituent layers, i.e., each UAZ contains information on the slope, the availability of sewer and water service, planned land use, and so on for all points lying inside of it. As will be described in detail below, *What If?* projects future land use patterns by balancing the supply of, and demand for, land suitable for different uses at different locations.

Alternative development scenarios for a city's future can be discovered by defining alternative suitability, growth, and allocation assumptions. The results generated by considering these alternative scenarios provide concrete and understandable expressions of the likely results of a scenario's underlying policy choices and assumptions. For instance, *What-If* might show that there is insufficient land simultaneously to accommodate high growth, low residential densities, and strict agricultural protection policies, forcing the community to choose between highly desirable, but inconsistent, policy goals. *What If?* is the most appropriate tool for areas that are experiencing, or anticipating, rapid urbanization and the associated problems of traffic congestion, inadequate public infrastructure, and the loss of agricultural and open land. Areas that are currently undeveloped and will remain so in the future have few impacts and policy options to consider. *What If?* has been developed using Microsoft's Visual Basic and the Environmental Sciences Research Institute's (ESRI) MapObjects GIS component software. However, it is unique in providing a portable system which can be adapted to any city's GIS data and policy issues.

The objectives of *What-If* are 1) planning support systems to support traditional planning activities such as land use planning and urban modeling and emerging modes of collaborative planning, 2) creates alternative visions for the future in dependence of local land development policies. What if design is similar to the first California Urban Futures (CUF) model (Landis, 1994; Landis, 1995) and similar models such as the San Diego Association of Governments Sophisticated Allocation Process (SOAP) model

(San Diego Association of Governments, 1994). *What-If* modeling approach is based on a bottom up model. It has three different modules: land suitability analysis, for defining and weighting of factors for each land use type as well as allowed land use conversions, project future land use demand interactive definition of alternatives and scenarios, and allocate most suitable locations by combining results of land suitable analysis and projection of future land use. *What-If* has a vector-based GIS framework. To run *What-If* one needs data on urban land use (residential, commercial, industrial), digital elevation model (DEM), socioeconomic data (tabular data for every land use category), residential (intensive households parameters), commercial/industrial( e.g. employment vacancy rates), transportation infrastructure. *What-If* makes 25 years prediction in a 5-10 years time step, for maximum of 5 periods.

Dorood as a city has a history of 80 years. It is located beside two rivers (in Persian Dorood means two rivers). The growth of the city happened just after the railway passed through the area in 1937. Establishment of a cement factory and a defense manufacturing facility later contributed to the growth of city. During the early periods the city has expanded towards the western side of its original site.

However, recent developments have occurred mostly on the north-east side of the city. Dorood is the center of Dorood county and has about 80 kilometers distance from Khoram Abad, the center of province, Lorestan. Average temperature is 14 °C in Dorood area. The average annual rainfall is estimated about 562 millimeter and average humidity is 48 per cent. Dorood is located within the high earthquake hazard in the area and the country. The wind direction is from the south west to the north east. The city is constrained by mountains and rivers. The population of the city in 1966 has been 14060 which has significantly increased during the past decades. In 1996, the population of the city reached to 88152 and estimated to be more than 100000 in 2001 (Table 1). The family size ranges between 5.3 to 5.6. Population growth rate has been %2.6 per year during the past two decades. Natural population growth as well as migration from rural areas are the main contributors to the city's population growth.

**Table 1. Population of Dorood 1966-1996**

| Population | Year |
|---|---|
| 14060 | 1966 |
| 27621 | 1976 |
| 62517 | 1986 |
| 77299 | 1991 |
| 88152 | 1996 |

Source: Iranian Statistical Yeatbook

**Fig. 1. View of Dorood**

In 2001 the total area of the city was about 1325.7 hectares with population estimated around 100462. Gross population density was 76 and net density was about 483 person per hectare. Physical development of the city as well as its culture have been very much influenced by the railway, the cement factory and the defense manufacturing facility. In 1996, there has been 15006 employment in the city from which 3.2 percent in agriculture, 44.8 per cent in industries and 52 per cent in service sectors which shows Dorood as an industrial city serving the regions as well as its own population (Table 2).

**Table 2. Employment in Dorood 1986-1996**

| 1996 | | 1986 | | |
|---|---|---|---|---|
| **%** | **Number of Employees** | **%** | **Number of Employees** | |
| 3.2 | 264 | 2.2 | 223 | Agriculture |
| 20.3 | 3069 | 29.9 | 3027 | Industry |
| 24.5 | 3676 | 11.3 | 1144 | Construction |
| 52 | 7797 | 56.6 | 5731 | Service |
| 100 | 15006 | 100 | 10125 | Total |

**Fig. 2. Recent developments on high slops of western side of the city**

Population growth has increased pressure on agricultural land around the city which needs adequate response from planning side. Recent population growth of the city has increased pressures on its limited agricultural lands. Constrained by mountains, rivers and industrial pollution from different sides, agricultural lands are the main available lands for urban development. Planners and policy makers are concerned with further development of city towards the agricultural lands.

## 4. GIS Layers and Data

What-If requires four main types of data for a given study area. 1) current land uses. 2) maps of land suitability factors (slopes, soils, floodplains, and so on) in the study area. 3) projections for the area's future residential population and employment are required to project future land use demands. 4) land use control policies (such as land use plans, zoning ordinances, or infrastructure expansion plans). The procedures used to obtain each of these kinds of data for Dorood city are described briefly below.

### *Land Use Map*

Land use map: any projection for the future must be based on the present and the past. As a result, the first piece of information required to project the city's future land use patterns was a

GIS layer showing the city's existing land use patterns. Land use layer for this study was indirectly produced based on a 1/25000 land use of the area prepared for city master plan and a recent thematic map of the city and its surrounding provided by the Iranian Survey Organization (ISO). However, field investigation was carried out to update the maps. In this layer, land use of the area classified into 15 groups.

***Land suitability Maps***

Like most medium and small cities, Dorood does not have a detailed parcel-level GIS system, significantly limiting the availability of digital spatial information. Fortunately, recent national survey of Iran had been finished for the province and the city. It provided an adequate source of digitized data for the study area at 1/25000 scale. This allowed the following suitability factors to be considered for Dorood: slopes, agricultural soils, 25 years flood plains, power lines, and rivers.

*Slope Map*: This layer was produced using 1/50000 and 1/25000 topographic data available for the study area. A TIN model was created and "Derive Slope" command in Arcview Spatial Analyst™ extension was used to create the slope map. In this study four classes of slopes were utilized: 1) less than 7 per cent, 2) 7 per cent to 15 per cent, 3) 15 per cent to 30 per cent, 4) more than 30 per cent.

*Soil Type Map*: This layer was produced based on a paper map for soil types already created by Emko Planning Consultants for the study area. Based on this map attempts were made to identify areas that had slight, moderate, or severe limitation for agricultural use. Soils were classified into five types based on their suitability for agriculture: 1) very good soils, 2) good soils, 3) medium soils, 4) unsuitable soils, 5) rocky and sandy soils.

*River Buffer Map*: This layer was produced using Arcview 3.2 buffer analysis on two rivers crossing the city. We considered 60 meters buffer distance from each river, according to the physical conditions, experts' opinion and river regulations for the area. Therefore, the area was divided into those within 60 meters of the rivers and those outside 60 meters distance from the rivers.

*Power lines buffer Map*: ISO data were used to create power lines buffer. This layer was another 60 meters buffer zone on power lines layer. Existence of rail stations, cement factory and defense manufacturing facilities has created major need for electricity and thus power lines.

*25-Year Flooding Potential Map*: This layer was produced using topographic map of the area and the maximum water levels of the rivers during a 25-year flooding. According to the previous studies done in the region each 25 years there is a flood potential which increases the water level by 4 meters. Considering the slope of the rivers basin in the eastern side (3 per cent) and in the western side (4 per cent), it was calculated that water level at its maximum will cover up to 333 meters in the eastern side and 250 meters in the western side of the rivers.

***Land use control and Display Maps***

*Land Use Control Map*: This layer was produced based on regional policy, which divided the land into three categories as: lands suitable for agriculture, lands suitable for urban development and undevelopable lands.

*Existing and Future Water Supply Map*: The current water supply network, the service area and areas outside the service area used for water supply layer in this study. The service area is the area that water network will cover it within the next few decades. It is usually determined by the regional water company responsible for water supply.

*Census Tracts Map*: According to the Iranian statistical Center (ISC), city is divided into two census tracts. It is also used by city's municipality as administration districts and service delivery.

*Concentric Growth Map*: This layer was produced using the existing city center and buffer analysis around the city center. We considered 1500 meters for each circle.

*Radial Growth Map*: This layer was created based on the existing and future roads of the city. We used a 100 meters buffer along the major roads.

*UAZ Map*: Arcview overlay command was used to combine the existing land use map and the suitability map layers into a single Arcview shape file. The shape file contained a large number of irregularly shape polygons called "uniform analysis zones" (UAZs). The UAZs were uniform internally with respect to all of the factors considered in the model, i.e., all points inside a UAZ have the same current land use, the same slope, the same soil type. These small polygons, which ranged in size from one-half hectare to several hectares in size, comprised the spatial units for which the suitability analysis was conducted and future land use patterns were projected. During the UAZs production many small polygons were generated. Arcview scripts and ArcInfo commands were utilized to eliminate these small polygons.

*Display Maps*: Display layers are not used in the analytical parts of the *What-if?*, but they are helpful for visualization of the area. We created 5 display layers: rivers, power lines, major roads, all roads, city boundary.

## 5. Application of What If

Determining land use suitability is the first stage in the *What if?* application. To do this stage, several four steps must be taken: (1) identifying suitability the factors, (2) specifying the suitability factor weights, (3) specifying the suitability factor ratings, and (4) specifying the permissible land use conversions. In this study 5 factors were used for suitability analysis for all 8 land use types: slope, soil, 25 years flood plain, river buffer, and power line buffers. Although it is very ideal to add some more factors in the suitability analysis, but the data and their accuracy is very important. For most cases at least at this time necessary data for including further number of factors are not available. For factor weights this study used the weights given in Table 3 based on previous studies. For determining factor ratings a mini Delphi expert approach was employed. Table 4 shows the factor ratings used. The fourth suitability step in *What-if* model is the specification of land uses that may be converted from their current use to another use as a result of the projection process. In this study no land uses were identified for conversion. Therefore only undeveloped lands were available.

After providing all necessary information for suitability factors in the above four steps, what-if performed land suitability analysis for each land use categories in the study area and presented the results in a GIS layer for each land use. The maps show each location's suitability for each land use on a scale from "not considered" and "unsuitable" to "high." What-If? also provides land suitability reports. Fig 3 and 4 show the land suitability analysis for the study area for commercial and industrial development.

**Table 3. Land Suitability Factors' Weights**

| Utilities buffer | 25-year flood | River buffer | Agr.soiles | slopes | Scenarios |
|---|---|---|---|---|---|
| 2 | 2 | 2 | 3 | 2 | Farm preservation |
| 2 | 2 | 2 | 3 | 3 | Suburbanization |

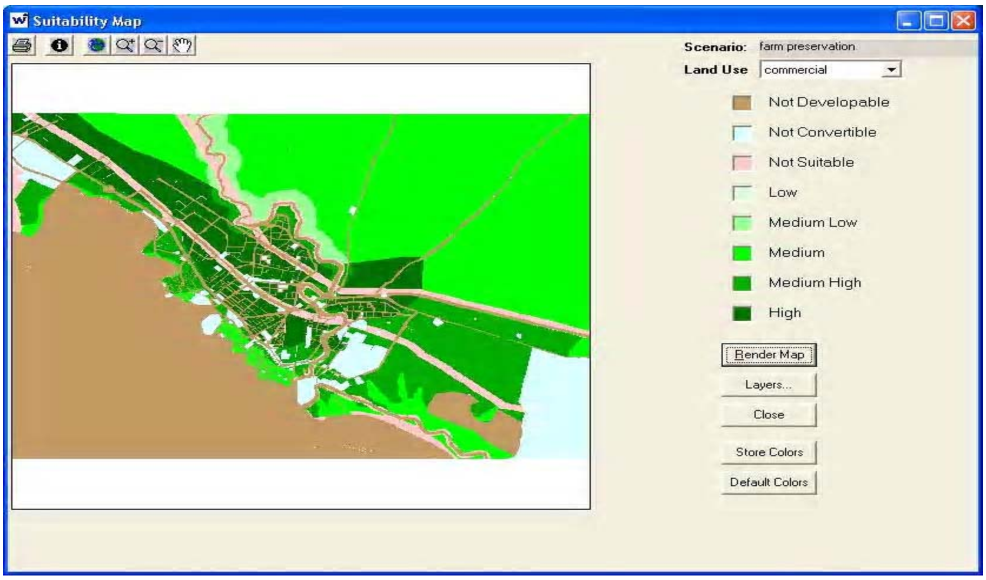



**Fig. 3. Land suitability analysis for commercial development**

**Table 4. Land Suitability Factors' Ratings**

| **Medical** | | **Educational** | | **Official** | | **Industrial** | | **Residential** | | **Recreation** | | **Urban Facilities** | | **Commercial** | | **Class** | **Factors** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 7%< | |
| 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | %7- %15 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | >%15 | |
| 2 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | Very Good | |
| 5 | 5 | 5 | 5 | 5 | 5 | 2 | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Good | |
| 2 | 2 | 2 | 2 | 2 | 2 | 5 | 5 | 1 | 1 | 2 | 2 | 3 | 3 | 2 | 2 | Mediu m | |
| 3 | 3 | 3 | 3 | 3 | 3 | 1 | 0 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | Bad | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Very Bad | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 60m < | |
| 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | > 60m | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | Inside | |
| 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Outside | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 60m < | |
| 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | > 60m | |
| Sub | Farm | Sub | Farm | Sub | Farm | Sub | Farm | Sub | Farm | Sub | Farm | Sub | Farm | Sub | Farm | Scenario Type | |

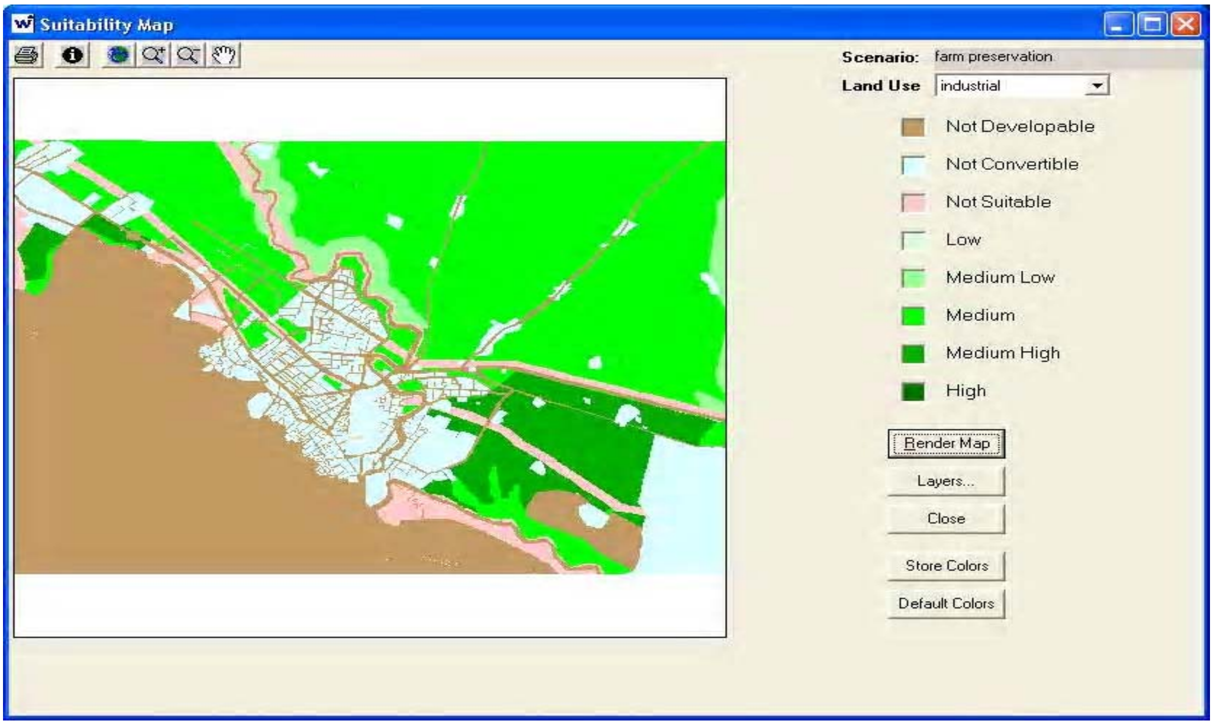



**Fig. 4. Land suitability analysis for industrial development**

**Table 5. Population Projection for High Growth and Low Growth Scenarios**

| Year | Family Size | Population (Low Growth) | Number of Families | Population (High Growth) | Number of Families |
|---|---|---|---|---|---|
| 2001 | 5.3 | 100516 | 18965 | 100516 | 18965 |
| 2011 | 5.2 | 116553 | 22433 | 128660 | 24742 |
| 2021 | 5.1 | 135380 | 26545 | 164685 | 32291 |
| 2031 | 5.1 | 157041 | 30792 | 210797 | 41332 |

The second phase of What-If? Application is to calculates the demand for land by converting the five main categories of land use demand; residential, industrial, commercial, preservation, and locally-oriented uses, into the equivalent future land use demand. In this study demand for land for different land uses were predicted for both “low growth”, and “high growth” scenarios as defined in What-If?.

For low growth the minimum growth of 1.5 per cent population growth and for the high growth, 2.5 per cent growth were assumed. Under these assumptions, the city’s residential population would grow from 100516 in 2001 to over 157041 in 2031 in low growth scenario and to 210797 in high growth scenario (Table 5). To predict demand for residential lands first number of households for each of the time periods was estimated. To estimate demand for residential land assumptions were made on: types of new houses, residential density, average number of persons per house (5.2), vacant homes.

The demand for non-residential (e.g., industrial, retail, and office uses) in *What-If* is derived from user-specified values for the projected employment in each year and the assumed employment densities for each non-residential use. To estimate employment growth in industrial sector in the city for low and high growth, 3.5 and 5.5 per cent were applied respectively. For commercial and office sectors growth rates of 2.5 and 3.5 were used for low and high growth scenarios (Table 6-8). Therefore, employment would grow from 15006 in 1996 to 31718 at low growth scenario and to 56658 at high growth scenario in 2031. What-if allows the planners or decision makers to specify the amount of land that should be set aside for local land uses (e.g., local retail and neighborhood parks) in each projection year based on the per capita measure.

**Table 6. Employment in the city 1986 and 1996**

| Sector | Employment 1986 | Employment 1996 | Average Growth Rate (%) |
|---|---|---|---|
| Industrial | 4171 | 6745 | 4.9 |
| Commercial | 1728 | 2350 | 3.1 |
| Office | 1108 | 1508 | 3.01 |
| Total | 10125 | 15006 | 4 |

**Table 7. Employment Projection for Dorood in Low Growth Scenario**

| Year | Industrial Sector | Commercial Sector | Office Sector |
|---|---|---|---|
| 2001 | 8567 | 2737 | 1745 |
| 2011 | 11300 | 3402 | 2233 |
| 2021 | 15940 | 4355 | 2858 |
| 2031 | 22485 | 5575 | 3658 |
| Current Density | 163.8 | 313.15 | 158.6 |
| Future Density | 180 | 340 | 170 |

**Table 8 . Employment Projection for Dorood in High Growth Scenario**

| Year | Industrial Sector | Commercial Sector | Office Sector |
|---|---|---|---|
| 2001 | 8567 | 2737 | 1745 |
| 2011 | 15057 | 3936 | 2461 |
| 2021 | 25720 | 5553 | 3470 |
| 2031 | 43933 | 7833 | 4892 |
| Current Density | 163.8 | 313.15 | 158.6 |
| Future Density | 210 | 380 | 200 |

Local parks and recreational activities, cultural and religious centers, educational, medical, and urban facilities are among the most important local uses. Iranian standards for small cities per capita local land uses (Table 9-10) were used in this part. The third phase of What if? Application is projecting the future land use patterns by allocating the projected land use demands, to different locations on the basis of their relative suitability, as defined by the assumptions in a user-selected suitability scenario. *What If?* generates a series of maps showing the projected land use patterns in each projection year. It also generates reports showing the projected land use in each projection year and the assumptions that underlie a scenario. Two public policies for preserving farmland in Dorood were considered. The first assumed that policies would be enacted which prohibited development in areas with good agricultural soils, close to power lines, within the 25-year flood plain, or near rivers. This "Preservation" policy was incorporated into the suitability portion of the model by assuming that prohibited residential and non-residential development is prohibited in all locations that either: (1) had soils with slight limitations for agricultural uses; (2) were located in the 25-year flood plain; (3) were located within 60 meters of power lines; or (4) were located within 60 meters of a river and (5) were located near the rivers. Development of the city was also forbidden in areas with high slopes. The alternative "Development" policy did not consider the environmental impacts of development and prohibited development only in areas with high slopes. The second "Growth Controls" policy assumed the city enacted a growth policy which limited development to areas that have public water and sewer service. In the land allocation section of this study four scenarios were considered.

1) agricultural land protection and low growth
2) agricultural land protection and high growth
3) suburbanization with low growth
4) suburbanization with high growth

What-if requires researcher to determine the allocation order for land uses. In his study residential, commercial, office, and industrial land uses were given first to four priority respectively. During the allocation process infrastructure and land use controls (e.g. infrastructure plans, road networks) can be added to the analysis. If no land use control is considered, *what-if* will continue the allocation process only based on land suitability, demands and allocation order. Also, user should determine the minimum acceptable UAZ size for each land use. The minimum UAZ size prevents the allocation of small UAZs to land uses, which needs a larger minimum lot sizes. For example industrial activities need larger parcels of land compared to residential land uses. Table 11 shows the minimum and maximum UAZ size for different land uses applied in land allocation process in this study:

The third phase of What if? Application is projecting the future land use patterns by allocating the projected land use demands, to different locations on the basis of their relative suitability, as defined by the assumptions in a user-selected suitability scenario. *What If?* generates a series of maps showing the projected land use patterns in each projection year.

**Table 9. Local land use demand at low growth scenario**

| Low Growth | | | | | | |
|---|---|---|---|---|---|---|
| | District 1 | | | District 2 | | |
| | 1390 | 1400 | 1410 | 1390 | 1400 | 1410 |
| | 35671 | 41056 | 47832 | 33646 | 39050 | 45315 |
| Educational | 8917 | 10264 | 11958 | 8411 | 9762 | 11328 |
| Medical | 97284 | 111972 | 120452 | 91764 | 106500 | 123588 |
| Recreation | 48642 | 55986 | 65226 | 45882 | 53250 | 61794 |

**Table 10. Local land use demand at high growth scenario**

| High Growth | | | | | | |
|---|---|---|---|---|---|---|
| | District 1 | | | District 2 | | |
| | 2011 | 2021 | 2031 | 2011 | 2021 | 2031 |
| Educational | 61956 | 79314 | 101530 | 58700 | 75147 | 96192 |
| | 15489 | 19828 | 25382 | 14675 | 18786 | 24848 |
| Medical | | | | | | |
| | 168972 | 216312 | 276900 | 160092 | 204948 | 262344 |
| Recreation | | | | | | |
| Utilities and Services | 84486 | 108156 | 138450 | 80046 | 102474 | 131172 |

It also generates reports showing the projected land use in each projection year and the assumptions that underlie a scenario. Two public policies for preserving farmland in Dorood were considered. The first assumed that policies would be enacted which prohibited development in areas with good agricultural soils, close to power lines, within the 25-year flood plain, or near rivers. This "Preservation" policy was incorporated into the suitability portion of the model by assuming that prohibited residential and non-residential development is prohibited in all locations that either: (1) had soils with slight limitations for agricultural uses; (2) were located in the 25-year flood plain; (3) were located within 60 meters of power lines; or (4) were located within 60 meters of a river and (5) were located near the rivers. Development of the city was also forbidden in areas with high slopes. The alternative "Development" policy did not consider the environmental impacts of development and prohibited development only in areas with high slopes. The second "Growth Controls" policy assumed the city enacted a growth policy which limited development to areas that have public water and sewer service. In the land allocation section of this study four scenarios were considered.

1) agricultural land protection and low growth
2) agricultural land protection and high growth
3) suburbanization with low growth
4) suburbanization with high growth

What-if requires researcher to determine the allocation order for land uses. In his study residential, commercial, office, and industrial land uses were given first to four priority respectively. During the allocation process infrastructure and land use controls (e.g. infrastructure plans, road networks) can be added to the analysis. If no land use control is considered, *what-if* will continue the allocation process only based on land suitability, demands and allocation order. Also, user should determine the minimum acceptable UAZ size for each land use. The minimum UAZ size prevents the allocation of small UAZs to land uses, which needs a larger minimum lot sizes. For example industrial activities need larger parcels of land compared to residential land uses. Table 11 shows the minimum and maximum UAZ size for different land uses applied in land allocation process in this study:

The last part of what-if allocation model deals with growth type. allocation part and user can run the allocation for each of these. Fig.5. shows the land use map projected based on the Farm Preservation/Low Growth scenario of this study which was considered as desired development scenario.

## CONCLUSIONS

To application of What-If in the study area shows that city of Dorood has limited options for its future development. Most of its developable lands are also high quality agricultural lands.

Two types of growth pattern, concentric and radial patterns exist in what-if lands are also high quality agricultural lands.

City is constrained by high slope lands in most of the sides, and with agricultural lands in the other sides. Perhaps land preservation and low growth option provides a better future development scenario for the city. Scenarios developed in this study by means of *What-If* provide better and visible ideasabout the future sustainable development options for the city.

**Table 11. Minimum and Maximum UAZ size for Different Land Uses**

| Land Use | Minimum size | Maximum size |
|---|---|---|
| Residential | 0.05 | 10 |
| Commercial | 0.02 | 5 |
| Office | 0.1 | 5 |
| Industrial | 1 | 20 |
| Urban Services | 0.2 | 4 |
| Recreation | 0.2 | 10 |
| Educational | 0.2 | 5 |
| Health Care | 0.3 | 4 |

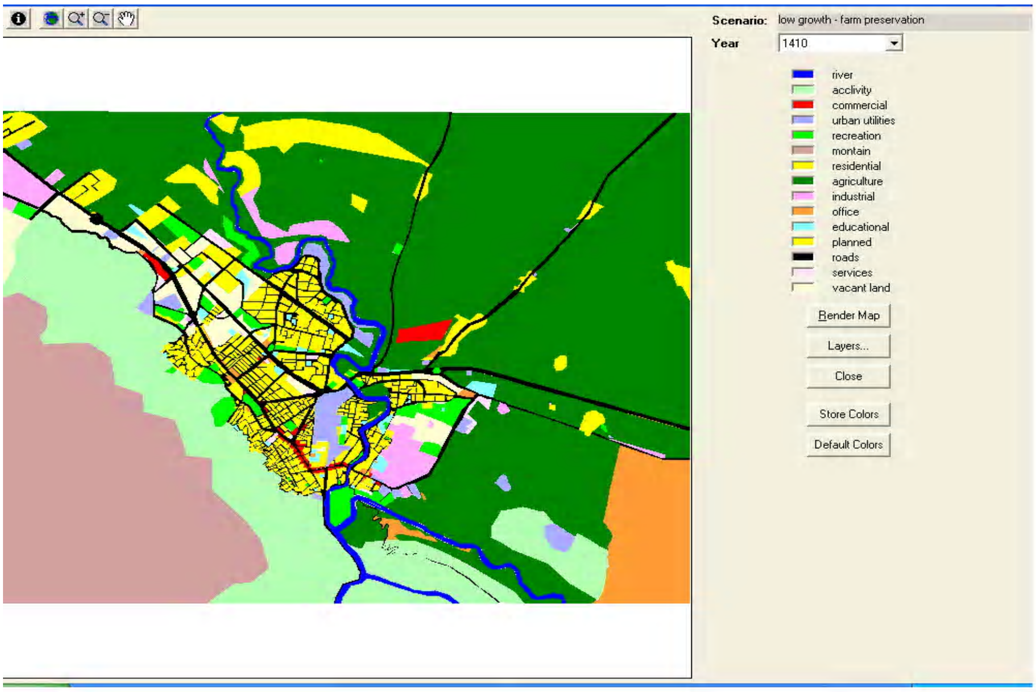



**Fig. 5. Land use map of Dorood city for year 2031**

As the basic motivation for this study was to assess the applicability of *What-If* in a very broad basis, it is obvious that if what-if? is used within a planning framework and institutional setting with enough recourses and data, useful information can be obtained from the software. This information is particularly useful for planners and decision makers of Dorood city who want to preserve the city's agricultural lands while accommodating future growth to achieve sustainable urban development. The results of what-if model is almost similar to the suggested development areas in the master plan of the city. If other scenarios are selected for future growth of the city most of the farmland and prime farmland will be lost. Although what-if has not been specifically designed for sustainability assessment, but users can introduce their assumptions and indicators in various parts of the software.

## REFERENCES

Alexander D. and Tomalty R., (2002). Smart growth and sustainable development: challenges, solutions and policy directions, Local Environ., **7** (4), 397-409.

Alley, J., (1993). Using 3-D CAD Perspective Images as Evidence in Planning Hearings. Plan Canada, July, 27-30.

Batty, M. and Xie,Y., (1994). Modeling inside GIS. Part 1: Model structures, Exploratory spatial data analysis and aggregation. Int. J.Geographic. Info. Sys., **8**(3), 291-307.

Bier, T., Post, C., Weizer, W. and Burgess, P., (1998). Development trends in Medina County.

Doyle, S., Dodge, M. and Smith, A., (1998). The potential of web-based mapping and virtual reality technologies for modeling urban environments. Computers, Environ. Urban Sys., **22**(2), 137-155.

Edamura, T. and Tsuchida, T., (1999). Planning support system for an urban environment improvement project. Environ. Plan. B., **26**(3), 381-391.

Esnard, A. and MacDougall, E. B., (1997). Common ground for integrating planning theory and GIS topics. J. Plan. Edu. Res., **17**(1), 55-62.

George, V. R., (1997). HyperSpace: Communicating ideas about the quality of urban spaces. J. Plan. Edu. Res., **17**(1), 63-70.

Harris, B. and Batty, M., (1993). Locational ,models, geographic information and planning support systems. J. Plan. Edu. Res., **12**(3), 184-198.

Harris, T. M. and Elmes, G. A., (1993). GIS applications in urban and regional planning: The north American Experience. Appl. Geo., **13**, 9-27.

Heikkila, E., (1998). GIS is Dead; Long Live GIS! J. Am. Plan. Associat., **64**(3), 350-360.

Hopkins, L. D., (1999). Structure of a planning support system for urban development. Environ. Plan. B., **26**(3), 333-343.

Kammeier, H. D., (1999). New tools for spatial analysis and planning as components of an incremental planning-support system. Environ. Plan. B., **26**(3), 365-380.

Klosterman, R. E., (1998). Computer applications in planning. Environ. Plan.

Klosterman, R. E., (1999). The What if? collaborative planning support system.

Klosterman, R. E., (2000). Planning in the information age. In Hoch CJ, Dalton LC, So FS

Landis, J. D. and Zhang, M., (1998a). The second generation of the California urban futures model. Part I: Model logic and theory. Environ. Plan. B., **25**(5), 657-666.

Landis, J. D., (1994). The California urban futures model: A new generation of metropolitan simulation models. Environ. Plan. B, **21**, 399-420.

Landis, J. D., (1995). Imagining land use futures - Applying the California urban futuresmodel. J. Am. Plan. Associat., **61**(4), 438-457.

Landis, J. D., Monzon, J. P. Reilly, M. and Cogan, C. (1998). Development and pilot application of the California urban and biodiversity analysis (CURBA) Model. Monograph 98-1 (Berkeley, CA: Institute of Urban and Regional Development).

McHarg, I., (1969). Design with nature. Garden City, NJ: Natural History Press.

Miralles, J., Altur, V. and Gielen, E., (1998). Urban land use planning for sustainable development. Methodology for obtaining the aptitude of the soil for a sustainable urban development as an approach to the municipal planning. Application in the Comunitat Valenciana (Spain). GIS PLANET. Annual Conference Proceedings, Lisbon, Portugal, September, CD-Rom.

Monteverde, R., Marini, L., Zelayeta, M., Moyano, G., (1998). City planning and management. GIS PLANET, Annual Conference Proceedings, Lisbon, Portugal, September 1998, CD-Rom.

Ranzinger, M. and Gleixner, G., (1997). GIS datasets for 3D urban planning. Computers, Environ. Urban Sys., **21**(2), 159.

Schuur, J., (1994). Analysis and design in computer-aided physical planning. Environ. Plan. B., **21**(1), 97-108.

Shi, X. and Yeh, A.G. O., (1999). The integration of case-based systems and GIS in dvelopment control. Environ. Plan. B., **26**(3), 345-364.

Shiffer, M. J., (1992). Towards a collaborative planning system. Environ. Plan. B., **19**(6), 709-722.

Singh, R.R., (1999). Sketching the City: a GIS-based Approach. Environ.Plan. B., **26**(3), 455-468.

*Int. J. Environ. Res., 1(3): 231-236, Summer 2007*
*ISSN: 1735-6865*

# The Role of Climate Study in Analyzing Flood Forming Potential of Water Basins

**Rowshan, G. R.** [1]**, Mohammadi, H.**[1]**, Nasrabadi, T.** [2*]**, Hoveidi, H.**[2] **and Baghvand, A.**[2]

[1]Department of Geography, University of Tehran, Tehran, Iran
[2]Faculty of Environment, University of Tehran, Tehran, Iran

Received 10 Feb. 2007; Revised 5 April 2007; Accepted 25 April 2007

**ABSTRACT:** Internationally recognized Golestan forests are among the most endangered features threatened by anthropogenic activities. Being located in north-west of Iran, south-east of Caspian Sea, Gorganroud watershed is mostly influenced by deforestation activities. In this study the identification of regional atmospheric and hydrologic patterns and their role in conforming floods in Gorganroud water basin are discussed. A 33-year period (1970-2003) was taken in to consideration in the process of data gathering. Gradual change from Mediterranean to Semi-arid climate during recent decades in Gorganroud watershed indicates regional climate change. Increased share of 24-hour precipitation in average annual precipitation in one hand and decreasing rate of snowy on rainy days ratio on the other hand stipulate this climate change. The relatively sharp ascending pattern of annual peak flow of the basin during recent years may be considered as an alarming factor concerning streams inundation. Climate study in suspected water basins may provide invaluable data concerning flood forming potential of regional precipitations. The results of this study confirm the fact that precise analysis of climatic and hydrologic in watersheds threatened by flood-forming run-offs may be used efficiently in monitoring such areas and saving human lives.

**Key words:** Gorganroud watershed, Climate change, Precipitation pattern, Iran

*Corresponding author: Email-tnasrabadi@gmail.com

## INTRODUCTION

Considering ascending rate of population growth accompanied by technological improvements and consequent human requirement to raw materials and housing, anthropogenic environment exploitation and deterioration are widely observed all around the world. This demolition procedure has been reinforced during recent decades (Gumbricht *et al.*, 2004). Continual use of fossil fuels is among the most outstanding man-made features that have resulted in climate change, global warming, glacier melting, reinforcing the continental hurricanes and changing the precipitation patterns (Heratha and Ratnayake, 2004; Costelloe *et al.*, 2003; Huntingford *et al.*, 2003). Domestically in Iran, environment exploitation has undergone a more rapid rate in recent years. According to the reports issued by the ministry of interior, internationally recognized Golestan forests are among the most endangered features threatened by anthropogenic activities. Being located in north-west of Iran, (south-east of Caspian Sea) Gorganroud watershed is mostly influenced by deforestation activities. Destructive floods in Northern Khorasan and Golestan provinces in August 2001 and particularly in August 2005 are considered as major consequences of exploitation in internationally preserved zone of Golestan national park. Considering several floods occurred in Gorganroud watershed in recent years, a study was run on regional atmospheric and synoptic systems which are among the most effective features in conforming heavy precipitation. In this study the identification of regional atmospheric and hydrologic patterns and their role in conforming floods in Gorganroud water basin are discussed.

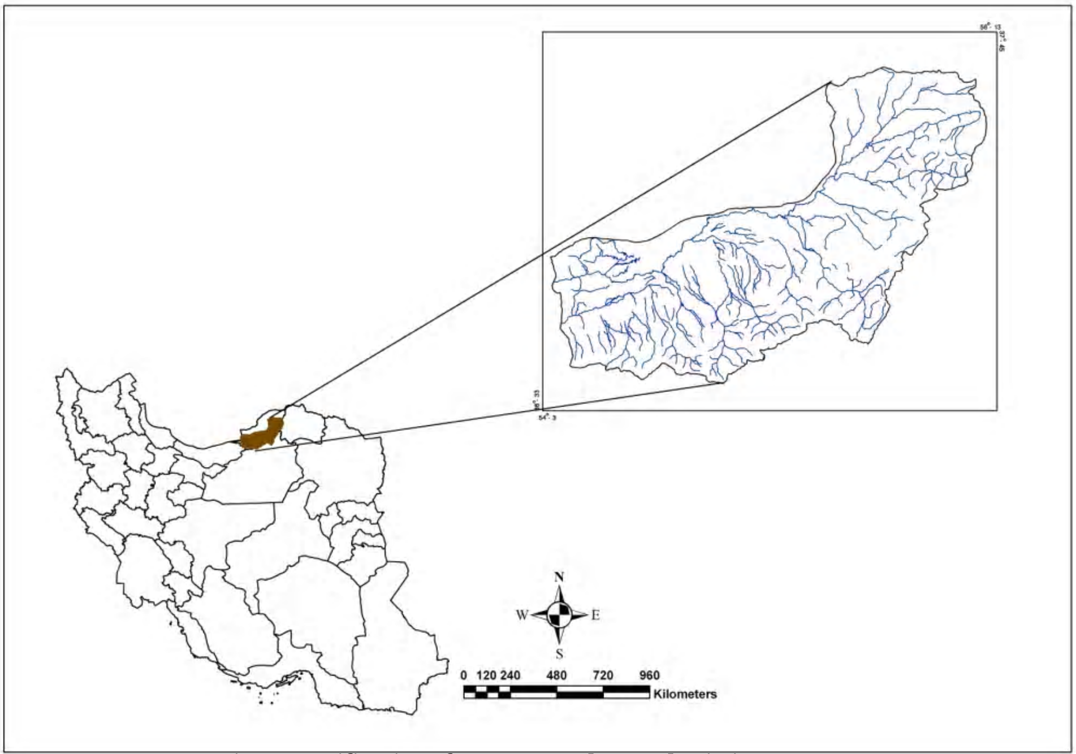



**Fig.1. Specification of Gorganroud water basin in Iran's map**

## MATERIALS & METHODS

In this study, Gorgan station is considered for climatic data collection. This station is located in south-east of Caspian Sea and in 54° 16' east longitude and 36° 51' north latitude. Specification of the study area is schematically shown in Fig.1.

A 33-year period (1970-2003) was taken in to consideration in the process of data gathering. Furthermore, the climatic change rate through this period is also discussed. In other words, this 33-year period is divided in to three 11-year subdivisions and the data are analyzed separately for each span of time.

In order to determine annual climate type of the station, De Martin method with following equation is used (Alizadeh, 2002):

$$IA = P / T+10$$

Here:

IA: De Martin index

P: Average Annual Precipitation (millimeter)

T: Average Annual Temperature (degrees centigrade)

De Martin categorization of different types of climate is illustrated in Table 1.

The IA equated from 33-year period data equals 21.64 and consequently shows that regional climate locates in Mediterranean categorization. But if 11-year period subdivisions are considered with IA amounts of 23.5, 20.7 and 19.66 respectively, it is observed that the type of climate in last 11-year period is changed from Mediterranean to semi-arid category. This change rate is schematically shown in Fig. 2. with a bar diagram. The IA equated from 33-year period data equals 21.64 and consequently shows that regional climate locates in Mediterranean categorization. But if 11-year period subdivisions are considered with IA amounts of 23.5, 20.7 and 19.66 respectively, it is observed that the type of climate in last 11-year period is changed from Mediterranean to semi-arid category. This change rate is schematically shown in Fig. 2. with a bar diagram.

**Table 1. Climate categorization according to De Martin method**

| De Martin index (IA) range | Type of climate |
|---|---|
| IA<10 | Arid |
| 10<IA<19.9 | Semi - Arid |
| 20<IA<23.9 | Mediterranean |
| 24<IA<27.9 | Semi- humid |
| 28<IA<34.9 | Humid |
| IA>35 | Hyper Humid |

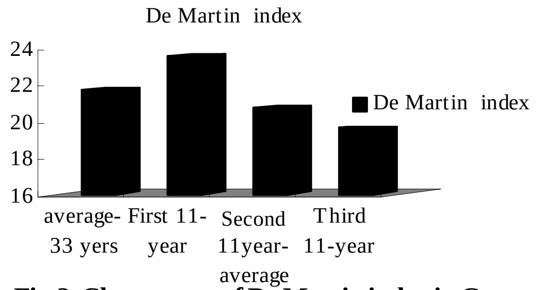



**Fig.2. Change rate of De Martin index in Gorgan station for three 11-year periods**

In order to ascertain the role of atmospheric systems in conformation of regional floods, the ratio of the number of snowy days on rainy days as well as the ratio of temperature and snowy days in the study period have been analyzed separately. The result of this analysis is shown in Fig.5. As it is seen in Fig. 5, the ratio of snowy on rainy days is decreasing in a slight manner, while the ratio of temperature on snowy days increases with a relative rapid rate during the specified 33-year period. This fact does reinforce the flood potential in the mentioned watershed. Considering hydrologic fluctuations in Gorganroud watershed, maximum peak flow as a major effective parameter in determination of flood behavior has been considered. Accordingly, the average maximum of annual peak flow during recent decades in the watershed is identified and illustrated in Fig.6. According to Fig. 6, peak flow parameter has undergone an ascending rate during recent years. In order to highlight the increasing rate of this parameter quantitatively, the 21-year is divided into three 7-year periods and the average annual peak flow is determined for each period separately.

## RESULTS & DISCUSSIONS

Average annual precipitation versus average temperature is studied in order to find any contingent correlation (Durman *et al.*, 2001; Hulme *et al.*, 2002). As it is seen in Figure 3, annual precipitation of the region is descending remarkably with a slope of -4.31, while the average temperature is ascending with a negligible rate of 0.006. Accordingly, overall warming of the region in the considered period may play a key role in increasing the flood risk by reinforcing convective precipitations with high intensity and short periods. A comparison between annual and 24-hour precipitation pattern is shown in Fig.4. The objective of this comparison is determining the share of 24-hour precipitation in the annual average one. According to Fig. 4, the behavior of both types of precipitation (24-hour and annual) is convergent specifically by the end of the period. This convergence is a typical characteristic of arid climate. Fig.7, illustrates the increasing behavior of this parameter in recent years. Such condition indicates a reinforced tendency towards regional flood conformation. In order to analyze meteorological systems of the region, the latest synoptic maps before the flood occurrence in August 2005 in three different levels of 700 hectopascal, 850 hectopascal and ground level have been considered. Such selection has been used in similar studies (Ferraris and Reale, 2001). These maps are illustrated in Figures 8, 9 and 10 (NOAA, 2005). In the map of ground level pattern, the existence of north and north-west flows accompanied by sharp flow gradient highlights the maintenance of a cold front in the study area.

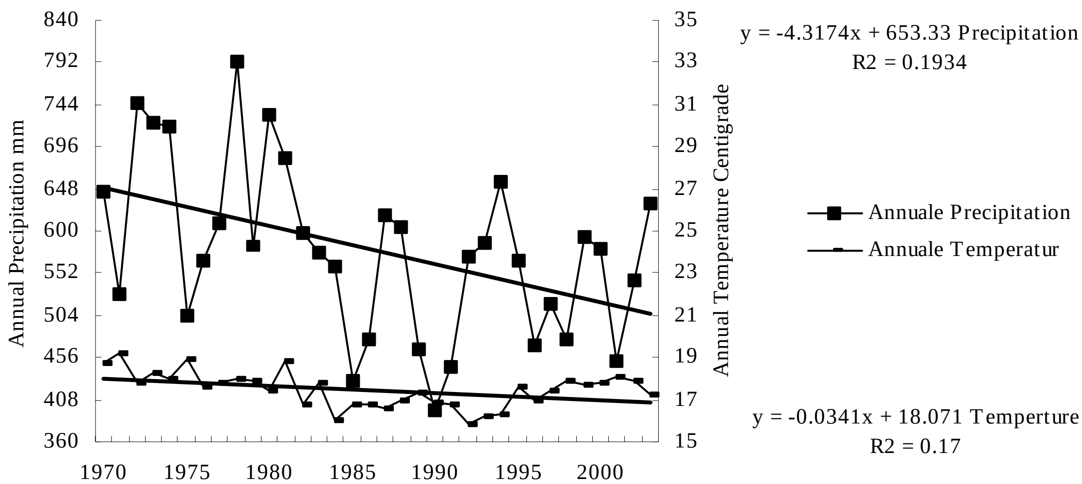



**Fig. 3. Annual temperature and precipitation ambrothermic diagram of Gorgan station**

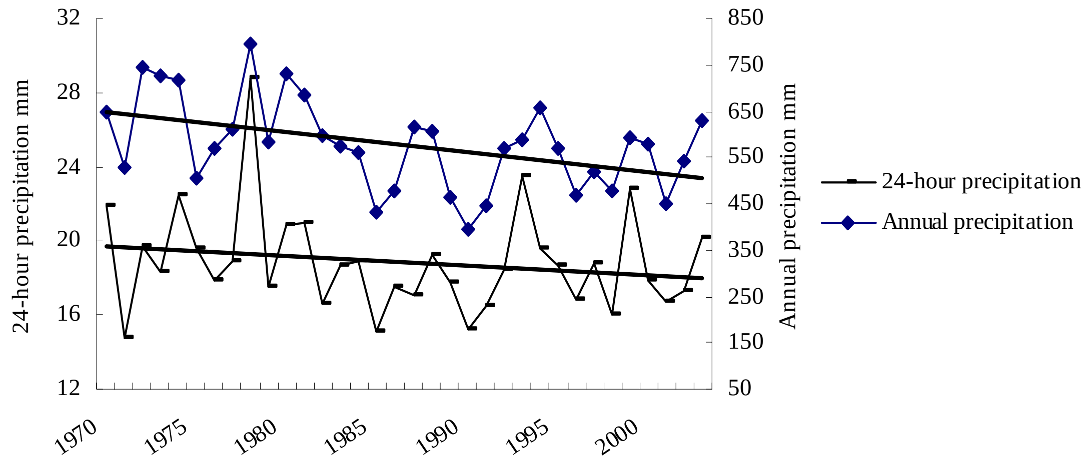



**Fig. 4. A comparison between 24 hr and annual precipitation of Gorganroud watershed**

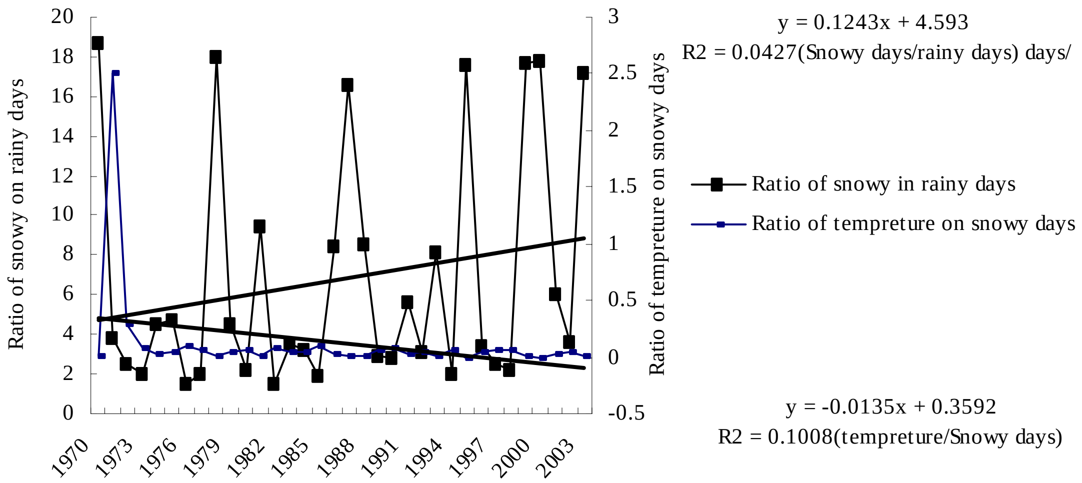



**Fig. 5. The ratio of snowy and rainy days compared with the ratio of temperature and snowy days in study period**

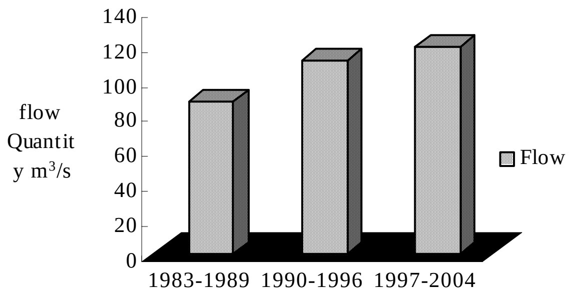



**Fig. 6. Annual average of peak flow in Gorganroud watershed during recent decades**

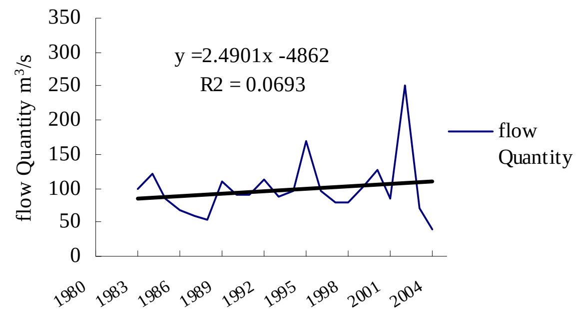



**Fig. 7. Amounts of average annual peak flow for three 7-year periods in Gorganroud watershed**

The interaction between a high-pressure system from north-west (Europe) and a low-pressure one from south-east (India) is observed in this level. In considered period, a sharp pressure gradient is observed in southern part of Caspian Sea. In the map indicating 850 hectopascal levels the direction of advections on Caspian Sea is seemed to be north and north-west ward. Furthermore, a high-pressure system is drawn in to northern Iran from Scandinavia is also designated. The average height of elevation curves is around 1485 goe-potential meter. Finally, in the map of 700 hectopascal level the most outstanding features are the existence of a blocking high-pressure on northern Caspian, a deep trough on central and particularly eastern parts and a high-pressure ridge on western parts.

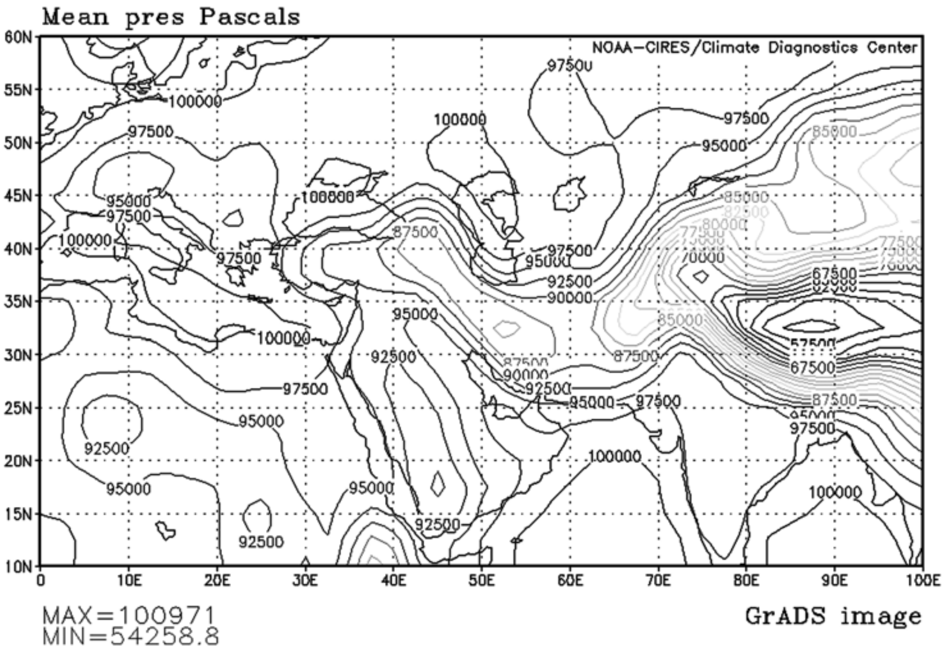



**Fig.8. Synoptic map in ground level**

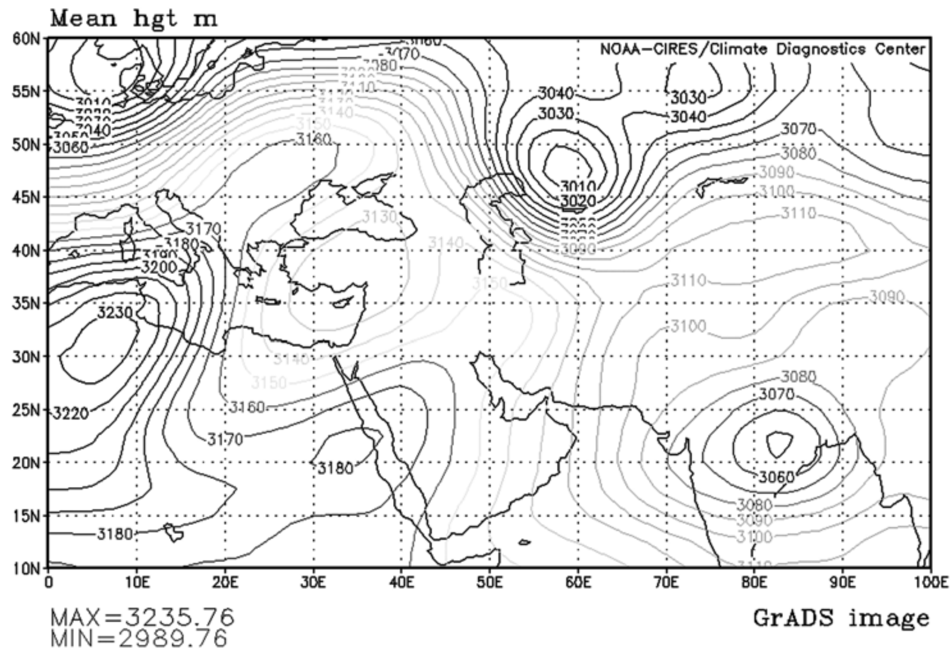



**Fig.10. Synoptic map in 700 hectopascal level**

The major direction of curves is north-west – south-east and the average height of them is about 3140 geo-potential meter. High pressure centers are observed on Caspian Sea in all maps. Not only high pressure centers but also cyclone systems in southern coastline of Caspian Sea are contributed in formation of high intensity precipitations and consequently increasing the regional flood potential.

## CONCLUSION

Climate study in suspected water basins may provide invaluable data concerning flood forming potential of regional precipitations. The results of this study confirm the fact that precise analysis of climatic and hydrologic in watersheds threatened by flood-forming run-offs may be used efficiently in monitoring such areas and saving human lives. Gradual change from Mediterranean to semi-arid

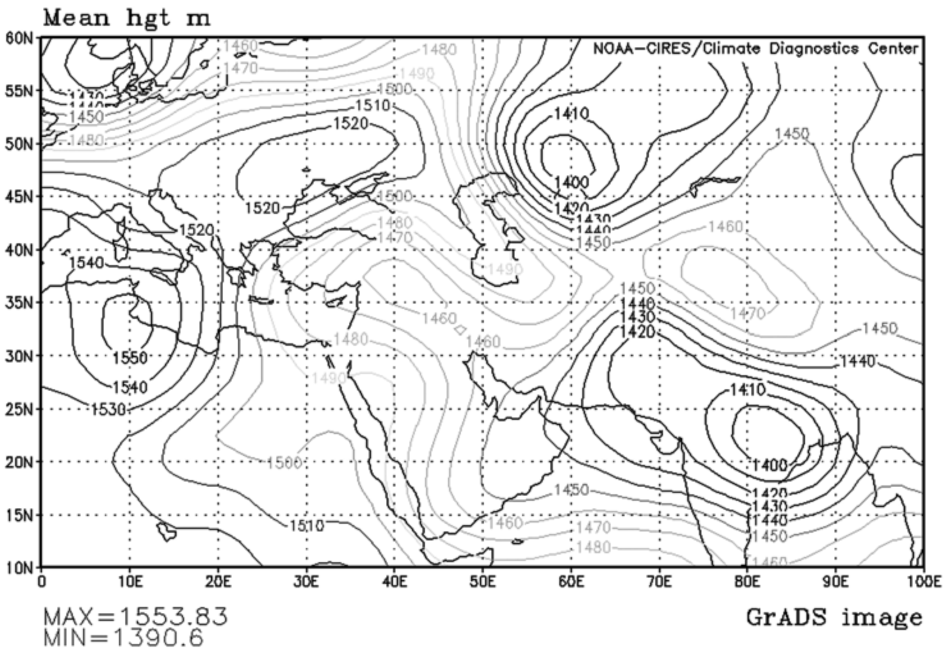



**Fig.9. Synoptic map in 850 hectopascal level**

climate during recent decades in Gorganroud watershed in addition to constant decrease in amount of average annual precipitation indicates the climate change in the region. This change automatically imposes its own characteristics to the local atmospheric and hydrologic situation. Increased share of 24-hour precipitation in average annual precipitation in one hand and decreasing rate of snowy on rainy days ratio on the other hand stipulate this climate change. Consequently, hydrologic behavior of the basin was highly influenced by newly imposed condition. The relatively sharp ascending pattern of annual peak flow of the basin during recent years may be considered as an alarming factor concerning streams inundation. Finally, recent synoptic maps before flood occurrence in August 2005 indicate the existence of high-pressure centers on Caspian Sea. Paying more attention to gathered information in this study could save hundreds of people's lives. Similar studies are highly recommended for other water basins specially those who are threatened by flood potential.

## REFERENCES

Alizadeh, A., (2002). Principles of Applied Hydrology, Imam Reza University publication, 14th. Ed. Costelloe, J.F., Grayson, R.B., Argent, R.M. and McMahon, T.A., (2003). Modeling the flow regime of an arid zone floodplain river, Diamantine River, Australia, Environ. Model. Software, **18**, 693-703.

Durman, C. F., Gregory, J. M., Hassell, D. C., Jones, R. G. and Murphy, J. M., (2001). A comparison of extreme European daily precipitation simulated by a global and a regional climate model for present and future climates, Quarter. J. Royal Mete. Soc., **127** (573), 1005-1015.

Ferraris, L. and Reale, O., (2001). Synoptic and hydrological analysis of a flood event, Physics Chemi. Earth, **26**(9), 655-661.

Gumbricht, T., Wolski, P. and McCarthy, T.S., (2004). Forecasting the spatial extent of the annual flood in the Okavango Delta, Botswana, J. Hydrol. **290**, 178-191.

Heratha, S. and Ratnayake, U., (2004). Monitoring rainfall trends to predict adverse impacts, a case study from Sri Lanka (1964–1993). **14**, 71-79

Hulme, M., Jenkins, G.J., Lu, X., Turnpenny, J. R., Mitchell, T. D., Jones, R. G., Lowe, J., Murphy, J. M., Hassell, D., Boorman, P., McDonald, R., Hill, S., (2002). Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report. Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK.

Huntingford, C. Jones, R.G. Prudhomme, C. Lamb, R. Gash, J.H.C. and Jones, D.A., (2003), Regional climate-model predictions of extreme rainfall for a changing climate, Quarter. J. Royal Mete. Soc., **129** (590), 1607–1621.

NOAA, (2005). National Center for Environmental Prediction, http://www.cdc.noaa.gov

*Int. J. Environ. Res., 1(3): 237-241, Summer 2007*
*ISSN: 1735-6865*

# Assessment of Indoor Airborne Pollutants of Beam Rolling Mills Factory

**Rafiei M.[1], Gadgil A. S.[2], Ghole, V. S.[3*], Gore, S. D.[4], Jaafarzadeh, N.[5],Golbabaei, F.[6]**

[1]Department of Environmental Science, University of Pune, Pune 411007, India
[2]Department of Geography, University of Pune, Pune 411007, India
[3] Departmentof Chemistry, University of Pune, Pune 411007, India
[4]Department of Statistics, University of Pune, Pune 411007, India
[5]Ahwaz Jondishapour University of Medical Sciences, Ahwaz, Iran
[6]University of Tehran Medical Sciences,Tehran, Iran

Received 20 Nov. 2006; Revised 28 March 2007; Accepted 15 April 2007

**ABSTRACT:** Air pollutants from iron and steel making operations have historically been an environmental concern. The factory located at Ahwaz, Iran, has two production lines namely, 630 and 650, which produce iron parallel edge. The objective of the study is to determine indoor respiratory particulate matter (RPM) and FeO concentrations and their comparison with NIOSH standards. This is a cross–sectional study of personnel working in different environmental conditions. There were significant differences in mean concentrations of RPM ($P< 0.05$) in line 650 but not in line 630 as compared to NOISH standard (3 $mg/m^3$). The FeO concentrations in line 630 and 650 are significantly lower than the NIOSH standard (5 $mg/m^3$). There is maximum FeO concentration in station 7 (0.8 $mg/m^3$), due to remains of iron on the billets. In other words, after cutting the beam by saws, carried out with water pressure of 150 Bar and immersing in cooling beds, the temperature decreases from 550 °C to 150 °C. As the result, airborne iron oxide concentrations decrease in the respiratory air zone of workers. There is maximum RPM concentration in station of Billet rejecter for line 630 (7.645 $^{mg}/m^3$), because this station carries out peel action on metal. The primary form of RPM is not directly related to the iron handling but may be related to improper ventilation and exhaust system.

**Key words:** RPM, FeO, Airborne, Beam Rolling Mills

*Corresponding author: Email-vsghole@chem.unipune.ernet.in

## INTRODUCTION

Air pollutants from iron and steel making operations include gaseous substances such as oxides of sulfur, nitrogen dioxide and carbon monoxide. In addition, particulates such as soot and dust, which may contain iron oxides, have been the focus of control. Particulate matter (PM) is the general term used for a mixture of solid particles and liquid droplets found in the air. These particles, which come in a wide range of sizes, originate from many different stationary and mobile sources as well as from natural sources. They may be emitted directly from a source or formed in the atmosphere by the transformation of gaseous emissions. Their composition varies with place, season and meteorology (Colls, 2002). Potential health effects depend on the number of particles in the respire range, the chemical composition of the dust and the duration and concentration of exposure. Particles in the atmosphere consist of either solid particles or fine liquid droplets. The greatest effect on health is from particles 10 microns (PM-10) or less in diameter, which can cause and aggravate bronchitis, asthma and other respiratory diseases. Because of the importance of determination of these pollutants, many researchers have tried to evaluate the work places (Hester and Harrison, 1999). Woskie *et al.*, (2002) collected samples for dust, diesel exhaust, quartz, and welding fumes from highway and highway construction workers. Respire quartz exposures exceeded the National Institute for Occupational Safety and Health (NIOSH) norms.(Woskie, *et al.*, 2002 and Kemp *et al.*, 2003). The objective of the present study is to determine indoor respiratory particulate matter and FeO concentrations and their comparison with NIOSH standard. The factory (Iran National Steel Industrial Group – Ahwaz) under study has two production lines namely, 630 and 650, which produce iron parallel edge. This is a cross – sectional study of workers working in different environmental conditions.

## MATERIAL & METHODS

Twenty stations in each line 630 and 650 were selected. The instrument measuring RPM and iron oxide were fixed on the workers body in respiratory zone. Total sample size for RPM and FeO fumes was 20 and 17 in line 650, 20 and 13 in line 630 respectively. Air samples were collected using low volume sampling pump (model SKC, made in England) operated at flow rate of 2 L/min$^{-1}$ on membrane filters of pore size 0.5 micrometer and diameter 27mm. Then analytical balance with 0.01 mg precision was used (Swiss make and model no. XT220A-Pecisa; NIOSH, 1997 & ASTM, 1996). The samples of iron oxide content were determined by Atomic Absorption Spectrophotometer method using CTA 3000 Atomic Absorption Spectrophotometer (ChemTech Analytical Instruments Limited, UK) equipped with Air/acetylene flame.

Reagent grade chemicals were used. Concentrated HCl (32%, Merck, Germany), concentrated $HNO_3$ (Merck, Germany), concentrated $HClO_4$ (Merck, Germany), and concentrated $H_2SO_4$ (Merck, Germany) were used to dissolve the filters containing metal samples. Stock solutions of 1000 microgram/mL$^{-1}$ of Fe were purchased from Chem Tech analytical (made in UK). Standard solutions of each metal were prepared by successive dilution of these stock solutions. Before use, all the glassware were cleaned with a detergent, rinsed with distilled water, soaked in 1:1 HNO3, rinsed in distilled water and then dried. 100 microgram/ml Fe was prepared by adding 10 ml of stock solution (1000 mg/ml) with Calibration standards, 0.5, 1, 2.5, 5, 7.5; 10 microgram /ml were prepared by diluting appropriate amount of this solution. The calibration standards were aspirated in the air/ acetylene flame and the resulting absorbances were recorded. Calibration curve was constructed by plotting absorbance versus metal concentration. The best fit line for data was calculated and drawn by the instrument software. This line was used to determine the concentration of iron in the samples (NIOSH, 1997 & ASTM, 1996).

The samples and blank filters were transferred into 25 mL beakers. Each beaker was covered with watch glass and placed on a hot plate (140 $^0$C) in a fume hood. The samples were dissolved and a light yellow solution was obtained. The digested samples were transferred to 10 mL volumetric flask and diluted to the volume the concentrations of iron in sample solutions were determined using the above calibration curve (NIOSH, 1997 & ASTM, 1996).

## RESULTS & DISCUSSIONS

Table 1 shows difference between mean RPM concentrations in line 650 and NIOSH standard value (3 mg/m$^{-3}$) (P< 0.05). It is higher than the standard. The mean value of RPM concentrations was in 630 and 650 lines (3.09 and 3.78 mg/m$^{-3)}$ respectively. Figure 1 illustrates maximum RPM concentration in station of Cabin of saws and minimum RPM concentration in station Stand 2 for line 650 (6.32 and 2.11 mg/m$^{-3)}$ respectively. Figure 2 illustrates maximum RPM concentration in station of Billet rejecter and minimum RPM concentration in station Stand 4 for line 630 (7.64 and 1.65 mg/m$^{-3}$) respectively. Table 2 summarizes the results of comparison of the mean of respire iron oxide concentrations with NIOSH standard value (5 mg/m$^{-3}$). There is a significant difference between mean FeO concentrations in line 650 and NIOSH standard value (P< 0.05). It is much lower than the standard. The mean value of FeO concentrations was in 630 and 650 lines (0.90 and 0.14 mg/m$^{-3}$) respectively. Figure 3 illustrates that maximum FeO concentration for station of Stand 7 and minimum FeO concentration in station Saws for line 650 (0.82 and 0.0 mg/m$^{-3}$), respectively. Figure 4 illustrates maximum FeO concentration in station of Cabin of stand 1 and minimum FeO concentration in station Cabin of furnace for line 630 (0.42 and 0 mg/m$^{-3}$) respectively.

## CONCLUSION

Table 1 illustrates, the mean of RPM concentrations in respiratory air zone are significantly different (P< 0.05) in line 650 but not in line 630 as compared to NIOSH standard

**Table1. Comparison of mean concentration values of RPM* with NIOSH (mg/m³)**

| Source | Number of sampling | Mean | Standard deviation | P- Value | 95% CI | | |
|---|---|---|---|---|---|---|---|
| | | | | | Lower | Upper | NIOSH standard |
| Line 630 | 20 | 3.09 | ±1.43 | 0.76 | -7.57 | -6.23 | 3 |
| Line 650 | 20 | 3.78 | ±1.03 | 0.03 | 0.30 | 1.26 | |

*Respiratory particulate matter

**Table 2. Comparison of mean concentration values of FeO* with NIOSH (mg/m³)**

| Source | Number of sampling | Mean | Standard deviation | P- value | 95% CI | | |
|---|---|---|---|---|---|---|---|
| | | | | | Lower | Upper | NIOSH standard |
| 630 | 13 | 0.90 | ±0.11 | 0.001 | -4.96 | -4.23 | 5 |
| 650 | 17 | 0.14 | ±0.23 | 0.001 | -4.97 | -4.84 | |

(3 mg/m³). The reason lies behind two furnaces of 20 and 40 tonnage in line 650, but, there is one furnace in line 630. In final mills actions in line650, there are four numbers of working stands and saw machines, but in line 630, there are three numbers of working stands and one saw machine. As a result, the average of RPM concentrations in line 650 (3.78 mg/m³) is higher than line 630 (3.09 mg/m³) with interval confidence of 95%. As depicted in fig. 1, there is a maximum concentration in station number 1 for Cabin of Saws in line 650 (6.32 mg/m³). The iron cutting carried out by four saw machines that are located around the station 13 can be the major reason. High speed of the saws that generate high air velocity can cause turbulence in the air and due to this the dust does not settle fast. Meanwhile miss location of SawsCabins, push particulate pollutants in toworking environment. Fig. 2 illustrates, that there is a maximum RPM concentration in station of Billet rejecter in line 630 (7.645 mg/m³). As Billet rejecter carries out peel action on metal and primary stand in one hand and proximity to entrance, billet storage and transport plat form, on the other hand, the pollution load in this station is more than other stations. Processing of production results in emission of some particulate matter.

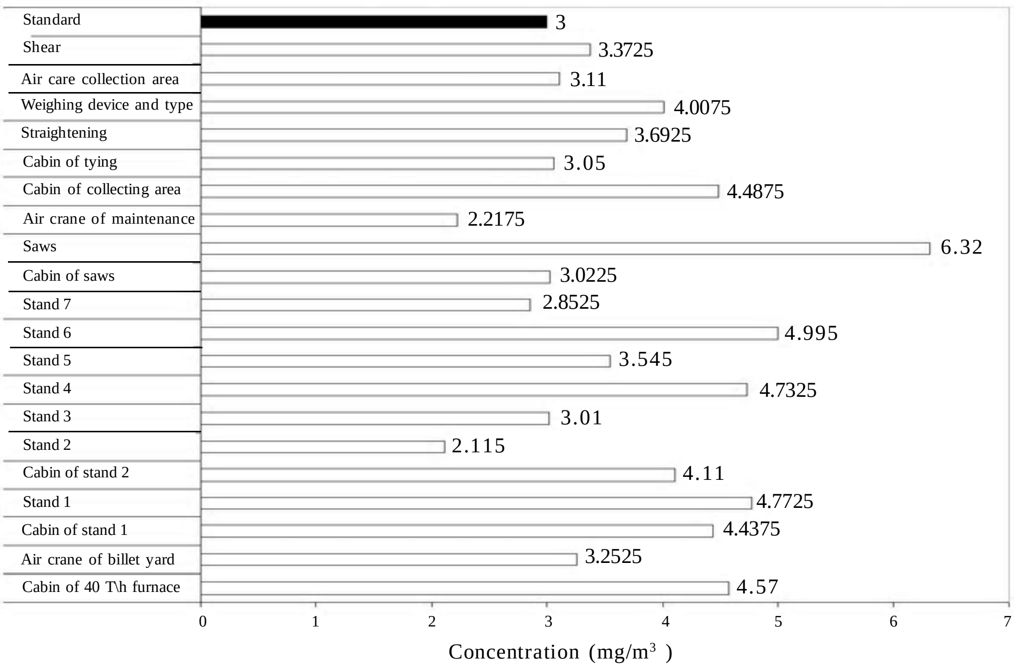



**Fig. 1. Comparison of RPM Concentrations with NIOSH Standard in Line 650**

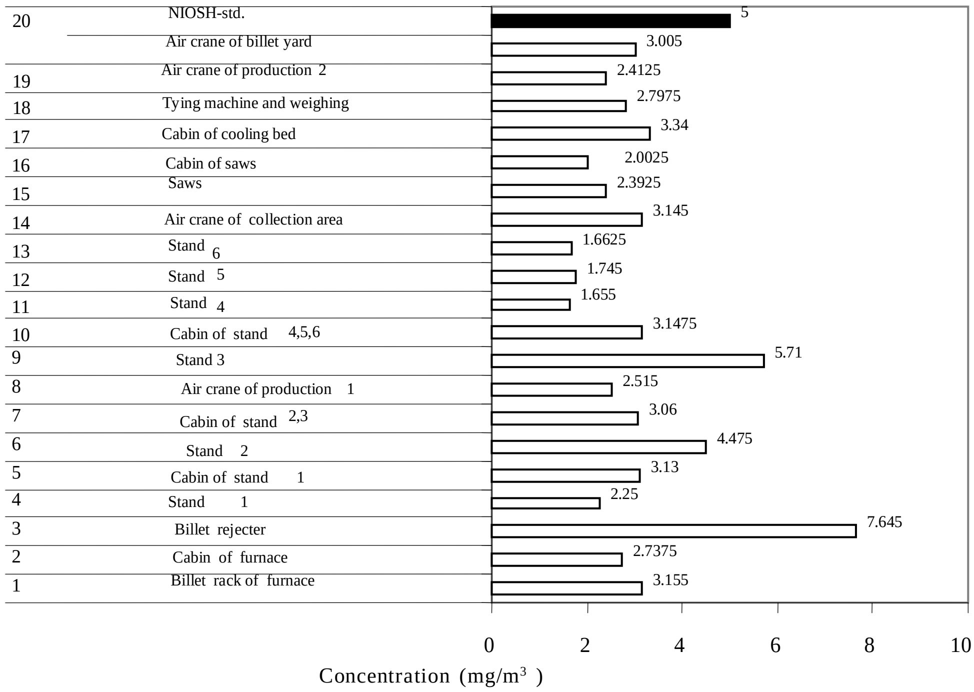



**Fig. 2. Comparison of Mean value RPM Concentrations with NIOSH Standard in Line 630**

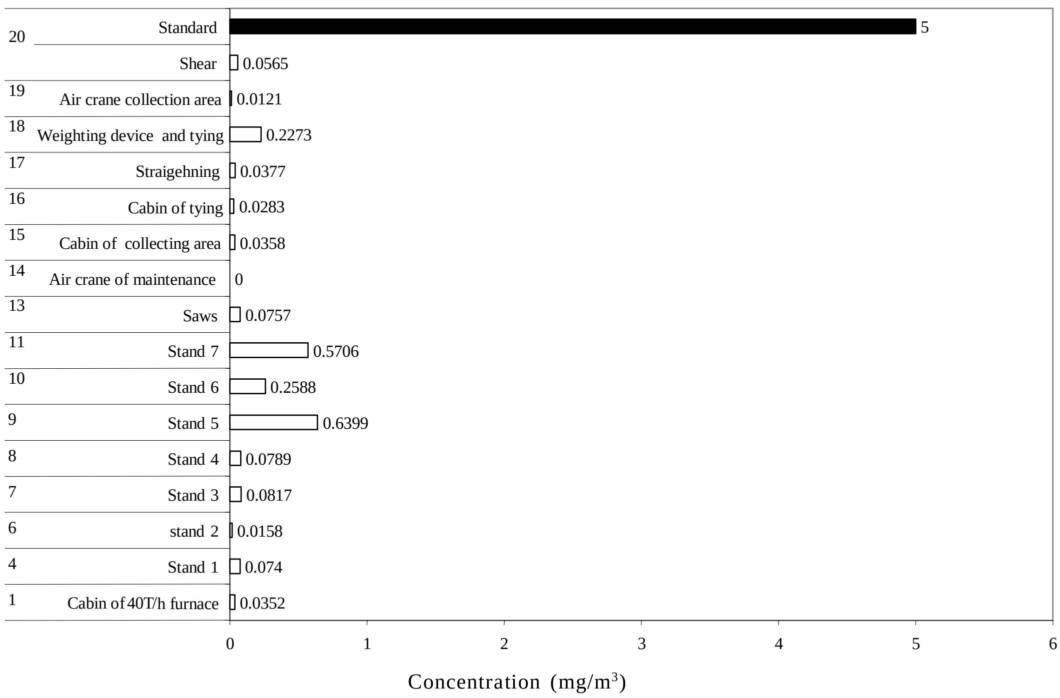



**Fig. 3. Comparison of FeO Concentrations with NIOSH Standard in Line 650 in terms of mg/m$^3$**

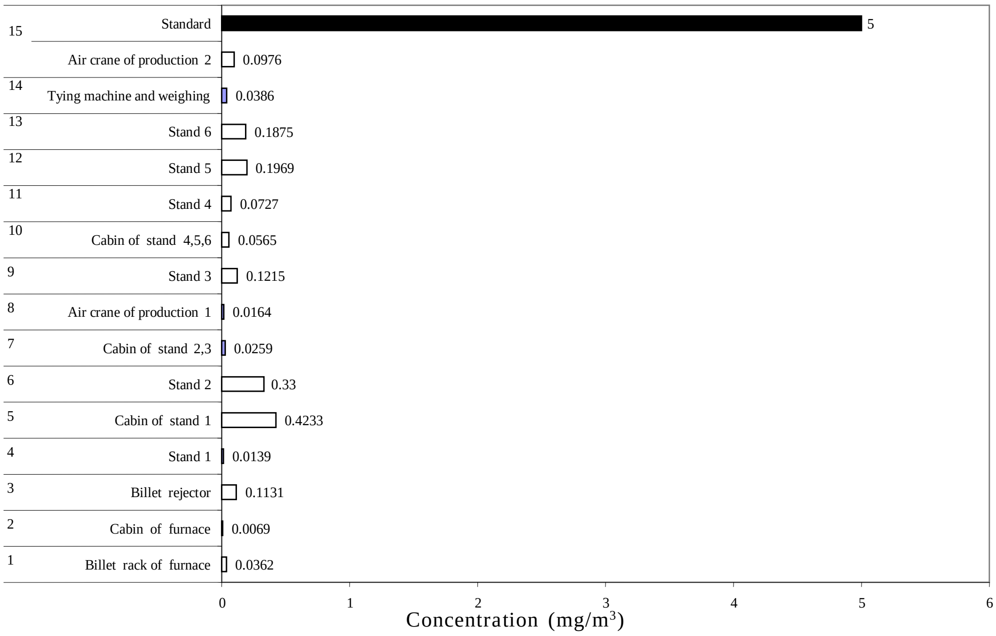



**Fig. 4. Comparison of FeO Concentrations with NIOSH Standard in Line 630 in terms of mg/m$^3$**

The average FeO concentrations in lines 650 and 630 (0.23 and 0.11 mg/m$^3$) respectively with interval confidence of 95% which is much lower than NIOSH value standard. Due to temperature decreases from 550 °C to150 °C, airborne iron oxide fumes decrease in worker's respiratory air zone. Considering the wind direction, Iron oxide fumes in Stand 7 of line 650 are higher than in stand 1 of line 630. As a result, it is not a serious problem on health of workers.Therefore, it can be concluded that pollution load is more in RPM. It is recommended that the equipment of all sampling workstations, especially in stations of Air crane cabin of Billet yard, Cabin of stands 2, 3, 4, 5, 6, and Billet rejecter be house kept and corrected. The workers should be trained to use personal protective equipments including respiratory mask.

## ACKNOWLEDGEMENTS

Authors are thankful to the Engineer Mr. Rasuli Ministry of Iran National Steel Industrial Group and Dr. B. Mombani, chief of Health, Safety and Environmental (HSE) who let us undertake this project. We acknowledge Mr. H. Tabesh, Mrs. M. Shabab and Mr. A. Lahijanzaden for their kind cooperation.

## REFERENCES

American Society for Testing and Materials (ASTM), (1996). Atmospheric Analysis: Occupational Health and Safety; Protective Clothing. Annual book of ASTM standards. 370.

Colls, J., (2002). Air Pollution, 2nd. Ed. Springer. 590.

Hester, R. E. and Harrison, R. M., (1999). Air Pollution and Health.Royal Society of Chemistry. Cambridge. 295.

Kemp, P. C., Kemp, H. G., Esposito, B., Lysek, G. and Murray, F., (2003). AIHA Journal, **64**, 269-275.

NIOSH, (1997). Manual of Analytical Methods.,4th. Ed. **3**, USA. 832.

Woskie, S. R., Kalil, A., Bello, M. Virji, A., (2003). collected samples for dust, diesel exhaust, quartz, and welding fumes from highway and highway construction workers. AIHA Journal, **63**, 447-457.

*Int. J. Environ. Res., 1(3): 242-247, Summer 2007*
*ISSN: 1735-6865*

# Evaluation of Industrial Dyeing Wastewater Treatment with Coagulants

**Nabi Bidhendi, Gh. R., Torabian, A., Ehsani, H., Razmkhah, N.*, and Abbasi, M.**

Faculty of Environment, University of Tehran, P. O. Box 14155-6135, Tehran, Iran

Received 5 Jan. 2007; Revised 10 April 2007; Accepted 30 April 2007

**ABSTRACT:** Textile industry is the major source of water consumption and wastewater pollution. There are various treatment techniques to remove textile wastewater pollution. Coagulation-flocculation is a widely used process to remove pollution due to suspended particles. In this research, different coagulants like Alum, Lime, $FeCl_3$, $FeSO_4$ and $MgCl_2$ were applied to select the suitable ones with optimum removal efficiency of sulfuric dyes. Settling characteristics of flocs formed in the coagulation process were studied in a laboratory scale settling column unit. Parameters such as color, COD, TSS, turbidity and settled sludge volume have been evaluated. The optimum coagulant dose and pH value were determined by comparing the effectiveness of these coagulants.Results showed other coagulants except lime could eliminate color and COD. In this case, $FeSO_4$ was chosen as an optimum coagulant for color removal because of the lowest required coagulant dose, minimum settled sludge volume and maximum de-colorization.

**Key words :** Dye removal , Coagulation , Textile wastewater , De-colorization

*Corresponding author: Email- nrazmkhah@yahoo.com

## INTRODUCTION

Wastewater is the major environmental issue of the textile industries besides other minor issues like solid waste, resource wastage and occupational, health and safety. Textile and dyeing mills use many kinds of artificial composite dyes and discharge large amounts of highly colored wastewater. Pretreatment, coloration and after treatment of fibers, usually require large amounts of water and variety of chemicals. Variations in the fabric quality and treatment process results into large fluctuation in daily flow rates and pollutants concentrations. Textile wastewater pollutants are generally caustic soda, detergents, starch, wax, urea, ammonia, pigments and dyes that increase its BOD, COD, solids contents and toxicity. These wastes must be treated prior to discharge in order to comply with the environmental protection laws for the receiving waters. Biological treatment processes are frequently used to treat textile effluents. These processes are generally efficient for biochemical oxygen demand (BOD) and suspended solids (SS) removal, but they are largely ineffective for removing color from the wastewater (McKay, 1979; Taebi Harandi, 1986) because dyes have slow biodegradation rate (Bennett and Reeser, 1988). Now, the treatment technologies recommended meeting color removal requirements are physicochemical treatment operations, including adsorption (Ahmad & Ram, 1992; McKay, 1979), ozonation (Lin's, 1993), oxidation (Boon, *et al.*, 2000), chemical precipitation (Dziubek & Kowal, 1983), etc. Each has its merits and limitations in applied de-colorization treatment operations. But Coagulation-flocculation is the most common chemical treatment method for de-colorization (Carliell, *et al.*, 1994; Bennett & Reeser, 1988). All test results in Iran and other countries show chemical treatment is effective enough to treat textile wastewater and decrease considerable COD and dye. Hengame Goya factory is located in *Eshtehard* industrial town. In this factory, sulfuric colorants and 522 black color made in Shanghai China commercially named *sulfur black* 522 BR 200% are usually used for dyeing process.

## MATERIALS & METHODS

Both suspended and colloidal particles don't settle under gravity so they can't be removed by physical processes. Reason of this event is that some suspended solid have trifle weight and the charges present on colloid surfaces result into repulsion and do not allow them to agglomerate and form flocs. Coagulation process neutralizes the charge present on the particles surfaces with the help of coagulants whereas flocculation makes them to come close to each other to make flocs by slow agitation. Settling follows coagulation and flocculation to remove resultant flocs from the wastewater (Beulker & Jekel, 1993). Designing of coagulation, flocculation and settling tank requires study regarding optimum dose of coagulants at suitable pH to give maximum removal and settling characteristics of resultant flocs (Cooper, 1993; Jorgenson, 1974).

Factory wastewater samples were averagely taken weekly and then conveyed to the laboratory of Environment Faculty in Tehran University per month. Parameters such as pH, COD, dye concentration and TSS were determined. Then, COD and dye removal efficiencies were calculated. Experimental conditions of all tests are:

1.All tests have been performed in (25°C±2). Because temperature is one of the effective parameters on density, viscosity and thus retained volume of coagulant.

2.The volume of studied wastewater was 500 cc. Method No.522 in Standard Method was used to determine COD (chemical oxygen demand). COD concentration of the samples was measured by potassium dichromate method using HACH spectrophotometer. Color was determined by comparative methods using HACH spectrophotometer DR/2000. The color measurement unit is Pt/Co. TSS was determined in conformity with Standard Method using HACH Spectrophotometer RD/2000. PH was measured using digital SCHOTT pH meter model CG824 (accuracy pH$\pm$0.1) .Turbidity was determined using ANNA turbidity meter and the measurement unit is NTU (Rinker & Starent, 1974). All experiments were conducted using the jar testing method to determine the optimum pH value and coagulant dose. Six beakers positioned on magnetic stirrers were dosed with 0.5-L dye solution and a specified dosage of coagulant. The samples were stirred rapidly for 90 seconds, followed by 20 minute slow stirring for flocculation. The generation of flocs can be watched during this period. Flocs were allowed to settle for one hour before withdrawing samples for analysis. These procedures are performed for several times so that the optimum pH and dose of coagulant can be calculated (Hosseinian, 1991; Metcalf & Eddy, 1979; Torkian, 1996).

## RESULTS & DISCUSSIONS

In this study, coagulation-flocculation processes are used to de-colorize and bio-degraded textile finishing industry effluents. The optimum coagulant dose and pH value are determined by comparing the effectiveness of alum, $FeSO_4$, $FeCl_3$, lime, $MgCl_2$ for obtaining maximum color, TSS and COD removals. For each case, the optimum pH is primarily determined for 400 mg/L coagulant concentration based on more color and COD removal and also less settled sludge. Then the optimum effective dose of coagulant is calculated at the optimum pH. Finally at constant optimum pH and coagulant dose has been evaluated. According to figure 1 and 2 the optimum pH for 400 mg/L alum is 8.2 due to higher color and COD removal and lower volume of settled sludge. Figure 3 and 4 shows that the optimum dose of alum for color and COD removal is 200 mg/L.

To evaluate lime effect on color and COD removal of dyeing wastewater, first its effect at a constant pH for different doses of lime has been evaluated**.** Fig. 5. shows that 250 mg/L lime eliminates only 29 % COD and just 2.5 % color. After 3 hours no settled sludge has been found. Thus lime is not recommended for color removal of dyeing wastewater.

According to Figs. 1 and 2 the optimum pH for 400 mg/L $FeSO_4$ is 9.4 due to higher color and COD removal and lower volume of settled sludge. Figure 3 and 4 shows that the optimum dose of $FeSO_4$ for color and COD removal is 200 mg/L. According to figure 2 and 6 the optimum pH for 400 mg/L $FeCl_3$ is 8.3 due to higher color and COD removal and lower volume of settled sludge. Figure 4 and 7 shows that the optimum dose of $FeCl_3$ for color and COD removal is 200mg/L.

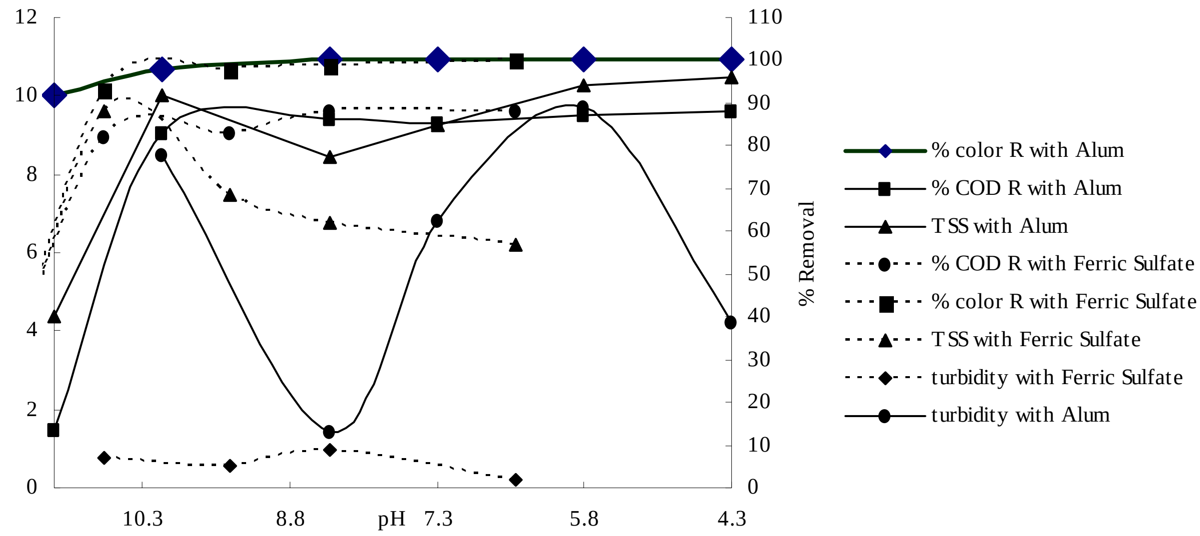



**Fig.1. % Removal of Color, COD & TSS and turbidity for different pH. (For 400 mg/L Alum or 400 mg/L of $FeSO_4$)**

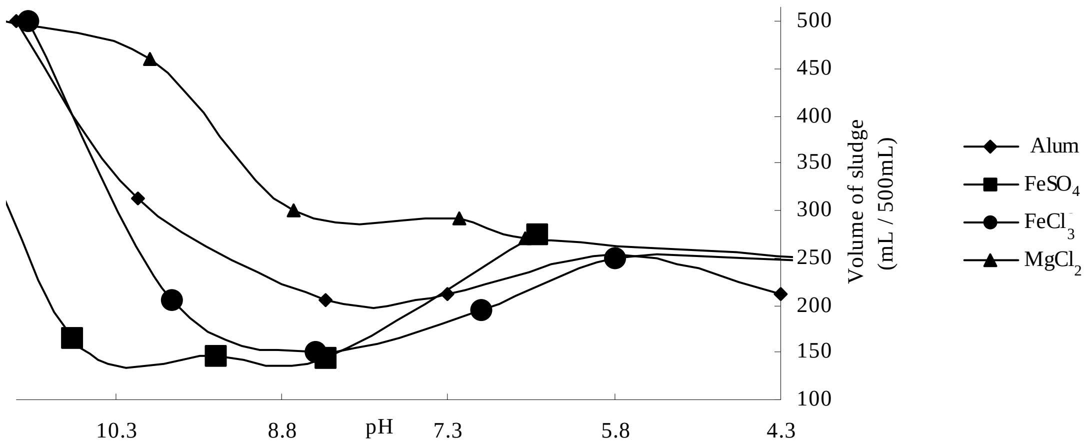



**Fig. 2. Settled sludge volume for 400 mg/L of coagulants**

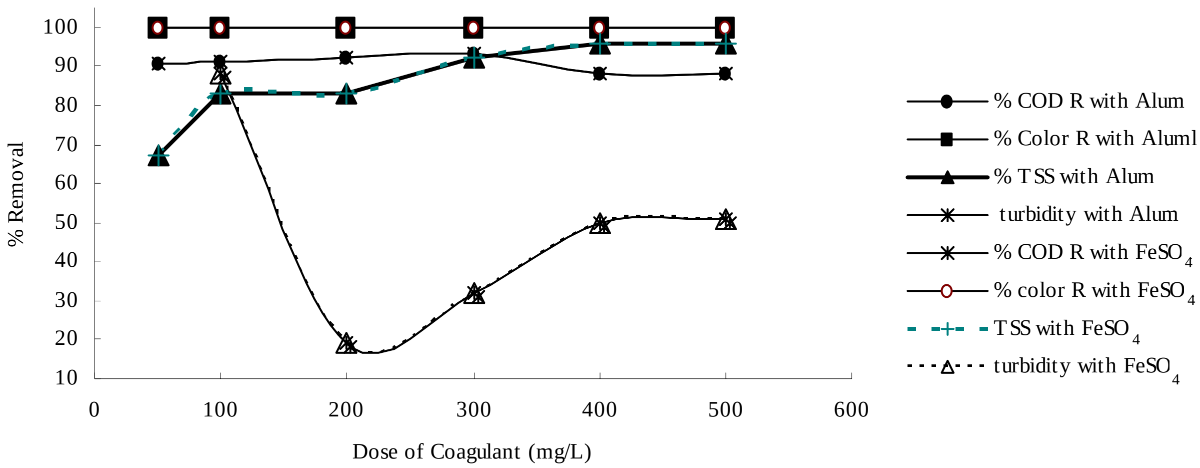



**Fig. 3. % Removal of Color, COD & TSS and turbidity for different doses of coagulant (At optimum pH=8.2 for Alum Or at pH=9.4 for $FeSO_4$)**

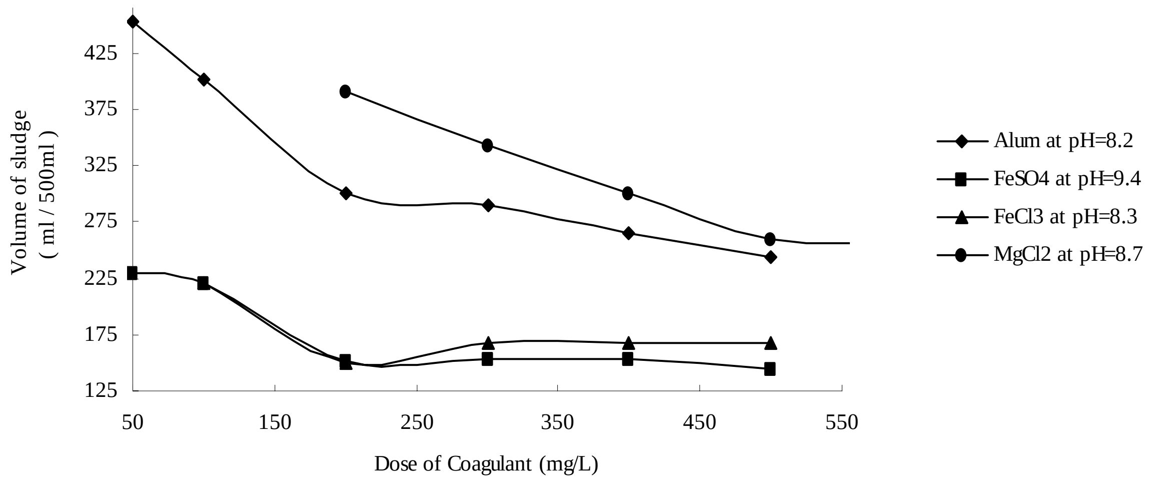



**Fig. 4. Settled sludge volume for different coagulants at their optimum pH**

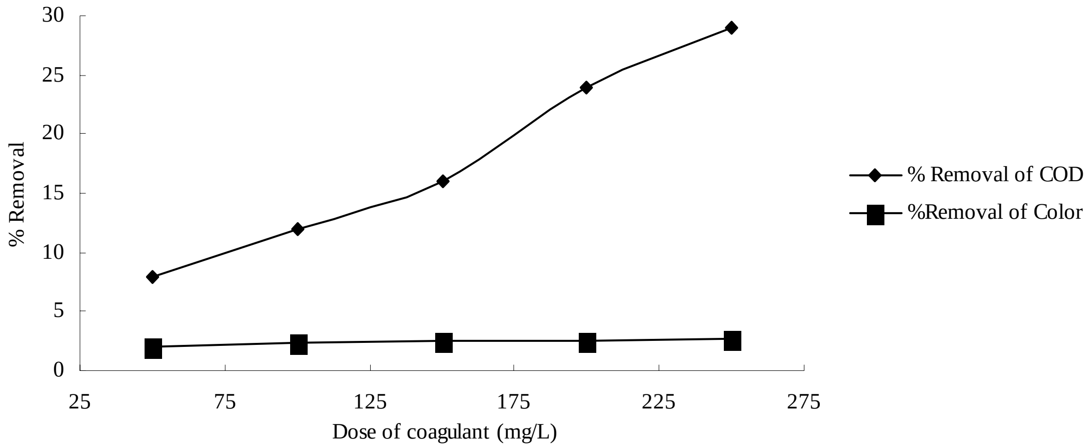



**Fig. 5. % Removal of Color & COD for different doses of lime (At pH= 10.3)**

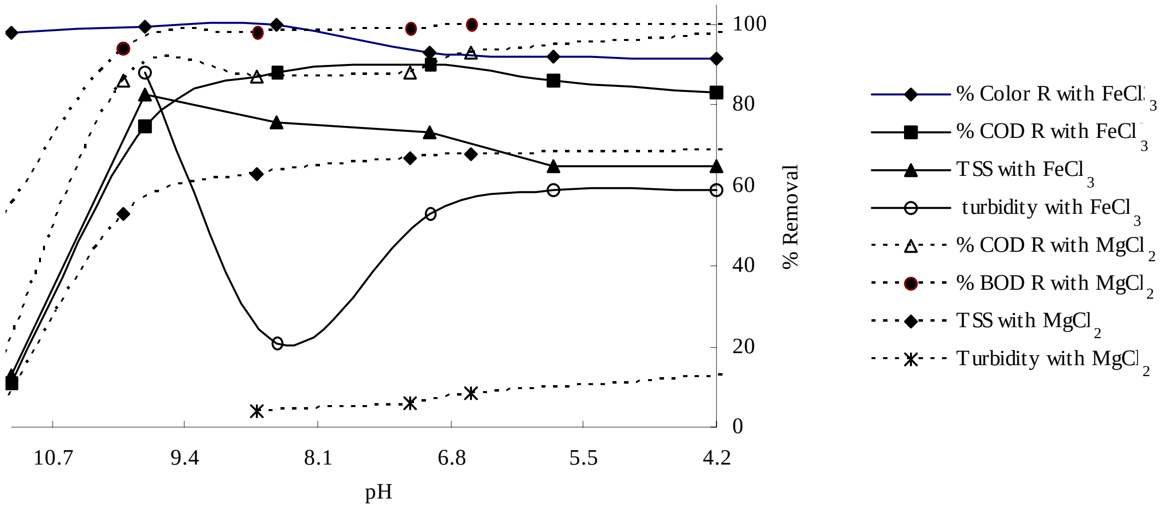



**Fig. 6. % Removal of color, COD & TSS and turbidity for different pH.**
**(For 400 mg/L $FeCl_3$ or 400 mg/L of $MgCl_2$)**

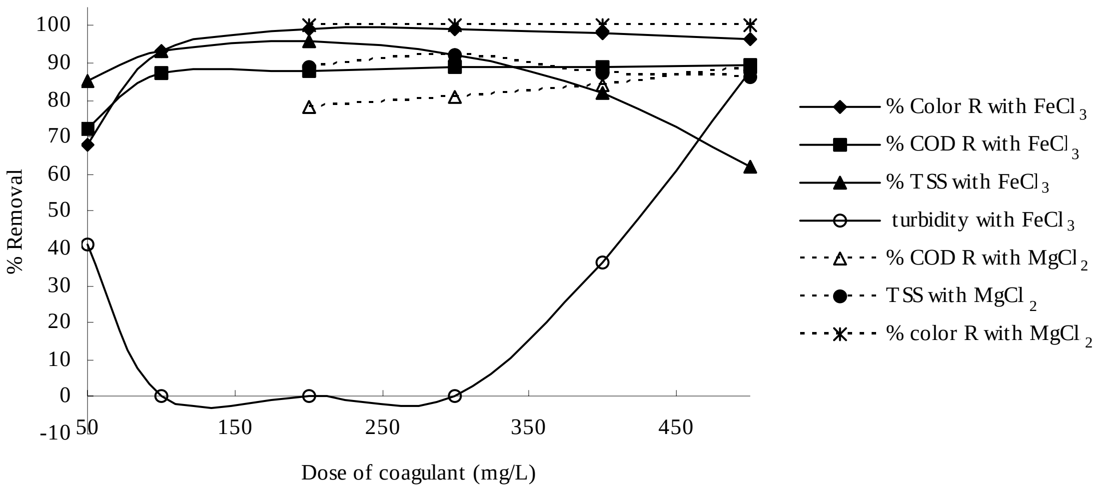



**Fig.7. % Removal of Color & COD or TSS and turbidity for different doses of Coagulant (At Optimum pH=8.3 for $FeCl_3$ or pH=8.7 for $MgCl_2$)**

According to figure 2 and 6 the optimum pH for 400 mg/l $MgCl_2$ is 8.7 due to higher color and COD removal and lower volume of settled sludge. Figure 4 and 7 shows that the optimum dose of $MgCl_2$ for color and COD removal is 500 mg/L.

## CONCLUSION

The results of the tests showing all coagulants except lime removed color. Both ferro sulfate and alum removed color at low concentration with roughly high efficiency whereas low concentration ferric chloride removed less dye. It was observed that magnesium chloride started to remove color in concentration higher than 200 mg/L. Lime didn't effect on COD removal. Magnesium chloride started to remove COD with concentration higher than 200 mg/L. Ferric chloride, alum and ferro sulfate had same COD removal with concentration higher than 100 mg/L.

Magnesium chloride and alum generated large amount of sludge it can cause sludge disposal problem and involve extra costs. To select the best coagulant, in addition to above parameters, it should be considered parameters such as required coagulant dose, coagulant cost and optimum pH after reaction for discharging into environment. Therefore alum because of large amount of generated sludge, ferric chloride and ferro sulfate because of their high cost are not appropriate for dye removal. In this study, ferric sulfate ($FeSO_4$) is recommended as the best coagulant to remove sulfuric dyes. Before industrial wastewater treatment, it would be better considering other aspects to decrease wastewater volume and mitigate its contamination. Following considerations are recommended increasing industrial wastewater treatment efficiency and also mitigating wastewater contamination of this industry:

- Proper process control to save water consumption in industrial units;
- Recovery and recycle;
- Substitution of soaps with lower BOD detergents or dye oxidation steam with acetic acid bath;
- Separation of dyeing wastewater from other units due to its different components;
- Investigation on used coagulant fluctuation on effluent wastewater;
- Investigation on rate and time effect in rapid and slow mixing on effluent wastewater
- The ability of various dyeing process wastewater reuse for using in other processes;
- The ability of dye bath reuse and finally
- Use pretreatment systems especially for dye removal.

## REFERENCES

Ahmad, M. N. and Ram, R. N., (1992). Removal of basic dye from wastewater using silica as adsorbent. Environ. Pollut., **77**, 79-86.

Bennett, D. H. and Reeser, D., (1988). Pre-treatment of CTMP effluent by lime to reduce sulphite and color. Environmental conference charleston, S.C, 199-207.

Beulker, S. and Jekel, M., (1993). Precipitation and coagulation of organic substances and color from industrial wastewater. Wat. Sci. Tech., **28** ,193-199.

Boon Hai Tan, A. K., Tjoon Tow Teng, A. K. and Mohd Omar, A. K., (2000). Removal of Dyes and industrial dye wastes by maghesium chlorie. Wat. Res., **34**(2),507-601.

Carliell, C. M., Barclay, S. J. and Naidoo, N., (1994). Anaerobic decolorisation reactive dye in conventional sewage treatment processes. Water. SA., **20** , 341-344.

Cooper, P., (1993). Removing color from Dyehouse wastewaters. J.S.D.C. , **109**, 97-100.

Dziubek, A. M. and Kowal, A. L., (1983). Water treatment by coagulation & adsorption with dolomite. Chemistry for protection of environment. In Proceedings of an International Conference, Toulouse, France, 205.

Hosseinian, S. M., (1991). Principles of designing municipal and industrial wastewater treatment plants. Shahrab press, 273, Tehran, Iran

Jorgenson, S. V., (1974). Recirculation of wastewater from the textile industry is possible when combined precipitation ans ion exchange treatment is used. Vatten, 394-396.

Lin, S. H. and Lin, C. M., (1993). Treatment of textile waste effluents by ozonation and chemical coagulation. Wat. Res., **27** (12), 1743-1748.

Metcalf & Eddy, (1979). Wastewater engineering treatment disposal and reuse. (McGrawHill co.). McKay, G. (1979). Waste color removal from textile effluents. J. Am. Dye. Report., **68**, 29-36.

Rinker, T. L. and Starent, T. N., (1974). Activated sludge and alum coagulation treatment of textile wastewater. proc.29th. purdue Ind.Wastewater conf, 456-471.

Taebi Harandi, A., (1986). Using coagulants in decolorisation of textile wastewater. (University of Tehran). MS. Desertation, University of Tehran, 160, Tehran, Iran.

Torabian, A., (1997). Evaluation of Tehran textile wastewater and its decolorisation by Magnesium carbonate. J. Environ. Stud., **23** (20),1-14.

*Int. J. Environ. Res., 1(3): 248-251, Summer 2007*
*ISSN: 1735-6865*

# Helminth Parasitic Load in Soil of Northern Lahore

**Baig, A. S. A.*, Rana, M. S., Zaki, M. T. and Khan, K.**

Centre for Integrated Mountain Research (CIMR), Quaid-I-Azam Campus, University of the Punjab, Lahore, Pakistan

Received 20 March 2005; Revised 30 Jan. 2007; Accepted 15 March 2007

**ABSTRACT:** Environment conservation is the common concern at all levels from local to global. Most of the recent environment problems and ill effects stem from ecological misappropriation and neglect to recognize the limits of ecosystem, its. Rapid population growth, low income, lowest health facilities, poor sanitation, lack of education. Personal and community hygiene poverty has enhanced the incidence percentage of parasite infections. This situation is further worsened due to ignorance about the hazard of parasite infection. In order to minimize the risk factors, Municipal Corporation has taken some bold steps. In order to develop an integrated system for solid waste management, the Municipal Corporation has divided the Lahore city (Pakistan) into six towns. For each of these a decisional model is applied so as to define the composition and amount of solid waste flows to be collected and diverted to the dumping sites.

**Key words:**Municipal, Waste, Soil, Helminth, Organic, Lahore

*Corrosponding author: Email- sikandarstar@yahoo.com

## INTRODUCTION

Waste is never consistent. It varies widely in composition and depending on use of available material by different areas. It may be hazardous material or non hazardous material (Richard and Bernard, 2000). Improper and insufficient disposal of urban solid waste is polluting water and soil in several ways.

Similarly application of different types of organic wastes may have a marked effect on soil biomass and its activity and hence increasing the environmental hazards (Jedidi, *et al.*, 2004).

Quantitative and qualitative changes in the composition of solid waste not only contaminated soil, water and air but also causes serious health hazards (Lis, *et al.*, 2004).

The food processing and production industries are increasing the organic solid waste. It is also increasing the population of scavenger, vectors (i.e. flies, mosquitoes) which are responsible for spreading respiratory, gastrointestinal and skin diseases, cholera, diarrhea, tubercolosis, typhoid, mums, hepatitis and malaria (Russ and Meyer-Pittrof, 2004). The major protozoan species that effect human are *Entamoeba histolytica*, *Giardia intestinalis*, *Cryptosporidium*, *Toxoplasma*, *Cyclospora* and *Isospora* species. These parasites exist in environment as oocysts or spores which are transmissive stages in many environmental conditions i.e. water, soil and food (Sinski, 2003).

Philippe (1997) and Traub, *et al.*, (2002) reported that by gardening or walking bare-foot outside, human had potentially been exposed to soil contaminated with canine faeces. Surveys of contaminated areas in many countries have almost invariably shown the presence of viable eggs of *Toxocara canis* (*T.canis*) in around 10% of soil samples (Smith, *et al.*, 2001). Trichiuriasis was the most common helminthic infection associated with significantly lower serum vit A. The prevalence of the trichiuriasis was greater in pre-school children because of poor sanitary facilities (Rim, *et al.*, 2003). *A.lumbricoides* has been assumed to be the most world wide prevalent (Gharavi, *et al.*, 2003). This condition occurs most commonly in children who have close contact with their pets or who live in areas such as public parks where contamination of the ground by the dog faeces is abundantly available (Mafiana, *et al*., 2000). Rockiene (1995) reported that soil samples analysis showed that they were infected with helminths ova and this revealed a close correlation between soil contamination and human ascariasis. Infestation with *A.lumbricoides* causes intestinal complications, massive gastrointestinal bleeding especially in temprate and tropical countries (Sangkhathat, *et al*., 2003). Atukorala and Lanerolle (1999) recorded the prevalence of soil transmitted helminthic infection, living conditions and personal hygiene in school girls aged 14 -18 years old in both urban and rural areas in Sri Lanka. In developing countries with high population gowth rate, low income, lowest health facilities, poor nutrition, joint family systems (particularly in rural areas) with maximum chances of contact provide ideal condition for intestinal helminthic infections (Doligalska, *et al*., 2003). In addition lack of education, personal and community hygiene and poverty has further enhanced the incidence percentage of parasitic infections. This situation is further worsened due to ignorance about the hazards of parasitic infections.

## MATERIALS & METHODS

To record the rate of generation of solid waste (SW) and its physical composition, samples were collected near the transfer station of Ravi Town (northern Lahore; Pakistan),i.e. Scheme No. 2 and Shad Bagh. To record the prevalence of various parasites including heliminths, a total of 75 soil samples collected from colonies of Ravi Town .i.e. *Khokar Road, Saddiqia Colony* and *Scheme No 2* situated near the open dumping stations in November and December 2003 to January 2004. For the collection and recovery of helminthes eggs and larvae the marshy areas are preffered and Sodium hypochlorite technique (WHO, 1991) was used.

## RESULTS & DISSUCTION

Figure 1 shows physical composition of SW samples. It was observed that organic waste (domestic waste) was in high quantity consisting of vegetables and fruit residues (Tables 1 & 2). As the SW is transferred to the open dumping station .i.e. Mehmood Bottie, the scavengers (dogs, cats, cattle and rodents) were observed wandering in the area of waste dumping. Similarly the children of the age 4-10 years belonging to the poor families and nomads were also observed playing in vicinity of dumping stations with dogs, glass marbles and kites. Permanent depressions with stagnant water were the breeding sites for vectors (mosquitoes and flies), hence increasing the intensity of malaria, diarrhea, typhoid, hepatitis, dysentery, gastrointestinal infections and whooping cough etc. The soil samples examination showed various helminths eggs and larvaes flourishing in the soil. The soil had been contaminated with eggs, larvae and parasites of dogs, rodents, cattle and horses. The polluted soil was being ingested by children playing in vicinity of dumping sites.The soil contamination was the result of excreta shed by the wild and domestic animals. The most abundant parasites in the area of study include:

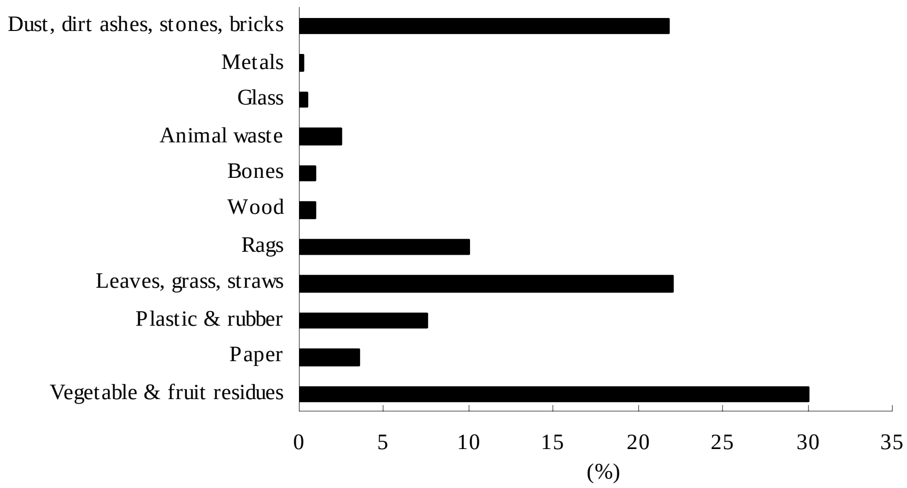



**Fig.1. Average composition of municipal wastes in lahore**

**Table 1: Solid waste generated in Pakistan and Indians major cities**

| Cities | Solid Waste Generated (tones/Day) |
|---|---|
| Lahore | 3960 |
| Karachi | 6000 |
| Mumbai | 6050 |
| Dehli | 4000 |
| Calcutta | 3500 |
| Banglore | 2000 |
| Chennai | 2000 (USW); 500 (debris) |
| Lukcnow | 1500 |
| Hyderabad and Secunderabad | 1300 |
| Ahmedabad | 1280 |
| Surat | 1000 |

*Ancylostoma duodenale*(A *duodenale*.)
*Trichuris trichiura*(T *trichiura*.)
*Strongyloides stercoralis*(*S. stercoralis.* )
*Enterobius vermicularis(E.vermiculars)*
*Ascaris lumbricoides(A.lumbricoides)*
*Diphyllidium caninum(D.caninum)*
*Diphyllobothrium latum(D.latum)*
*Toxocara canis(T.canis)*
*Apophallus donicus (A. donicus)*
*Capillaria hepatica (C.hepatica)*

Similarly a boiler was found where carcasses of horses and cows were present. The employee of age 10-22 were boiling dead animals bodies in open boilers to get their bones, teeth and horns. As they were burning and boiling the dead, a crossive smell was reaching about 3km away in the air along with the cloud of smoke, thus increasing the air, soil and water pollution, also generating health hazards.

## CONCLUSION

The findings of the present study indicate that improper and unscientific dispose of SW, may pollute air, water and soil in several ways. It also indicate the infected stages of the parasites shed from the rodent’s excreta, that may be ingested by man via water, air or adultereted food. These are strong evidences suggesting parasitic infections cause not only acute or serious debilitations but can subvert health, growth and physical capabilities of the infected person (Kassi, 2002). As man is the potential host of wide variety of parasitic infections (Robert and Janovy, 2000). Very important sources of zoonoses (diseases or infections transmit from vertebrate animals to man via food stuff or soil) in human comes from food stuff of animal origin and can be directly tranmissed from environment (Zamo *et al*., 2003).

**Table 2: Waste form Oakistanis, India and North European cities-a comparison**

| Item | Pakistan | India | N. Europe |
|---|---|---|---|
| Paper | 2.70% | 4% | 27% |
| Vegetable/putrescible matter | 30.72% | 75% | 30% |
| Dust etc. under 10 mm | 27.83% | 12% | 16% |
| Metals | 0.32% | 0.4% | 7% |
| Glass | 20.02% | 0.4% | 11% |
| Textiles | 7.45% | 3% | 3% |
| Plastics | 5.63% | 0.7% | 3% |
| Other, stores, ceramics, wood etc. | 1.45% | 7% | 3% |
| Weight/person/day | 0.55 kg/capita/day | 414 g | 845 g |
| Weight/dweling/day | | 2.5 kg (6 person) | 2.5 kg (3) |
| Density kg/$m^3$ | 478 | 570 | 132 |
| Anima waste | 2.35% | | |

The numbers of parasites have been increased with increase in population and solid waste. Environmental contamination with helmintheic infective stages needs regular indication for recognition of parasite species under molecular data and improvement of effective measures to prevent human zoonotic diseases (Doligaska and Donskow, 2003). Infections involving helminths or parasite worms affect more than 25 % of population worldwide (Protol , 2003).

Intestinal Ascariasis can be the cause of massive gastrointestinal bleeding, especially in temprate and tropical countries (Sangkhat *et al*., 2003). Infection with *A..lumbricoides* constitute one of the most common helminth disease in the world especially in the tropical and sub tropical regions. Transmission of this disease involves environmental contamination with eggs and therefore is classified as a soil transmitted disease. Therefore the option of integrated control programmes based on chemotherapy in combination with sanitation and health education, together with strong community involvement, must be considered in order to ensure the positive long-term effect of such programs. Nationwide parasite control project is necessary to reduce possible morbidity due to parasite diseases in the country. Hence it is necessary to adopt sanitary land filling techniques to avoid such problems.

The inhabitants are so used to the existing conditions that their children play in vicinity of these open damping sites. In June when storms come, the dust along with various eggs, spores etc and particulate matter from the dumps spread in the neighboring areas and not only adulterate the water sources, spread the infectious parasitic agents, yet also increase the intensities of diseases ,already prevailing in the areas i.e. respiratory and skin diseases. Most cases of tuberculosis have been identified from *Siddiqia Colony and Khokar Road* as it is seen contagious set of diseases. Thus, more and more inhabitants including children are becoming victim of such diseases due to malnutrition, poor sanitation conditions polluted water and lack of education.

## REFERENCES


Atuorala,T. M. S. and Lanerolle, P., (1999). Soil transmitted helminthic infection and its effects on nutritional status of adolescent school girls of low socioeconomic status in Sri Lanka. J. Trop. Paediatrics, **45**, 18-22.

Doligalska, M. and Donskow, K., (2003). Environmental contamination with helminth infective stages in water and foodborn diseases. Acta Microb.Pol., **52**, 45-56.

Gharavi, M. J., Ashraf, F., Vosough, P. and Rokni, M. B., (2003). Survey on intestinal parasitic infection in Leukemic children and evaluation of their serum immuaglobins. Iranian J. Pub. Health, **32**, 19-21.

Jedide, N., Hassan, A., Van Cleemput, O. and M'Hiri, A., (2004). Microbial biomass in a soil amended with different types of organic wastes.Waste Manag. Res., **22**, 93-99.

Kassai, T., (2000). Important zoonoses in Hungary caused by parasitic helminths. Living animals. Mgyar-Allatorvoso-Lapja, **122**, 203-208.

Lis, D. O., Ulfig, K., Waalazlo, A. and Pastuszka, J. S., (2004). Microbal air quality in office at Menerpal Landfills. J. Occup. Environ. Hyg.,**1**, 62-68.

Mafiana, C. F., Sam-wob, S. O. and Aikinsete, A. A.,(2000). Epidemiology of Ascariasis in some rural communities in Ogun State, Nigeria. Global J. Pure. Appl. Sci., **1**, 23-26.

Philippe, J., (1997). Important zoonotic helminth infections. Veterinary Exchange, **19**, 4-9.

Protol, I., (2003). Antiparasitic drugs and location: focus on anthelmintics, scabicides and pediculicides. J. Hum. Lact., **19**, 42-45.

Rim, H. J., Chai, J. Y., Min, D. Y., Cho, S. Y., Eom, K. S., Hong, S. J., Sohn, W. M., Yong, T. S., Deodato, G., Standgaard, H., Phommasack, B., Yun, C. H. and Hoang, E. H., (2003). Prevelance of intestinal parasite infections on national scale among primary school children in Loa. Parasitol Res., **91**, 267-272.

Roberts, L. S. and Janovy, J. J., (2000). Foundation of parasitology, 5th. Ed. W.C.B. Company, U.K, 347-410.

Rockien, A., (1995). The human parasitoses in lithuania. Acta Zoologic. Lituan. Parasitol., **25**, 3-7.

Russ,W. and Meyer-Pittroff, R., (2004). Utilized waste products from the food production and processing industries. Crit. Rev. Food Sci. Ntur.,**44**, 57-62.

Sangkhathat, S., Patrapinyokul, S., Wudhisuthimethawee P., CH-Edphaopan, J. and Mitamun, W., (2003). Massive gastrointestinal bleeding in infants with ascariasis. J. Pediatr., **38**, 1696-1698.

Sinski, E., (2003). Environmental contamination with protozoan parasites infective stages:biology and risk assessment.Acta Microbial. Pol., **52**: 97-107.

Smith, H., Dekaminsky, R., Niwas, S., Soto, R. and Jolly, P., (2001). Prevalence and intesty of infections of *Ascaris lumbricoides* and *Trichuris trichiura* and associated socio-demiographic variables in four rural Honduran communities. Mem. Ins. Oswaldo Cruz., **96**, 303-314.

Traub, R. J., Robertson, I. D., Irwin, P., Mencke, N. and Thompson, R. C., (2002). The role of dogs in transmission of gastrointestinal parasites in a remote tea growing community in northeastern India. Am. J. Trop. Med. Hyg., **67**, 539-545.

World Health Organization (WHO), (1991). Basic Laboratory Techniques in Medical Parasitology. 1st. Ed. Geneva, Switzerland, 133-210.

Wright, R. T. and Nebel, B. J., (2000). Environmental science towards a sustainable future.8th. Ed., Upper Saddle River, New Jersey 07458, USA, 394-396, 466, 487.

Zamo, A. C., Belghyti, D., Lyagoubi, M. and Elkharrim, K., (2003). Parasito-logical analysis of untreated waste water of the"Ville Haute"urban emissary (Maamora sdistrict, Kenitra, Morocco). *Sante*., **13**, 269-272.

*Int. J. Environ. Res., 1(3): 252-257, Summer 2007*
*ISSN: 1735-6865*

# The Impact of Urban Sprawl up on Air Pollution

**Pourahmad, A.[1*], Baghvand, A.[2], Zangenehe Shahraki, S.[3], Givehchi, S.[3]**

[1]Faculty of Geography, University of Tehran, Tehran, Iran
[2] Faculty of Environment, University of Tehran, Tehran, Iran
[3] Geography and Urban Planning, University of Tehran, Tehran, Iran

Received 15 Jan. 2007; Revised 25 Feb. 2007; Accepted 15 March 2007

**ABSTRACT:** About half a century ago, following the introduction of urban sprawl up concept, various studies have been conducted to describe the mechanism and the formation of this phenomenon. Some of these studies aimed at finding the negative and positive impacts of such phenomenon on urban area with emphasis on how such concept may be looked open from environmental, economical and social perspectives.The main research objective, in this article, focuses on adverse impacts of urban sprawl on air pollution in a mega city such as Tehran. Therefore, attempts have been made to show a relationship between urban sprawl up and the increase in air pollutants concentration. Three methods have been investigated to validate such a concept methodologically. Tehran has been chosen as a case study to further demonstrate validity of such a correlation between urban sprawl up and rise in air pollution scientifically. The results confirmed a function relating air pollution increase to urban sprawl up.

**Key words**: Air Pollution, Sprawl, Tehran, Transportation, and Urban

*Corresponding author: Email-apoura@ut.a.ir

## INTRODUCTION

Urban "sprawl" is a word that has entered into the literature of urban planning since half a century ago, and up to now; various definitions have been presented such as:

"A pattern of land use in an urbanized area that exhibits low levels of some combination of eight distinct dimensions: density, continuity, concentration, clustering, centrality, nuclearity, mixed uses and proximity (Glaster *et al.*, 2001)".The term is also used variously to mean the gluttonous use of land, uninterrupted monotonous development, leapfrog discontinuous development and inefficient use of land (Peiser, 2001).

According to the Vermont forum on sprawl: Sprawl is dispersed, auto-dependent development outside of compact urban and village centers, along highways, and in rural countryside (Menon, 2004). Dieleman and Wegener (2004) suggest that causes of urban sprawl can be grouped into two categories: the general drift of socio-economic change in developed societies and government spatial planning policies, and conclude that in the absence of strong planning interventions at regional and local levels, further urban deconcentration is likely to occur (Dieleman & Wegener, 2004).

There is one basic difference between the causes of urban sprawl in a developed country and that of a developing country. Sprawl in developed countries is usually a matter of preference. It may have begun with the industrial revolution, and later reinforced by government policies. The entire culture in developed countries (especially the USA) is centered on automobile use. This coupled with government policies that encourage the move to sub-urban areas, and subsidize the use of private transport has fueled urban sprawl in the developed world to a great extent (Menon. 2004).

The story in developing countries is different. In a developing country such as Iran, sprawl is fueled more by necessity. A lot of the underlying causal factors are historical, and have built up over a number of years. Sprawl, in Iran, is concentrated around certain pockets of dense human population the mega cities. The causes of sprawl here can be traced to historical reasons too.

Most often to the colonial legacy that some developing countries have acquired, for example in Iran mega cities, such as Tehran, were developed as administrative centers, transportation hubs, where people from the rural areas came in search of employment and stayed on. These became central cities after the colonial masters left. The growth of these mega cities was unplanned and gradual. This trend has continued into the post-colonial period too. Most of these mega cities remain the dominant source of employment, education and so forth. And therefore people still migrate from the rural areas. In certain developing countries, since the majority of the population is poor and in need of employment, they usually move to the cities to look for a better standard of life. This has led to burgeoning centers of urbanization that are growing outward, away from the city center. However, as these countries are urbanized at rapid rates, these pockets are increasing and so is the problem of sprawl (Taghvayee & Sarayi. 2003).

Studies and data show that in Iran, the capital Tehran has encountered with urban sprawl and the problems resulting from it. So population of this city has changed from 210 thousand people in 1921 to 702 million in 2000. At the same time, area has changed from 720 to 73950 hectare in this period of time. Better stated, the population has increased by 33 times but the area has become 109 times more. (The statistic center of Iran and comprehensive plan of Tehran).Urban sprawl in Tehran has resulted in many negative consequences in environmental, economical and social dimensions. One of the most important environmental effects of urban sprawl is the increase in air pollution.

In spite of the fact that the causes of urban sprawl in developed and developing countries are different, it has the same results and consequences. Some impacts and results of urban sprawl are: the extermination of desirable agricultural lands around the city, the cost increase in urban infrastructures and services, the cost increase time and length of inner city trips, the increase of energy consumption, the existence of vacant and depleted lands in the cities, social segregation, the increase of road transportation specially private cars, air pollution and so on.

Studies in North American cities show that "sprawl" in those cities has caused the extermination of 1.5 million hectares of agricultural lands (Benfield and Raimi. 1999) or in Australian cities the cost of infrastructures and services has noticeably increased as a result of this phenomenon. (Frunk & Pivo. 1995). In Liverpool as a city inflicted by sprawled through the 20th century, the ecological and spatial segregation of social classes increased. Despite some counteracting policies this trend towards increased segregation seems to be continuing. (Couch & Karecha. 2006). Burton (2001) found that where there was a large proportion of high density housing, segregation tended to be low. Density seemed to be a key factor in limiting segregation; segregation would be less across the whole of a more compact city.

One of the most important environmental results of urban sprawl is the deterioration of air quality.

Studies carried out in various countries about sprawl, have shown that one of the main effective factors in air pollution of the cities is urban sprawl. Air pollution can be stated as the disturbance of mixed natural structure of air as the result of the entrance of pollutants into air. Inevitably, the entrance of pollutants into air means the reduction in air quality too. Air pollution originates in two ways:

1- natural air pollution which results from the entrance of natural pollutants like volcanic dust, pollen of plants, dust arising from desert zones in arid regions, gas arising from the disintegration of organic substance in the nature, etc.

2- air pollution as a consequences of human activities like transpiration, dwelling and residential areas, industries, productive units.

But today, what is known as the main factor for air pollution is the humanity activities related air pollution that has influenced the earth in different ways.

## MATERIALS AND METHODS

It seems that urban sprawl in Tehran is one of the most important factors resulting in air pollution.

Because the main sources of air pollution in the city of Tehran are pollutants from transportation, in this research, studies are divided into three distinctive sections as follows:

A) Studying Changes in the distance and the length of urban travels arising from urban sprawl
B) The impact of urban sprawl on the mode of transportation (private or public transportation system).

C) Changes in the number of urban travels arising from sprawl pattern in the city of Tehran.
With attention to changes in the length, number, and mode of travels, the measure of fossil fuels consumption such as diesel fuel, gasoline and CNG in various periods studied, that all of them effect on pollutant measure in the city air.

## RESULT & DISCUSSION

With reference to data of population and area of Tehran metropolitan area, (presented in Table 1), it can be understood that the urban sprawl in this city in evident. As shown in Table (1), the population of the city was 210,000 people while its area was 720 hectare in 1921. But after 8 decades, its population became 7,020,000 and its area has risen to 78,900 hectare. This means that as the population has become 33 times of the past, at the same time, the area has increased by 109 times more. In other words, its density has decreased from 291.6 in 1921 to 88.9 persons per hectare in 2000, and now urban sprawl has brought about many problems.

According to studies, after the Second World War, the city grew in a disjointed manner in all directions along the outgoing roads, integrating the surrounding towns and villages, and growing new suburban settlements. This intensified social segregation, destroyed suburban gardens and green spaces, and left the city managers feeling powerless. A Deputy Mayor of the city in 1962 commented that in Tehran, “the buildings and settlements have been developed by whoever has wanted in whatever way and wherever they have wanted”.
Creating a city that “in fact a number of towns connected to each other in an appropriate way” (Madanipour, 2006).

**Table 1. Population, area and density in the city of Tehran**

| Year | 1921 | 1931 | 1941 | 1956 | 1966 | 1976 | 1986 | 1996 | 2000 |
|---|---|---|---|---|---|---|---|---|---|
| Population (million ) | 0.21 | 0.3 | 0.69 | 1.51 | 2.71 | 4.5 | 6.04 | 6.7 | 7.02 |
| Area (hectare) | 720 | 2420 | 4500 | 10000 | 19000 | 32000 | 62000 | 73950 | 78900 |
| Density (p/h) | 291.6 | 124 | 154 | 151 | 143 | 141 | 97.4 | 91 | 88.9 |

Source: The Statistics Center of Iran and the Municipality of Tehran

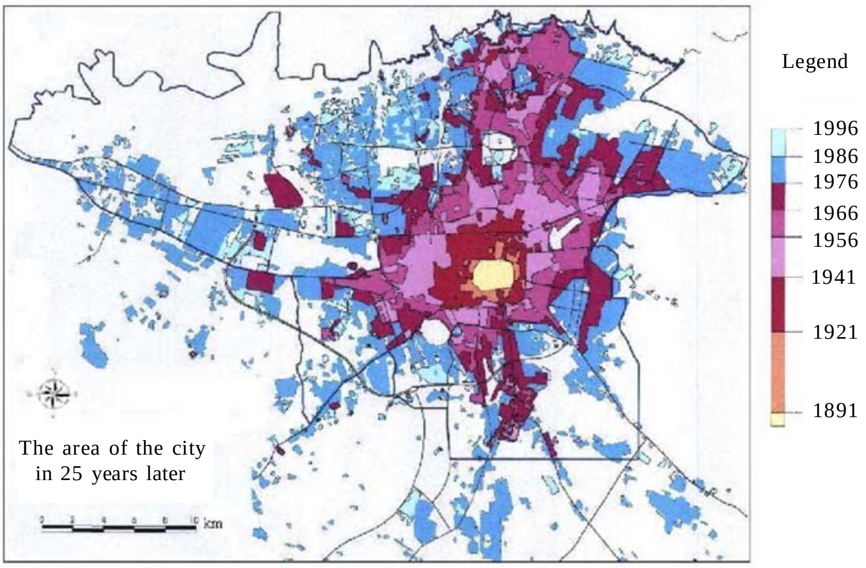



**Fig. 1. The physical development of Tehran**

Source: Ministry of Housing and Urban Development.

For better understanding of urban sprawl of this city and its impacts, the map of physical development of Tehran in various years is shown below.

A fter studying the magnitude of Tehran sprawl, for the purpose of testing this hypothesis, the impacts of urban sprawl on air pollution in this city has been studied using three different methods:

- *The impact of urban sprawl on the length and distance of urban travels.*
- *The impact of urban sprawl on the mode of transportation (private or public).*
- *The impact of urban sprawl pattern on increasing urban travels.*

Here three methods for the hypothesis of the research have been studied.

1-The impact of urban sprawl on the length and distance of urban travels:

One of the cardinal features of sprawl is driving, reflecting a well-established, close relationship between low density development and more automobile travel. For example, in the Atlanta metropolitan area, one of the nation s leading examples of urban sprawl, the average person travels 34.1 miles in a car each day _an average that includes the entire population, both drivers and non drivers. More densely populated metropolitan areas have far lower per capita daily driving figures than Atlanta, such as; 16.9 miles for Philadelphia, 19.9 for Chicago, and 21.2 for San Francisco in the USA (Texas Transportation Institute. 200).

**In the city of Tehran:**

In fact, when the distance between residential and commercial places or between residential place and shopping centers increases as a result of the increase of the city area and low density, the length of urban travels increases. (As it can be seen in Table 2).

Table (2) shows that the average length of travels in Tehran greater area has changed from 8.29 kilometers in 1986 to 33 kilometers in 2000. In Tehran city, it had an increase 2.4 to 8.1 kilometers within the same time period.

Relation between these two variables (density and the length of travel) is shown in the Fig. 1. So you can see, with the decreasing density, the length of travel is increasing.

Motor vehicles are leading sources of air pollution. Even though automobile and truck engines have become far cleaner in recent decades, the sheer quantity of vehicle miles driven results in large emissions of carbon monoxide, carbon dioxide, particulate matter, nitrogen oxides, and hydrocarbons into the air.

2-The impact of urban sprawl on the mode of transportation (private or public)

Many studies reveal that urban development pattern (compact or sprawl and spread city) has many effects on the mode of transportation (private or public vehicles) that are used in urban traffic. Urban sprawl or scattered pattern cause extended use of private vehicles and less walking and cycling because of further distance (Balsas. 2003). According to the Strategic Plan that produced by municipality for the period 1996- 2001, known as Tehran Municipality s first plan, or “Tehran 80”, main problems of the city are the pace and the pattern of urban growth; environmental pollution, and the absence of effective public transport (Madanipour. 2006).

**Table 2. The average of the length and distance of urban travels in Tehran city and Tehran greater area**

| Year | 1986 | 1996 | 2000 |
|---|---|---|---|
| The average of the length of travels in Tehran greater area. (km) | 8.29 | 9.55 | 33 |
| The average of the length of travels in the city of Tehran (km) | 2.4 | 4.7 | 8.7 |

Source: The Studies and Researches Centre of Architecture and Urban Development of Iran, and also Tehran great area, Transportation and Traffic Studies, (2003)

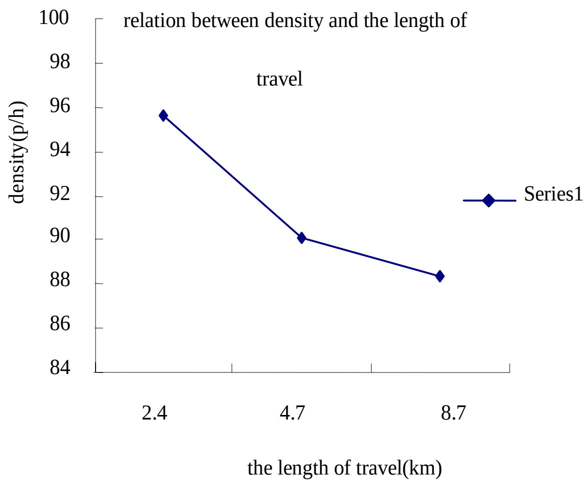



**Fig. 1. Relation between density and the length of travel**

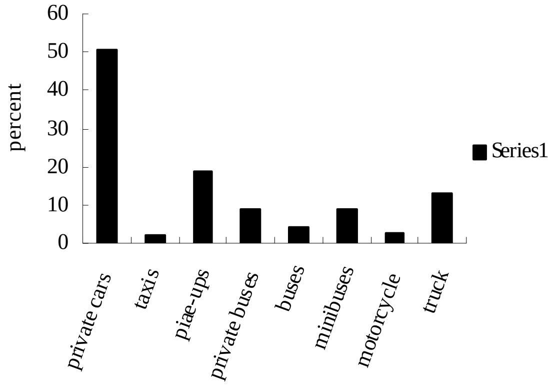



**Fig. 2. the share of the sorts of transportation vehicle in traffic.**

Source: Tehran Traffic Organization, (2003)

Studies about the share of modes of transportation in Tehran traffic show that more than 50 percent of urban travels are met by private vehicles. But the share of bus and minibus is around 15 percent. Underground is one of the best modes of transportation in cities because of its high speed and lesser pollution. The share of modes of transit vehicles are shown in Fig.1. According to data of studies conducted by Tehran Transportation Organization, the ownership rate of private car used to be 19 for one hundred family in 1971 but it reached 42 in 1996(Tehran Comprehensive Transportation and Traffic Studies of Tehran, 1999).However, the remarkable phenomenon is the increase in the number of motorcycles in this city. In fact, because of heavy traffic in most of the time and easier transport action of motorcycles given their compact size, and being cheaper, now people are inclined to utilize more this kind of transportation, in such a way that the number of motorcycles has risen from 520,000 in 1996 to 2 million in 2006. This mode of transportation is one of the most polluting transportation (The Problem of Group of Urban Traffic. 2006).

Moreover, more than 81 percent of private cars used in Tehran have been manufacture more than 10 years ago (The Center of Studies and Planning of Tehran Municipality, 2005). So their fuel consumption level is very high.

More dependence on private cars in urban transportation, cause increasing in consumption of gasoline, CNG and other fossil fuels and afterward that dispersion of pollutants in the air. Because of that, city planners and managers that believe in sustainable development have a straight decision

**Table 4. Quantity of daily consumption of fossil fuels (diesel fuel, gasoline and CNG) in Tehran city (million litters)**

| 1986 | 1996 | 2006 |
|---|---|---|
| 6 | 16.5 | 32 |

Source: Fuels and Oil Products Company in Iran, Tehran,(2007)

to decrease the urban transportation dependency on private vehicles.

3. *The impact of urban sprawl pattern on increasing urban travels:*

Sprawl pattern in Tehran is different from many other cities in the world, such that the settlements and town in the outskirts of the city center are more dormitories and satellite units. It means that its settlers travel to the city core for work in the mornings and return to their settlements in the outskirts or suburbs in the evening. Studies show that in the American cities, having over sprawl, about 65 percent of the suburb settlers have their working places in the suburb too. This means that the need for city travels has minimized (Richmond, 2001). But in Tehran, only 28 percent of suburb settlers work in their residential areas and the rest of the working places are a away from their residential areas or in the city center (Tehran Municipality, 2004).

Studies about the share of modes of transportation in Tehran traffic show that more than 50 percent of urban travels are met by private vehicles. But the share of bus and minibus is around 15 percent. Underground is one of the best modes of transportation in cities because of its high speed and lesser pollution. The share of modes of transit vehicles are shown in Fig.1. According to data of studies conducted by Tehran Transportation Organization, the ownership rate of private car used to be 19 for one hundred family in 1971 but it reached 42 in 1996(Tehran Comprehensive Transportation and Traffic Studies of Tehran, 1999).According to transportation and traffic studies in Tehran greater area, of the whole petroleum products used in the country in 2001, around 24 percent is used in Tehran.

## CONCLUSION

Tehran, as capital of Iran, has today encountered with urban sprawl, scattered and spread, and this phenomenon has had very undesirable effects on environmental, social and economical dimensions. One of its most important undesirable environmental effects is air pollution in this city, such that today, Tehran is one of the most polluted cities in the world. The relationship between two variables, urban sprawl and air pollution, in this paper is considered in three methods. In this paper urban sprawl in Tehran as a cause of the increased length of urban travels, a desirable public means of transportation in this city has not been implemented or urban sprawl causes more and more use of private cars, in other words, this has prevented a desirable public transportation being implemented in this city, settlements and towns in the periphery and suburban of Tehran are the kinds of dormitories and satellites settlements, and because of this much transportation and traffic in early and ending hours of work between city center and towns and surrounding areas and settlements are taking place.

These three factors cause the increase of fossil fuels used in motorized vehicles and the increase of many pollutants emission in the air of this city air and this causes air pollution of Tehran city.

Result of this research can help to urban planners to gain urban sustainable development. Consequences of this study may conduct to modify the physical pattern of urban development for reducing urban sprawl. Some strategies such as: compact city, urban smart growth, increasing population and building density are used to controlling this phenomenon as an efficient approach.

## REFERENCES

Anni, E. K., (2000). Urban sprawl: main study in American cities. (New York: University of California), 4-21.

Balsas, C. J. L., (2003). Sustainable transportation planning on college campuses. Trans. Policy J., **2**, (10), 35-49.

Benfield, F. K., Raimi, M. D. and Chen, D. D. T., (1999). Once there were green fields: how urban sprawl is undermining America s environment. Policy project. J. Am. Plan. Associat. **2**(4), 11-23.

Burton, E., (2001). The compact city: hunt or just compact? A preliminary analysis. Urban Stud., (37), 146-152.

Chris, C. and Jay, K., (2006). Controlling urban sprawl: some experiences from Liverpool. Cities, **23**(5), 83-90.

Dieleman, F. and Wegener, M., (2004). Compact city and urban sprawl. Built Environ., (30), 59-67.

Enviromental Protection Agency (US), (2001). Our built and natural environments: a technical review of the interaction between land use, transportation, and environmental quality. Washington: EPA. Pub. No. 231. 197-198.

Frunk, L. D. and Pivo, G., (1995). Impacts of mixed used and density on utilization of three modes of travel: Transport Res Rec. Transport Policy, (2), 42-52.

Green, H., Thomas, M., Iles, N. and Down, D., (1996). Housing in England. HMSO, London. 14-27

Howard, F., (2002). Urban sprawl and Public Health. Journal of Reports, May-June, **117**, 221-228.

Kenworthy, J. R. and Laube, F. B., (1999). An international sourcebook of automobile dependence in cities, 1960-1990. Boulder. University of Colorado Press. 87.

Madanipour, A., (2006). Urban planning and development in Tehran. Cities, **23**(6), 433-438.

Menon, N., (2004). Urban sprawl, Vision, The E-journal of the WSC-SD. **2**(3), 125-141.

Scientifically study of Tehran air pollution, (2002). Nafte Pars, (30). 7-8.

Peiser, R., (2001). Decomposing urban sprawl. Town Planning Review. **3**, (72), 96-108.

Richmond, E. D., (2001). Transitory dreams: How new rail lines often hurt transit systems. Boston: Taubman Center for state and local government. John F. Kennedy School of Government, Harvard University. **146**, 150 and 154.

Taghvayi, M. and Sarayi, H., (2003). Urban sprawl and carrying capacity of land ( Yazd city). J. Geo. Res., (73). 187-211.

Texas Transportation Institute, (2002). Annual urban mobility study. Urban mobility data. 32-40

The Center of Studies and Planning of Tehran Municipality, (2005). air pollution and physical structure of Tehran city. 71-76.

The Company of Quality Control of Air Tehran, (2005) Percentage of condition Tehran air pollution. 68.

The problem of group of urban traffic, (2006). Air pollution in Tehran. The Organization of Tehran Traffic and Transportation. 29-33.

*Int. J. Environ. Res., 1(3): 258-263, Summer 2007*
*ISSN: 1735-6865*

# Evaluation of Landscape Structure in Eram Park Using GIS

**Wahadj, R.[1], Karimi, S.[2], Adl, M.[2*], Reza Ghafari, A. R.[3], Onagh, A.[4] and Mohammadnejad, Sh.[5]**

[1]University of California, Berkeley. GIS research investigator. USA
[2]Department of Environmental Planning management and Training, Graduate Faculty of Environment, University of Tehran, Tehran, Iran
[3]Department of Physical Geography, University of Nottingham, Nottingham, England
[4]Department of Environment, Shahr_Sabz_Derakhshan Consulting Engineers, Tehran, Iran
[5]Environmental Affairs, Ministry of Industries & Mines, Tehran, Iran

Received 15 Nov. 2006; Revised 20 March 2007; Accepted 15 April 2007

**ABSTRACT:** The method of sampling unit was applied according to the importance of the park in urban landscape structure with the initial purpose of planning method to maximize environmental sustainability and recognizing the structural elements within the park. SWOT technique has been applied to analyze collected data and evaluate the strengths and weaknesses, opportunities and threats of affected areas. We used Geographical Information System (GIS) tools to apply neighborhood functions for extracting correspondent data in structural elements of landscape. The results of present study show that the volume of green spaces decreases in the surrounding area due to construction and farmlands activities.

**Key words:** Park, Landscape structure, Environment, Planning, Design, Ecology, SWOT, GIS

*Corresponding author: Email- mahsaadl@ut.ac.ir

## INTRODUCTION

The active part of urban environment and its activities is similar to any other ecosystem because of changes and sustainability process (Aminzadeh & Ghorashi, 2007). The important section of this Biotope (Plants and live creatures) is living in green space areas, but the most important point is their location (based on ecosystem diversity and original area) that situated in open and untouched areas. Urban green space is an important element not only because of being a recreational space and tourist attraction in the urban area but also it is a center to provide environmental services such as air purification, pollution absorption, development balance, decreasing surface water, biodiversity, reducing sound pollution and finally is a place for better living (Bahraini & Aminzadeh, 2007; Alexander, 1987; Dunay and Plater-Zyberk, 1991; Frey, 1999; Mazumdar, 2000; Rowely, 1996). Open and untouched areas are also important to preserve buffer for critical areas, future urban development support, air flow and pollution purification network; they are also ecologically important as well. These opportunities would be Productive when they are considered as an active part of a general urban landscape (Clay & Daniel, 2000; Daniel & Vining, 1983). Parks are only one single item of the total life elements. Therefore, these elements in urban landscape structure need to be evaluated. It is essential for landscape structure to have a plan as a goal which can maximize environmental sustainability (through fitting landscape structures).Physical, biological and cultural resources are three main bases of planning and decision making process in sustainable development. They also describe landscape structure by making different combinations of mosaic patches. It is important to study changes and their causes for prediction and controlling of the structures (Farino, 1998). Landscape can be defined as a part of land, that is observed in a comprehensive view, without any consideration to any single element (Hobber, 1996) by combination of human (society) and natural impacts (Burgi, 2004).

The science of landscape ecology considers matrix, patches and corridors as the main elements of landscape structure. Matrix is the main ecosystem of land use (Forman, 1995) that plays a key role in landscape and its usage (Ingegnoli, 2002) and can be considered as an important main controller of land movement (Forman and Gordon, 1986). Patches are regions with a special physical or biological condition isolated from the surrounding environment (Ingegnoli, 2002) and can be divided in to 5 groups according to the formation resources; disturbance patches, remnant patches, environmental resource patches, ephemeral patches, and human activity patches (Forman, 1995). To understand the nature of patches' distribution, their primitive condition and their time and relationship spaced regarded should be considered. Corridors connect 2 places or patches at the same time they can make a fragmentation between the 2 places or patches. Corridors can also be divided and classified based on the formation resources (Ingegnoli, 2002). Since any particular structure is important by providing a special function, the study and right recognition of patches, matrix and corridors can define the usage of landscape.

On the other hand, functioning process, changes, and land development can be controlled through right recognition, planning and exertion influence on identity, formation, location and other specialties of these elements. It can lead the urban environmental quality to a more suitable condition.

## MATERIALS & METHODS

Zanjan is located within 43˚ 27$^2$ to 48 ˚ 55$^2$ eastern latitude and 36 ˚ 25$^2$ to 37 ˚ 15$^2$ northern longitudes and that is 325 kilometer far from Tehran. Eram Park with an area of about 20 hectares is one of the 3 wide Zones of green space in Zanjan and is located at the far western part of the city on IRAN- TURKEY transit road via Tabriz city. Nowadays, this Park has a regional and local attraction for family picnic and passenger stop over to rest. There is an ample rainfall all through the year in the region. The highest precipitation is in spring (April and May) followed by mid-autumn and winter. The annual rainfall average is 297.1 mm. Average temperature in Zanjan is about 11 ºC, Maximum 40 ºC in July and Minimum -28.6 ºC in February and March. The annual average moisture is 53% with the highest percentage in Feb (85%), and March (86%). The lowest is in September (20%). An average yearly glacial day in the region is about 25 day/yr. The main wind blows from east with an average speed of 11.48 to 12.03 km/h. This region is located in moderate semi-humid area according to Koppen climate definer, and falls within semi-dry (De martonne) and cold semi-dry (Emberger). Geologically Eram Park is located around volcanic complex and is a part of Karaj formation. Amand geological structure is the most developed formation among all present units in the region. This complex consists of sediment and volcanic stones, which are almost made of tuff, shale, gravel, and andesite. The soil in this region falls within average permeability land that consists of 15% to 75% sand. The Surface texture of soil is moderate (Loam) and the bottom texture is heavy (clay loam) and there is a large amount of lime powder in different layers of soil. Plant coverage mainly consists of trees such as Fraxinus excelsior, Locust and Service tree and other kinds of trees are also available, Such as Populus nigra, Thuja orientalis, Platanus orientalis and Elm. The Most part of the patches has high plant density coverage but a small part of it especially in the western-side has no plant coverage.

The base of planning and decision making for sustainable urban development is highly dependent on physical and biological aspects. As it was mentioned, landscape structure, which is the reflection of reactions between natural elements and human, is assumed as function of time, and needs to be recognized; however, land and environmental functions can be assessed and controlled. Green space patches, open space patches and constructed patches are selected among several landscape structures; according to the research purpose .The most effective elements in this content include extent, time and study expenses in the region. It was also tried to explain current structural conditions according to the functions and sustainability and finally provide necessary solutions to change or influence on nature and location of patches. Sampling unit method was used to evaluate landscape structure to know the structural elements of study area. In the present investigation 9 shuttles (in size of 50x50

m) on 9 parts of study region (4 shuttles out around the park and 5 inside the park) are studied that are in a similar environment and each uses different structural conditions are studied. Geographical information system (GIS) tool with mapping ability, local query and decision making facilities was used (Karimi, 2003, Kenverski, 2004 and Demers, 2005). Functions and variables have been used such as digital map, format transformation, and transformation (Makhdoum et al., 2003). This includes attribute query function, statistical analysis, topographic functions, data revitalization and neighborhood. Several software and modeling techniques such as editor, built, clean, geo-referencing, X-tools, and special analysis, auto desk map, academic Ilwis, Arc info, and Arc GIS have been used to meaningfully complete present work. Then the average size of patches, the average of nearest neighborhood distance between patches and the number of patches were calculated in each shuttle to understand and find out the selected spaces (open, green and constructed). Finally through comparison of each patch's structure and their subsequent comparison with those of structures located outside the realm of park, ample data was generated for a more precise planning. The SWOT method has been applied as one of the most practical methods since 1960s to evaluate organizations, projects and study subjects in different sciences. In fact, this method tries to evaluate the efficiency of the whole network by mixing external factors such as opportunities and threats and internal strengths and weaknesses factors. (Arabi, et al, 2000 and OTA, 1994). The SWOT methods were also used at this project to study and evaluate the final landscape structure and to present practical suggestions.

## RESULTS & DISCUSSION

Based on the results of present investigation, description of each shuttle is brought out (Table 1). Table 2 & 3 show characteristic of area of study. Considering the results of tables 2 and 3, we may conclude that:

### A) Within the park

1. Moving from the western part to the central part, more green spaces are available, but from the central part to the eastern we see lesser green space can be found, because of man - made constructions.

**Table 1. Description of each shuttle within and around park**

| Shuttle Nos. | Location | description |
|---|---|---|
| 1 | Within park | Open remnant space patch, power transmission line corridor, path corridor and stream corridor |
| 2 | Within park | Tree planted green patches, trance patch, stream corridor and asphalt road corridor |
| 3 | Within park | Tree planted green patch, stream corridor and asphalt road patch |
| 4 | Within park | Tree planted green areas and hand-planted green spaces patch, pool patch, construction patch, stream corridor and asphalt road corridor |
| 5 | Within park | Farmlands patch, tree planted and planted green spaces patch, construction patch, remnant open space patch, and asphalt road and path corridor |
| 6 | Park vicinity | Remnant open spaces patch, farm land patch, residential constructions patch, tree planted green spaces patch and path corridor |
| 7 | Park vicinity | Farmlands including single planted trees patch, residential construction patch, remnant open space patch, asphalt way corridor and power transmission lines patch |
| 8 | Park vicinity | Farmlands including single patched trees, residential constructions patch, path corridor and irrigation canal corridor |
| 9 | Park vicinity | Bare spaces patch, Zanjanroud river floodway corridor and path corridor |

**Table 2. The status of structure, green, open, and built spaces in selected shuttles within the Eram Park**

| Shuttle No. | Mean patch size ($m^2$) | | | Mean nearest neighborhood distance(m) | | | Patch number | | |
|---|---|---|---|---|---|---|---|---|---|
| | Green space | Open space | Built space | Green space | Open space | Built space | Green space | Open space | Built space |
| 1 | - | 215.78 | 50.31 | - | 3.5 | - | - | 2 | 1 |
| 2 | 348.65 | 212.83 | 105.72 | - | 8 | 90 | 1 | 2 | 2 |
| 3 | 255.28 | 133.63 | 190.40 | 8 | 18.5 | 60 | 2 | 2 | 2 |
| 4 | 172.60 | 235.94 | 314.67 | 5.5 | 4 | 32 | 3 | 2 | 2 |
| 5 | 162.47 | 196.99 | 188.19 | 8.5 | 4 | 9 | 3 | 3 | 3 |
| Total | 939 | 995.17 | 849.29 | 22 | 38 | 191 | 9 | 11 | 10 |

However the eastern part has more green space than western part.

2. From west to east, there is an increase in the number of denser construction patches inside the Park. It is indicative of unorganized construction within the park.

3. From west to east, green spaces reduces. Thus fragmentation is obvious.Thus the best road to connect upper and downer patch of the park is through shuttles No. 2 &3 in south and No. 4 in north part of the Park.

**B) vicinity of the park**

1. There is a very large amount of green space in southern and northern areas of the Park. Such green spaces are scanty in the eastern and western parts due to uncontrolled construction projects and river floodways, respectively.

2. Although there are many patches (for instance 7 patches), in the eastern part, no more constructions should be permitted and the remnant space should be used as empty, or green space or related land use could be applied.

3. Constructed and under construction areas are mostly located in eastern and northern sides of the Park. Southern and western parts are still saved because of river floodway, garden and farm lands. Fortunately these parts are declared as preserved farmlands by the government.

**Table 3. Structure, Green, open, and built spaces status in selected shuttles around the Eram Park**

| Shuttle No. | Mean patch size ($m^2$) | | | Mean nearest neighborhood distance(m) | | | Patch number | | |
|---|---|---|---|---|---|---|---|---|---|
| | Green space | Open space | Built space | Green space | Open space | Built space | Green space | Open space | Built space |
| 6 | 187.16 | 193.42 | 161.73 | 8 | 8 | 15 | 2 | 3 | 3 |
| 7 | - | 78.29 | 322.71 | - | 16.5 | - | - | 7 | 1 |
| 8 | 212.54 | 315.06 | 75.78 | - | 5 | 22 | 1 | 2 | 3 |
| 9 | - | 269 | 155.86 | - | 4 | - | - | 2 | 1 |
| Total | 399.7 | 855.77 | 716.08 | 8 | 33.5 | 37 | 3 | 14 | 8 |

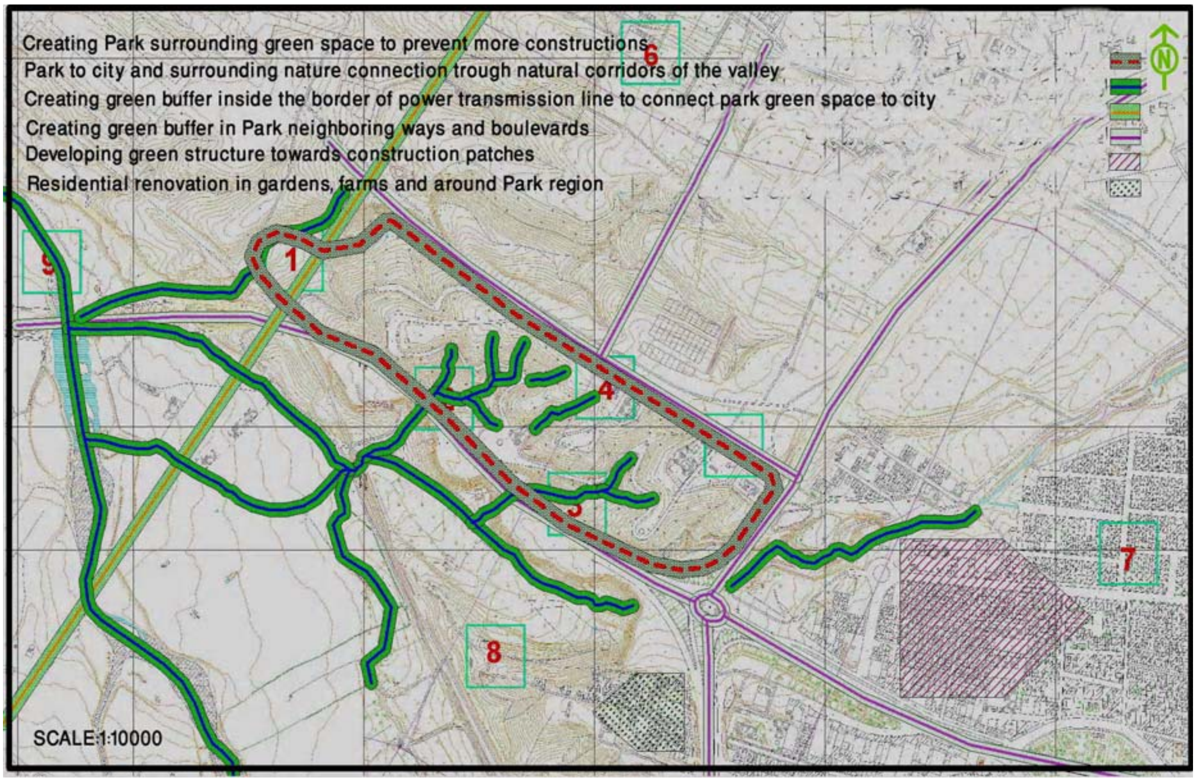



**Fig. 1. Map of landscape structure strategic plan**

**Table 4. Zanjan Eram Park Summary of results and landscape structure suggestions using SWOT Method**

| Decision making and study field | Current situation and Changes process | Opportunities and Strengths | Threats and Weaknesses |
|---|---|---|---|
| Evaluation of Landscape structure | - Generally the structure of the region consists of many general landscapes including vast open lands, built lands, fragmenting roads, hand planted green lands, gardens, natural corridors of river and floodways which surrounded ERAM Park.<br>- These patches and corridors have been scattered completely imbalanced and separately through out the region. There are some green, open and constructed patches inside the park that are located near each other without any logical proportion and have a noticeable disturbance as surrounding lands. | - Existence of open, green and large patches in upstream lands of the park.<br>- Existence of Zanjanroud natural corridors as main drainage of the study area at downstream of the park.<br>- inhibiting northern, southern and northeastern surrounding of the park from uncontrolled constructions<br>- Existence of green large patches inside the park<br>- Existence of small floodways inside the park as ecological aerial corridor of the park surrounding. | - Existence of traffic ways fragmenting corridors of the park from open green surrounding patches<br>- Developing construction patches at eastern, northern and north east of the park.<br>- Construction at downstream lands of the park.<br>- Imbalance among open, green and constructed patches.<br>- Great difference of the patches type at eastern, northern and north eastern sections around the park with southern and western sections.<br>- Existence of railroad as dividing corridor.<br>- Unsuitable dispersion of green, open and constructed patches inside the park.<br>- Dumping garbage in stream whose leachates finds its way in to the canals of park. |

## CONCLUSION

This study shows that green space mass inside the park is on a good and reasonable rate; mainly because of planting trees; but outside the Park, there are lots of constructions and also farmlands which have some constructions within them and thus have lesser green spaces with large open and uncontrolled areas.

To promote ecological sustainability and fitting landscape inside and outside the Park, the following recommendations are proposed:
1)Preserving current green space in the park (specially the parts in good condition) and its further development (as green corridor streets),
2)Developing current texture and gravity from central part of the park to the eastern and western parts (by fitting open areas),
3)Preserving current open and green patches inside and outside the park and prohibiting fragmentation,
4)Dispersing and fragmenting construction patches inside and in surrounding areas of the park,
5)Decreasing the average of closest neighboring distance between open and green patches by increasing location connections among them and doing vise versa for constructed areas,
6)Preserving and clearing current underground corridors in the southern part of the Park and further development of connections between open and green patches in the Park and mainland matrix.
7)Construction of green corridors with at least 12 meters width within the Park borders, not in lines and various green spaces, to prevent continual construction in the park, and finally
8)In larger scale, connection of Eram Park to other Parks in the City by green or water transmission corridors between them.

## ACKNOWLEDGEMENT

Thanks to Mr. Gh. Pasban hazrat, managing director of Baft shahr Consultant Engineering Company and Dr. A. Yavari from Faculty of Environment (university of Tehran) for their assistance and cooperation.

## REFRENCES

Arabi, M. Rafiee, M.A. and Ershaad, B.A., (2000). Fundamentals of Management. Cultural research Bureau press. 552 P.

Alexander, C., (1987). A New Theory of Urban Design. New York: Oxford University Press.

Bahrainy,H. and Aminzadeh, B., (2007). Evaluation of Navab regeneration project in central Tehran, Iran. Int. J. Environ. Res., **1**(2), 114-127.

Bürgi, M., Hersperger, A. M. and Schneeberger, N. (2004). Driving Forces of landscape change – current and new directions. Springer Netherlands. Land. Eco., **19**, 857-868.

Clay, G. R. and Daniel, T. C., (2000). Scenic landscape assessment: The effects of land management jurisdiction on public perception of scenic beauty. Landscape urban plan. **49**(1-2), 1-13.

Daniel, T. C., and Vining, J., (1983). Methodological issues in the assessment of landscape quality. In Altman, I., & Wohlwill, J. (Eds). Human Behavior and Environment., 6, Plenum Press: New York, 39-84.

Demers, M., (2005). Fundamental of Geographic Information System. Wily Publisher. 486 .

Farino, A., (1998). Principals and Methods in Landscape Ecology. Chapman and Hall Publisher, 235 .

Duany, A. and Plater-Zyberk, E., (1991). Towns and Town-making Principles. New York: Rizzoli International.

Forman, RTT., (1995). Land Mosaics: The Ecology of Landscape and Regions. Cambridge university press. 632 .

Forman, R. T. T. and Gordon. M., (1986). Landscape Ecology. John Wiley and Sons publisher, New York.

Frey, H., (1999). Designing the city: Toward a more sustainable urban form. London: E & F.N. Spon.

Hobber, W., (1996). Basic Concept of landscape Ecology and Their Application in Land Management. Physiol. Eco. Jao. **27**, 131-146.

Ingegnoli, V., (2002). Landscapes Ecology: A widening foundation. Springer. Springer-Verlag, New York, 375.

Kanevski, M. and Maignon, M., (2004). Analysis and Modeling of Spatial Environmental Data. EPFL press. 288 .

Karimi, S., (2003). Site selection for the Establishment of Industrial Sites in Qom province, using GIS. University of Tehran. 126.

Makhdoum, M., Darvishsefat, A., Jafarzadeh, H. and Makhdoum, A., (2003). Environmental Evaluation and Planning by Geographic Information System. Tehran University Press. 2543. 304.

Mazumdar, S., (2000). Autocratic control and urban design: The case of Tehran: Architectural Press.

OTA., (1994). Industry Technology and Environment competitive challenges and Business opportunities, Washington, DC: Congress of the United States, Office of Technology Assessment.

Rowley, A., (1996). Mixed used development: ambiguous, simplistic and wishful thinking. Plan. Prac. Res., **11**(1), 85-97.

*Int. J. Environ. Res., 1(3): 264-271, Summer 2007*
*ISSN: 1735-6865*

# Palm oil mill effluent digestion in an up-flow anaerobic sludge fixed film bioreactor

**Zinatizadeh, A. A. L.[1*], Salamatinia, B.[2], Zinatizadeh, S. L.[3], Mohamed, A. R.[2] and Hasnain Isa, M.[4]**

[1]Material and Energy Research Center, P. O. BOX 1415-4777, Tehran, Iran
[2]School of Chemical Engineering, Engineering Campus, University Sains Malaysia, Malaysia
[3]School of Natural Resources, Science and Researches Campus, Ahvaz Azad University, Pasdaran Blvd., Ahvaz
[4]School of Civil Engineering, Engineering Campus, University Sains Malaysia, Malaysia

Received 20 March 2006; Revised 25 Jan. 2007; Accepted 15 Feb. 2007

**ABSTRACT:** The effect of organic loading rate (OLR) provided by hydraulic retention time (HRT) and influent chemical oxygen demand ($COD_{in}$) on the performance of an up-flow anaerobic sludge fixed film (UASFF) bioreactor treating palm oil mill effluent (POME) was studied. Anaerobic digestion of POME was modeled and analyzed with two variables i.e. HRT and $COD_{in}$. Experiments were conducted based on a general factorial design and analyzed using response surface methodology (RSM). The region of exploration for digestion of POME was taken as the area enclosed by HRT (1 to 6 days) and $COD_{in}$ (5260 to 34725 mg/L) boundaries. A simultaneous increase of the variables determined a decrease of COD removal efficiency, SRT and SRF and an increase of COD removal rate, VFA/Alk., $CO_2$ fraction in biogas, methane production rate. The best COD removal rate for POME treatment in an anaerobic hybrid reactor has obtained at an OLR of 17.6 g COD/l.d while it was at 26.21 g COD/l.d (Corresponds to $COD_{in}$ of 26210 mg COD/l and HRT of 1 day) in the present study. Minimum and maximum SRT values obtained were 16 and 1904 days at OLR of 34.73 and 0.88 g COD/l.d, respectively. The present study provides valuable information about interrelations of quality and process parameters at different values of the operating variables.

**Key words:** Anaerobic digestion, UASFF reactor, POME, HRT, $COD_{in}$, RSM

*Corresponding Author: Email-aliazinatiz@yahoo.com

## INTRODUCTION

Palm oil mill effluent (POME) is a mixture of wastewaters generated from different stages of production process, sterilizer condensates, hydrocyclone waste, sludge separator and plant washing. It is hot (80-90 °C), acidic (pH 3.8-4.5) and contains very high concentration of organic matter (COD= 40000-50000 mg/L, BOD= 20000-25000 mg/L ;Najafpour, *et al.,* 2006). The palm mills in Malaysia faced the challenge of balancing environmental protection, their economic viability, and sustainable development after the department of environment enforced the regulation for the discharge of effluent from the CPO industry, under the Environmental Quality (prescribed premises) order and regulations 1997. There is an urgent need to find a way to preserve the environment which maintaining the economy in good conditions (Department of Environment Malaysia, 1999).

Biological treatment processes, in an effort to minimize cost, utilize microbial communities of varying degrees of diversity that interact in a multitude of ways to mediate a myriad of biological reactions, (Wise, 1987). Anaerobic digestion has been widely accepted as an interesting alternative for wastewater treatment and simultaneous fuel gas production. Its successful and economic employment arises from the development of new reactor designs (Jans and Man, 1988). It presents a number of significant advantages when compared with conventional aerobic wastewater systems (Droste, 1997; Metcalf & Eddy, 2003).

Due to the inherently lower efficiencies and loading rates of anaerobic filter and the occasional instability of the UASB, a hybrid of these two systems are being proposed an unpacked lower section and a packed upper section (Speece, 1988). Employing two technological approaches in up-flow anaerobic sludge fixed film (UASFF) reactor, microbial granules development and biofilm attachment on an inert media, allow independency of sludge retention of the hydraulic retention time (HRT), (Najafpour, *et al.,* 2006).

Owing to high anaerobic digestibility of POME, a wide range of anaerobic approaches have been examined. Among them, UASFF as a hybrid reactor has been the most efficient process due to its high ability to retain biomass even under overload (Najafpour, *et al.,* 2006). Effects of organic loading rate on the performance of the different biological reactors have been investigated for POME treatment (Ma and Ong, 1988; Borja and Banks, 1994a; Borja and Banks, 1994b; Borja, *et al.,* 1996; Fakhrul-Razi and Noor, 1999; Faisal and Unno, 2001; Norulaini *et al.,* 2001; Najafpor, *et al.*, 2005; Najafpour, *et al.,* 2006; Zinatizadeh, *et al.,* 2006). The studies have been carried out with the aim of process investigations in different anaerobic systems for POME treatment and changes in effluent quality parameters were discussed in a certain operating condition.

Response surface methodology (RSM) is a collection of mathematical and statistical techniques useful for analyzing the effects of several independent variables on the response (Box and Draper, 1987). RSM has an important application in the process design and optimization as well as the improvement of existing design. This methodology is more practical compared to the approaches mentioned above as it arises from experimental methodology which include interactive effects among the variables and, eventually, it depicts the overall effects of the parameters on the process (Baş and Boyaci, 2006).

In the present study, in addition of process analysis, a general factorial design was employed to describe and model variation trend in eight important responses (TCOD removal and removal rate, Volatile fatty acids to alkalinity ratio, CO2 fraction in biogas, solid retention time (SRT), sludge retention factor (SRF), methane production rate per volume of the reactor and feed) as function of two independent variables, HRT and influent COD concentration.

## MATERIALS & METHODS

A laboratory-scale, UASFF reactor was used in this study (Najafpour *et al.,* 2006). The glass bioreactor column was fabricated with an internal diameter of 6.5 cm and a liquid height of 112 cm. Total volume of the reactor was 4980 mL (including the section containing the gas-solid separator), and the working volume (total liquid volume excluding volume of the pall rings in fixed bed section) was 3650 mL. The column consisted of three sections; bottom, middle and top. The bottom part of the column, with a height of 80 cm was operated as a UASB reactor, the middle part of the column with height of 25 cm was operated as a fixed film reactor and the top part of the bioreactor served as a gas-solid separator. The middle section of the column was packed with 90 Pall rings with diameter and height each equal to 16 mm. The void age of the packed-bed reactor was 91.25 % and the specific surface area of the packing material was 341 m2/m3. An inverted funnel shaped gas separator was used to conduct the biogas to a gas collection tank. The UASFF reactor was operated under meso-philic conditions (38 ± 1 ºC) and temperature was maintained by circulating hot water through the bioreactor jacket. In order to distribute the feed uniformly in the reactor, an influent liquid distributor was mounted at the base of the column. The inoculum for seeding was an equal proportion mixture of sludge taken from a drainage channel bed of Perai Industrial Zone (Butterworth, Malaysia), digested sludge from a food cannery factory and animal manure. Details regarding the start up procedure can be found elsewhere (Najafpour, e*t al.,* 2006).

The bioreactor was fed with POME pre-settled for 1 h. The characteristics of POME are summarized in Table 1.

**Table 1. Characteristics of raw POME**

| Parameter | Amount |
|---|---|
| $BOD_5$ (mg/L) | 23000-26000 |
| COD (mg/L) | 42500-55700 |
| Soluble COD (mg/L) | 22000-24000 |
| TVFAs (mg acetic acid/l) | 2500-2700 |
| SS (mg/L) | 16500-19500 |
| Oil and grease (mg/L) | 4900-5700 |
| Total N (mg/L) | 500-700 |
| pH | 3.8-4.4 |

In order to describe the interactive effects of HRT and $COD_{in}$ on the responses, 36 continuous experiments were conducted as HRT varied from 1 to 6 days at 6 levels (1, 1.5, 3, 4, 5 and 6), and as influent COD concentration varied from 5260 to 34725 mg/L at 6 levels (5260, 10575, 14485, 21310, 26210, 34725 mg/L). HRT and influent COD concentration were chosen as two independent factors in the experiment design. TCOD removal and TCOD removal rate, Volatile fatty acids to alkalinity ratio, $CO_2$ fraction in biogas, solid retention time (SRT), sludge retention factor (SRF), methane production rate per volume of the reactor and feed were dependent output responses.

The experiment design is shown in Table 2. Regression analysis was performed to estimate the response function as below:

$$Y = \beta_0 + \beta_i X_i + \beta_j X_j + \beta_{ii} X_i^2 + \beta_{jj} X_j^2 + \beta_{ij} X_i X_j + ... \quad (1)$$

Where, *i* and *j* are the linear and quadratic coefficients, respectively, *ß* is the regression coefficient. Model terms were selected or rejected based on the P value with 95% confidence level. The results were completely analyzed using analysis of variance (ANOVA) by Design Expert software. Three dimensional plots and their respective contour plots were obtained based on the effect of the levels of the two factors. From these three-dimensional plots, the simultaneous interaction of the two factors on the responses was studied.

The following parameters were analyzed according to standard methods, (APHA, 1999): pH, alkalinity, TSS, VSS, BOD and COD. Total Kjeldahl nitrogen (TKN) was determined by colorimetric method using a DR 2000 spectrophotometer (Hach Co. Loveland, Co). Gas chromatographs equipped with thermal conductivity detector (TCD) and flame ionization detector (FID) were used for the determination of biogas and volatile fatty acid compositions, respectively, (Najafpour et al., 2006). The dry weight of the attached biofilm per unit wetted surface area of pall rings (X) was determined by drying a Pall ring at 80 ºC for 24 h before and after biofilm attachment.

## RESULTS & DISCUSSION

After a short and successful start up period, the reactor was operated at different HRTs and influent COD concentrations. In this study, the up-flow velocity was maintained relatively constant at 0.44±0.02 m/h while the influent COD concentration was increased from 5260 to 34725 mg/L (at six levels). The HRT was stepwise decreased from 6 to 1 day for each influent COD concentration, So that, the UASFF bioreactor was subjected to 36 different conditions. High performance of the UASFF reactor at steady state conditions with HRT and influent COD concentrations in the range under studied was successfully demonstrated. In order to analyze and model the interactive effects of the two variables ($COD_{in}$ and HRT) on the responses, Design-Expert software (Version 6) was used. In this program, general factorial design was selected. It allows the user to have factors that each has a different number of levels. The responses from the resulting 36 runs are shown in Table 2.

As various responses were investigated in this study, different degree polynomial models were used for data fitting. In order to quantify the curvature effects, the data from the experimental results were fitted to higher degree polynomial equations i.e. two factor interaction (2FI), quadratic and so on. In the Design Expert software, the response data were analyzed by default. Some raw data might not be fitted and transformations which apply a mathematical function to all the response data might be needed to meet the assumptions that made the ANOVA valid. Data transformations were needed for the TVFA and SRT responses as errors (residuals) were a function of the magnitude of the response (predicted values). Therefore, $\log_{10}$ function was applied for these responses, (Draper and Smith, 1998; Chapra and Canale, 2003; Ahmad, *et al.*, 2005). The model terms in the equations are after elimination of insignificant variables and their interactions. The interaction term, i.e. AB, was significant for all equations except the one defining TCOD removal rate. Based on the statistical analysis, the models were highly significant with very low probability values (from 0.0759 to < 0.0001). It was shown that the model terms of independent variables were significant at the 95 % confidence level. The square of correlation coefficient for each response was computed as the coefficient of determination ($R^2$). It showed high significant regression at 95 % confidence level. Adequate precision is a measure of the range in predicted response relative to its associated error or, in other words, a signal to noise ratio. Its desired

**Table 2. Experimental conditions and results of general factor design**

| Run | Variable | | Response | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Factor 1 A:HRT (d) | Factor 2 A:$COD_{in}$ (mg/L) | TCOD removal (%) | TCOD removal rate (g/l.d) | VFA/Alk. (eq. acetic acid/eq. $CaCO_3$) | $CO_2$ fraction in biogas (%) | SRT (day) | Retention factor | Methane production rate (l $CH_4$/ lreactor.d) | Methane production rate (l $CH_4$/ lfeed.d) |
| 1 | 1 | 5260 | 90.97 | 4.8 | 0.023 | 20.8 | 119 | 119 | 1.7 | 1.7 |
| 2 | 1.5 | 5260 | 93.16 | 3.3 | 0.014 | 17.7 | 204 | 136 | 1.1 | 1.7 |
| 3 | 3 | 5260 | 95.63 | 1.7 | 0.01 | 16.0 | 714 | 238 | 0.5 | 1.6 |
| 4 | 4 | 5260 | 96.77 | 1.3 | 0.011 | 15.4 | 1269 | 317 | 0.4 | 1.5 |
| 5 | 5 | 5260 | 96.96 | 1.0 | 0.008 | 14.9 | 1587 | 317 | 0.3 | 1.5 |
| 6 | 6 | 5260 | 97.24 | 0.9 | 0.008 | 14.7 | 1904 | 317 | 0.3 | 1.6 |
| 7 | 1 | 10575 | 89.60 | 9.5 | 0.025 | 26.5 | 39 | 39 | 3.2 | 3.2 |
| 8 | 1.5 | 10575 | 94.91 | 6.7 | 0.015 | 24.1 | 101 | 67 | 2.2 | 3.3 |
| 9 | 3 | 10575 | 96.35 | 3.4 | 0.01 | 17.9 | 363 | 121 | 1.1 | 3.4 |
| 10 | 4 | 10575 | 97.07 | 2.6 | 0.01 | 17.0 | 807 | 202 | 0.9 | 3.5 |
| 11 | 5 | 10575 | 97.64 | 2.1 | 0.009 | 16.1 | 1210 | 242 | 0.7 | 3.3 |
| 12 | 6 | 10575 | 97.68 | 1.7 | 0.007 | 15.9 | 1452 | 242 | 0.6 | 3.3 |
| 13 | 1 | 14485 | 87.40 | 12.7 | 0.028 | 30.2 | 26.5 | 27 | 4.3 | 4.3 |
| 14 | 1.5 | 14485 | 92.23 | 8.9 | 0.018 | 27.4 | 88 | 59 | 3.1 | 4.6 |
| 15 | 3 | 14485 | 97.10 | 4.7 | 0.005 | 19.9 | 363 | 121 | 1.6 | 4.8 |
| 16 | 4 | 14485 | 97.86 | 3.5 | 0.007 | 18.5 | 797 | 199 | 1.2 | 4.9 |
| 17 | 5 | 14485 | 98.00 | 2.8 | 0.007 | 15.1 | 1412 | 282 | 0.9 | 4.7 |
| 18 | 6 | 14485 | 98.14 | 2.4 | 0.007 | 17.9 | 1694 | 282 | 0.8 | 4.8 |
| 19 | 1 | 21310 | 86.72 | 18.5 | 0.044 | 35.9 | 22.7 | 23 | 5.6 | 5.6 |
| 20 | 1.5 | 21310 | 91.04 | 12.9 | 0.026 | 31.0 | 65 | 43 | 4.5 | 6.7 |
| 21 | 3 | 21310 | 97.51 | 6.9 | 0.006 | 22.2 | 231 | 77 | 2.3 | 6.9 |
| 22 | 4 | 21310 | 98.15 | 5.2 | 0.007 | 20.2 | 544 | 136 | 1.7 | 6.9 |
| 23 | 5 | 21310 | 98.33 | 4.2 | 0.006 | 19.0 | 1179 | 236 | 1.4 | 6.9 |
| 24 | 6 | 21310 | 98.40 | 3.5 | 0.006 | 17.7 | 1516 | 253 | 1.2 | 6.9 |
| 25 | 1 | 26210 | 84.43 | 22.1 | 0.103 | 42.1 | 19 | 19 | 6.6 | 6.6 |
| 26 | 1.5 | 26210 | 90.18 | 15.8 | 0.032 | 35.8 | 39.5 | 26 | 5.4 | 8.1 |
| 27 | 3 | 26210 | 97.81 | 8.5 | 0.007 | 25.8 | 237 | 79 | 2.9 | 8.8 |
| 28 | 4 | 26210 | 98.19 | 6.4 | 0.008 | 22.2 | 383 | 96 | 2.2 | 8.8 |
| 29 | 5 | 26210 | 98.44 | 5.2 | 0.008 | 20.4 | 909 | 182 | 1.7 | 8.6 |
| 30 | 6 | 26210 | 98.59 | 4.3 | 0.007 | 20.0 | 991 | 165 | 1.5 | 9.1 |
| 31 | 1 | 34725 | 80.56 | 28.0 | 0.288 | 48.7 | 16 | 16 | 8.0 | 8.0 |
| 32 | 1.5 | 34725 | 89.58 | 20.7 | 0.045 | 38.0 | 38.7 | 26 | 7.2 | 10.8 |
| 33 | 3 | 34725 | 97.90 | 11.3 | 0.008 | 28.1 | 217 | 72 | 4.0 | 11.9 |
| 34 | 4 | 34725 | 98.39 | 8.5 | 0.007 | 25.1 | 334 | 84 | 2.9 | 11.5 |
| 35 | 5 | 34725 | 98.57 | 6.8 | 0.007 | 22.8 | 672 | 134 | 2.3 | 11.5 |
| 36 | 6 | 34725 | 98.62 | 5.7 | 0.006 | 23.2 | 806 | 134 | 2.1 | 12.3 |

It was shown that the model terms of independent variables were significant at the 95% confidence level. The square of correlation coefficient for each response was computed as the coefficient of determination ($R^2$). It showed high significant regression at 95 % confidence level. Adequate precision is a measure of the range in predicted response relative to its associated error or, in other words, a signal to noise ratio. Its desired value is 4 or more, (Mason *et al.,* 2003). The value was found desirable for all models. Simultaneously, low values of the coefficient of variation (1.54-9.55 %) indicated good precision and reliability of the experiments as suggested by Khuri and Cornell, (1996); Kuehl, (2000) and Ahmad, *et al.,* (2005).

Two reduced quadratic models were selected to describe the response surface of TCOD removal and TCOD removal rate within the range of the factors. The regression equations (built with codified factors) are as follow:

$$TCOD\ removal = 94.72+9.04A-1.61B-4.94A^2+2.57AB \qquad (2)$$

$$Log_{10}(TCOD\ removal\ rate) = 0.92-0.45A+0.39B+0.13A^2-0.18B^2 \qquad (3)$$

Figure 1 shows simultaneous effects of the two factors on TCOD removal efficiency obtained from Eq. (2). It showed a significant decreasing trend in TCOD removal efficiency with the decrease in HRT at a constant influent COD. Whereas slight decrease in TCOD removal efficiency was observed when influent COD was increased under constant HRT and lower than 4 days. The lowest efficiency in TCOD removal was predicted to be 84.4 % at the highest OLR (corresponds to HRT of 1 day and $COD_{in}$ of 34725 mg/L) while the experimental value has been 80.6 %. In this condition, the reactor instability was temporarily observed after 4 days at OLR of 34.7 g COD/L.d. But the buffer supplied by adding $NaHCO_3$ in the feed and recycling effluent alkalinity into influent prevented pH changes a lot and pH was controlled at 6.92. The main reason for relatively poor efficiency at OLR of 34.7 g

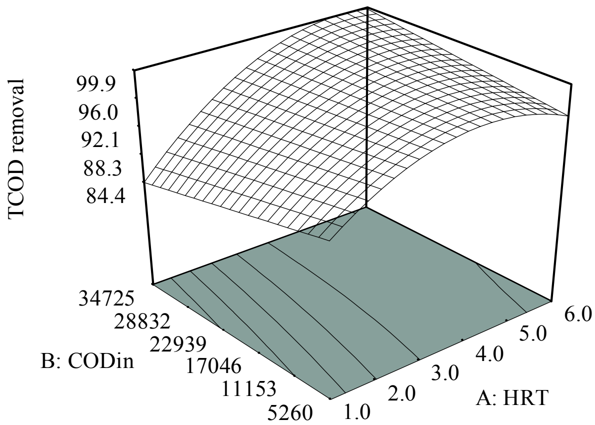



**Fig. 1. Response surface plot for TCOD removal**

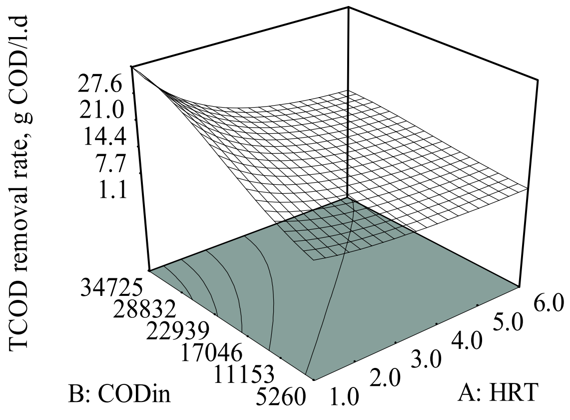



**Fig. 2. Response surface plot for TCOD removal rate**

The regression was conducted after transformation of raw data to a function of log base 10. Fig. 2 illustrates the effect of the factors on the TCOD removal rate in original scale. As can be seen, the TCOD removal rate increased with the increase in influent COD and decrease in HRT. The best COD removal rate for POME treatment in an anaerobic hybrid reactor has obtained at an OLR of 17.6 g COD/L.d (Borja, *et al.,* 1996) while it was at 26.21 g COD/L.d (Corresponds to $COD_{in}$ of 26210 mg COD/L and HRT of 1 day) in the present study. It might be attributed to larger amount of biomass in the form of granule due to bigger volume of UASB portion relative to total volume in a hybrid reactor.

The ratio of VFA/Alk. is an important indicator of the acid-base equilibrium and process stability (Sanchez, *et al.,* 2005; Fannin, 1987). When this ratio is less than 0.3-0.4, the process is considered to be operating favorably without the risk of acidification. The measurement of quantity and composition of the biogas produced, in terms of methane and carbon dioxide content, is of fundamental importance to evaluate the stability of the process (Stafford *et al.,* 1980). When the process is stable the amount and composition of biogas are stable too. A decrease in biogas production contemporary to an increase in $CO_2$ content can indicate an inhibition of the methanogenesis of the system. In fact, VFA/Alk. ratio and biogas composition are strictly linked one to each other.

The following two regression equations were obtained for the variation of VFA to alkalinity ratio (p) and $CO_2$ fraction in biogas.

$$\log_{10}(VFA/Alk.) = -1.95-0.73A+0.077B+0.42A^2+0.11B^2-0.52AB+0.33A^2B \quad (4)$$

$$CO_2 \text{ fraction in biogas} = 24.96-12.25A+8.94B+5.54A^2-4.68AB \quad (5)$$

The ratio of maximum to minimum for p was 55. Hence a logarithmic function with base 10 was required to fit the data. Fig. 3 illustrates the effects of the variables on VFA/Alk.. From the Fig. 3, the maximum value of the ratio is predicted to be 0.18 at highest OLR (corresponds to HRT of 1 and $COD_{in}$ of 34725 mg/L) whereas the actual value was 0.28 at this condition. The VFA/Alk. ratio remained lower than the suggested value throughout experiments.

Figure 4 shows the variation of the $CO_2$ fraction in the biogas as a function of the two factors studied. The $CO_2$ fraction increased with simultaneous decrease and increase in HRT and $COD_{in}$, respectively. The maximum $CO_2$ fraction in biogas was modeled to be 46.05 % whereas the actual is 48.7 %.

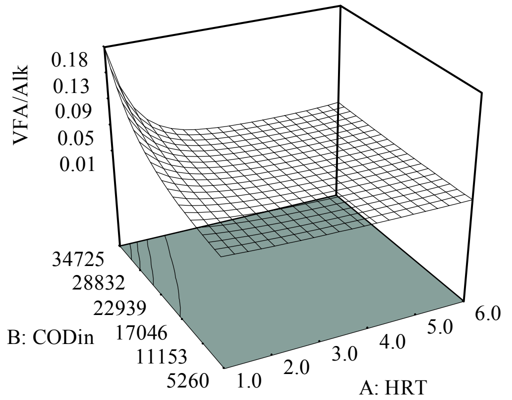



**Fig. 3. Response surface plot for VFA/Alk**

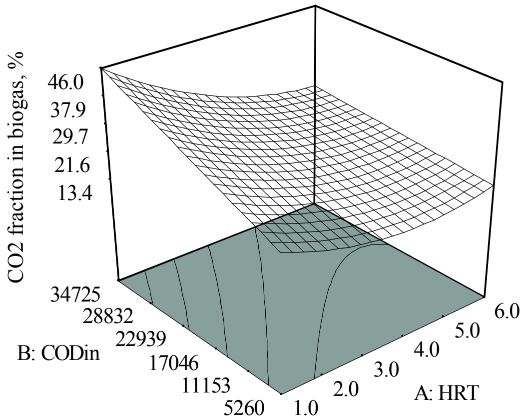



**Fig. 4. Response surface plot for $CO_2$ percentage in biogas**

It was also reflected by an increase in the effluent VFA concentration (from 158 to 843.2 mg acetic acid/l) and decrease in the effluent pH (from 7.63 to 6.92). This resulted from partial upsetting of the balance between acid formation and methane production in the anaerobic process due to high organic load at low HRT. The effluent pH remained within the optimal working range for anaerobic digestion (6.9 -7.9) throughout the experiment. SRT, as a process control parameter, was also determined by measuring VSS in the reactor and in the effluent at various concentrations of influent COD. The high SRT values denote effective role of the packed bed portion on process stability due to biomass retention which allows the system to cope with changes in OLR. Minimum and maximum SRT values obtained were 16 and 1904 days at OLR of 34.73 and 0.88 g COD/l.d, respectively. It was found that at the shortest HRT (1 day), the sludge age to HRT ratio was 16 which is in the range of safety factor (3-20) for the minimum SRT for successful operation of anaerobic biological reactors (Lawrence and McCarty, 1969).

HRT as an operating factor affecting SRT by following relationship:

$$SRT = \frac{X_r . HRT}{X_e} \qquad (6)$$

Where $X_{r,}$ is the concentration of sludge in the reactor (g VSS/l); $X_e$, is the concentration of VSS in the effluent of the reactor (g VSS/l). The SRT to HRT ratio is defined the sludge retention factor (SRF). The increase in retention factor involves increasing in HRT. Large values of retention factor providing longer SRT which favoring methanogenesis and improving process performance. The best option to achieve high SRT while maintaining HRT at low levels is biomass immobilization which is applied in the UASFF reactor in the form of granular sludge and biofilm attached on the packing.

In order to model interactive effects of the variables (HRT and $COD_{in}$) on the process control responses, SRT and SRF, two following quadratic models were obtained.

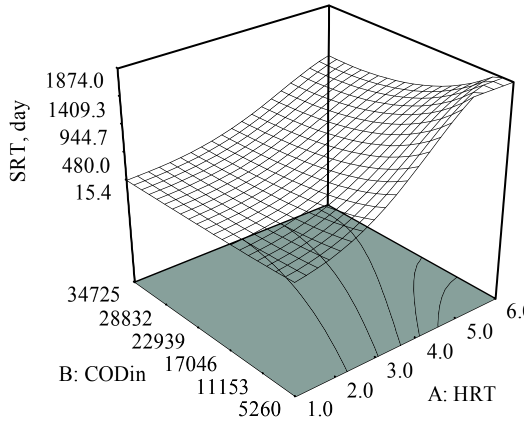



**Fig. 5. Response surface plot for SRT**

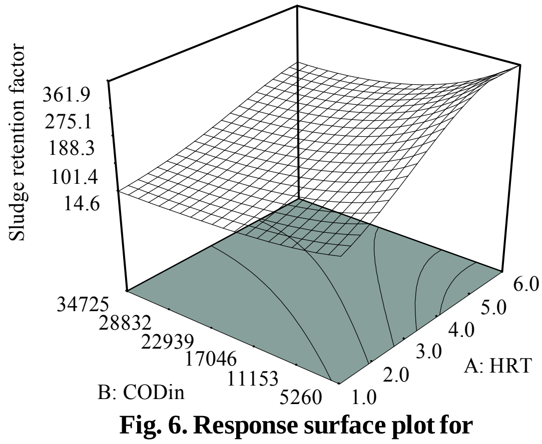



**Fig. 6. Response surface plot for sludge retention time**

$$Log_{10}\ (SRT) = 2.24+1.09A-0.31B-0.35A^2+0.098B^2+0.1AB \quad (7)$$

$$Log_{10}\ (SRF) = 1.85+0.59A-0.31B-0.2A^2+0.098B^2+0.1AB \quad (8)$$

Since maximum to minimum ratio for SRT and SRF were 119 and 19.8, respectively, a logarithmic function with base 10 was applied to fit the data. The same variation trend for SRT and SRF was observed as shown in Fig. 5 and 6, indicating inverse proportion between OLR and the responses. In this study, the up-flow velocity was maintained constant (0.44 m/h) (controlled by recycle ratio), therefore, increase in the concentration of VSS in the effluent was attributed to an increase in gas production rate due to increase in HRT and $COD_{in}$.

The methane production is a function of OLR (changing HRT or/and $COD_{in}$). The two following regression equations were selected to describe changes in methane production rate as function of the variables.

*Methane production rate per unit of reactor volume* $= 2.9-2.88A+2.29B+1.19A^2-1.24AB$ (9)

*Methane production rate per unit of feed* $= 6.31+0.96A+4.39B-0.52A^2+0.8AB$ (10)

## CONCLUSIONS

The UASFF bioreactor was a successful biological treatment process to achieve a high COD removal efficiency in a short period of time. The response surface methodology results demonstrated the effects of the operating variables as well as their interactive effects on the responses. A simultaneous increase of the variables determined a decrease of COD removal efficiency, SRT and SRF and an increase of COD removal rate, VFA/Alk., $CO_2$ fraction in biogas, methane production rate. The best COD removal rate for POME treatment in an anaerobic hybrid reactor has obtained at an OLR of 17.6 g COD/l.d while it was at 26.21 g COD/l.d (Corresponds to $COD_{in}$ of 26210 mg COD/l and HRT of 1 day) in the present study. Minimum and maximum SRT values obtained were 16 and 1904 days at OLR of 34.73 and 0.88 g COD/l.d, respectively. Experimental findings were in close agreement with the model prediction.

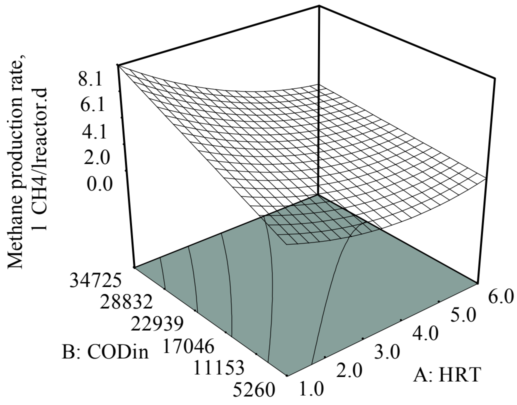



**Fig. 7. Response surface plot for methane production rate per unit of reactor volume**

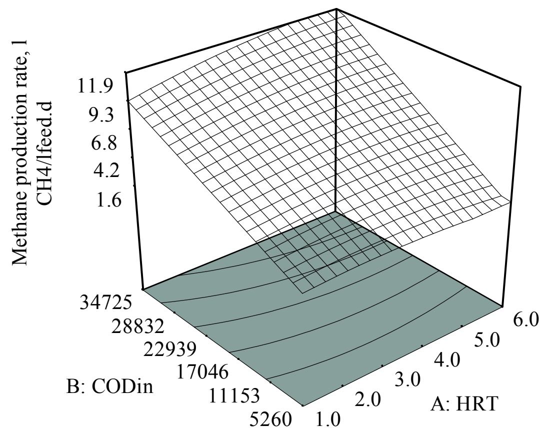



**Fig. 8. Response surface plot for methane production rate per unit of feed**

## ACKNOWLEDGEMENTS

The financial support provided by University Sains Malaysia (School of Chemical Engineering) as a short term grant (no. 6035132) is gratefully acknowledged. The greatest appreciation goes to the industry personnel for their full cooperation.

## REFERENCES

Ahmad, A. L., Ismail, S. and Bhatia, S., (2005). Optimization of coagulation–flocculation process for palm oil mill effluent using response surface methodology. Environ. Sci. Tech., **39** (8), 2828-2834.

American Public Health Association, (APHA), (1999). Standard Methods for the Examination of Water and Wastewater. 20th Ed., Washington, DC.

Bas, D., Boyaci, I. H., (2006). Modeling and optimization 2: usability of response surface methodology. Journal of Food Engineering, Article in press.

Borja, R. and Banks, C. J., (1994). Kinetic of methane production from palm oil mill effluent in an immobilized cell bioreactor using saponite as support medium. Biores. Tech., **48**, 209-214.

Borja, R. and Banks, C. J., (1994). Anaerobic digestion of Palm Oil Mill Effluent using an Up-flow Anaerobic Sludge Blanket (UASB) Reactor. Biomass Bio., **6**, 381-389.

Borja, R., Banks, C. J., Khalfaoui, B. and Martin, A., (1996). Performance evaluation of an anaerobic hybrid digester treating palm oil mill effluent. J. Environ. Sci. Health, **A31**, (6 ),1379-1393.

Box, G. E. P and Draper N. R., (1987). Empirical model-building and response surfaces, John Wiley & Sons, New York.

Chapra, S. C. and Canale, R. P., (2003). Numerical methods for engineers. fourth edition, McGraw-Hill, New York, 440-471.

Department of Environment Malaysia, (1999). Industrial processes & the Environment-Crude Palm Oil Industry, Handbook, **3**, 5-10.

Draper and Smith, (1998), Applied regression analysis. third edition, John Wiley & Sons, New York.

Droste, R. L., (1997). Theory and Practice of Water and Wastewater Treatment, John Wiley, New York.

Faisal, M. and Unno, H., (2001). Kinetic Analysis of Palm Oil Mill Wastewater Treatment by a Modified Anaerobic Baffled Reactor. Biochem. Eng., **9**, 25-31.

Fannin, K. F., (1987), Start-up, operation, stability and control. In: Chynoweth, D.P., Isaacson, R. (Eds), Anaerobic Digestion of Biomass. Elsevier, London, UK, 179-195.

Fakhrul-Razi, A. and Noor, M. J. M. M., (1999). Treatment of palm oil mill effluent (POME) with the membrane anaerobic system (MAS). Water Sci. Tech., **39**, 159-163.

Jans, T. J. M. and Man, D. G., (1988). Reactor design considerations and experiences with various wastewaters, published in a book entitle, Anaerobic treatment of industrial wastewater. ndc (Noyes Data Corporation).

Khuri, A. I. and Cornell, J. A., (1996). Response surfaces: design and analyses, second edition, Marcel Dekker, New York.

Kuehl, R. O., (2000). Design of Experiments: Statistical principles of research design and analysis. second edition, Duxbury press, Pacific Grove, CA.

Lawrence, A. L. and McCarty, P. L., (1969). Kinetics of methane fermentation in anaerobic treatment. J. Water Pollution Control Federation, **41**, R1-R17.

Ma, A. N. and Ong, A. S. H., (1988). Treatment of palm oil sterilizer condensate by an anaerobic process. Biologic. Waste, **23**, 85-97.

Mason, R. L., Gunst, R. F. and Hess, J. L., (2003). Statistical Design and Analysis of Experiments. eighth applications to engineering and science, second edition, John Wiley & son, New York.

Metcalf & Eddy, (2003), Wastewater engineering. fourth edition, McGraw-Hill, New York.

Najafpour, G. D., Yieng, H. A., Younesi, H. and Zinatizadeh, A. A. L., (2005). Effect of Organic Loading on Performance of Rotating Biological Contactors using Palm Oil Mill Effluents. Process Biochemistry, **40**, 2879-2884.

Najafpour, G. D., Zinatizadeh, A. A. L., Mohamed, A. R., Isa, M. H. and Nasrollahzadeh, H., (2006). High-rate anaerobic digestion of palm oil mill effluent in an up-flow sludge-fixed film bioreactor. Process Biochem., **41**, 370-379.

Norulaini, N., Zuhairi, A.A., Hakimi, M. I., Omar, M. A.K., (2001). Treatment of palm oil mill effluent (POME) using attached-film bioreactor: trickling filter as a case study, J. Ind. Tech., **10** (1), 41-54.

Sanchez, E., Borja, R., Travieso, L., Martin, A., Colmenarejo M. F., (2005). Effect of organic loading rate on the stability, operational parameters and performance of a secondary upflow anaerobic sludge bed reactor treating piggery waste. Biores. Tech., **96**, 335-344.

Speece, R. E., (1988). Advances in anaerobic biotechnology for industrial wastewater treatment. Published in a book entitle “Anaerobic treatment of industrial wastewater, ndc (Noyes Data Corporation).

Wise, D. L., (1987). Bioenvironmental systems. Chapter 6, CRC press, Boca Raton, Florida, 135-159.

Zinatizadeh, A. A. L., Mohamed, A. R., Najafpour, G. D., Isa, M. H., Nasrollahzadeh, H., (2005). Kinetic evaluation of high rate POME digestion in an UASFF bioreactor. Process Biochemistry, **41**, 1038-1046.

*Int. J. Environ. Res., 1(3): 272-279, Summer 2007*
*ISSN: 1735-6865*

# Dynamic Spatial Modeling of Urban Growth through Cellular Automata in a GIS Environment

**Mahiny, A. S.* and Gholamalifard, M.**

College of the Environment, Gorgan University of Agriculture and Natural Resources Sciences, Golestan Province, Iran
Depatment of Environment, College of Natural Resources and Marine Sciences, Tarbiat Modarres University, Noor, Manandaran Province, Iran

Received 10 Jan. 2007; Revised 25 Feb. 2007; Accepted 15 March 2007

**ABSTRACT:** Urban settlements and their connectivity will be the dominant driver of global change during the twenty-first century. In an attempt to assess the effects of urban growth on available land for other uses and its associated impacts on environmental parameters, we modeled the change in the extent of Gorgan City, the capital of the Golestan Province of Iran. We used Landsat TM and ETM+ imagery of the area and evaluated possible scenarios of future urban sprawl using the SLEUTH method. The SLEUTH is a cellular automaton dynamic urban-growth model that uses geospatial data themes to simulate and forecast change in the extent of urban areas. We successfully modeled and forecasted the likely change in extent of the Gorgan City using slope, land use, exclusion zone, transportation network, and hillshade predictor variables. The results illustrated the utility of modeling in explaining the spatial pattern of urban growth. We also showed the method to be useful in providing timely information to decision makers for adopting preventive measures against unwanted change in extent and location of the built-up areas within in the city limits.

**Key words:** Urban growth, Dynamic modeling, Cellular Automata, SLEUTH, Landsat, Gorgan

* Corresponding Author: Email-a_mahini@yahoo.com

## INTRODUCTION

Urbanization is one of the most evident global changes. Small and isolated population centers of the past have become large and complex features, interconnected, economically, physically and environmentally (Acevedo, *et al.*, 1996). One hundred years ago, approximately 15% of the world's population was living in urban areas. Today, the percentage is nearly 50%. In the last 200 years, while the world population has increased six times, the urban population has multiplied 100 times (Acevedo, *et al.*, 1996). Urban settlements and their connectivity will be the dominant driver of global change during the twenty-first century. Intensely impacting land, atmospheric, and hydrologic resources, urban dynamics has now surpassed the regional scale of megalopolis and must now be considered as a continental and global scale phenomenon (Acevedo, *et al.*, 1996).

Theoretical and descriptive explanations of urban growth have been well developed and documented in the literature since the middle 1950s. A half century of development in the field has involved great advances and significant changes in the theory and methodology, particularly the evolution of computer graphic technologies, and the introduction of new paradigms. During the 1950s and 1960s, research on urban modeling attempted to build large scale urban models (LSUMs), which Lee (1994) defined as models that seek to describe, in a functional/structural form, an entire urban area, in spatial, land-use, demographic and economic terms. According to Batty (1994), these modeling attempts were part of an effort to transform planning from an architectonic and intuitive art into an objective and rational activity. The LSUMs were severely criticized during the early 1970s.

However, large scale urban models have been blamed for problems such as hyper-comprehensiveness; grossness; hungriness wrong-headedness; complicatedness; mechanicalness; and expensiveness (Lee, 1973). Geographic information systems were a central component of these developments and there was much effort in linking these systems to traditional spatial models (Batty, 1994).

Understanding land use change in urban areas is a key aspect of planning for sustainable development. It also helps in designing plans to counter the negative effects of such changes. According to Clarke *et al.,* (1997), simulation of future spatial urban patterns can provide insight into how our cities can develop under varying social, economic, and environmental conditions. Since the late 1980s, applications of computers in urban planning have changed dramatically. The traditional top-down approaches described before were replaced by bottom-up approaches where complexity, self-organization, chaos and fractals are taken into consideration. The advances in the computing technology have contributed very much to make the approach a reality (Batty and Densham, 1996). In the bottom-up approach, system behavior is rendered deterministic and small changes at the micro-level can result in dramatic changes at the macro-level. Some examples of these new concepts and techniques in urban modeling include fractals and cellular automata (CA). Batty *et al.* (1989), were the pioneers of the application of these new paradigms in the urban dynamics research field.

The study of CA goes back to the late 1940s with the research of Neumann and Ulgam. Some examples of CA-based models developed and applied to the simulation of urban evolution are found in White and Engelen (White *et al.*, 1993;1994; 1997; Engelen *et al.*, 1995;1997), US Geological Survey (Clarke *et al.*, 1997; 1998), Li and Yeh (2000), AUGH-Generalised Urban Automata with help on line (Cecchini, 1996), Wu (1998), Phipps and Langlois (1997), Sembolini (1997), DUEM (Dynamic Urban Evolutionary Modeling developed by Batty *et al.*, 1999) and Barredo *et al.*, (2003).

Markov Chain Analysis has also been used to model change in land use and land cover (Mahiny, 2003 a). A Markovian process is simply one in which the future state of a system can be modeled purely on the basis of the immediately preceding state and will describe land use change from one period to another (Eastman, 2001b). This is accomplished by developing a transition probability matrix of land use change from time one to time two, which will be the basis for projecting to a later time period. The output from Markovian process has only very limited spatial knowledge (Eastman, 2001).

Cellular automata can be used and linked to the Markov chain results to compensate the lack of spatial knowledge. A cellular automaton is a cellular entity that independently varies its state based on its previous state and that of its immediate neighbors according to a specific rule. In the process, only a transition rule is applied that depends not only upon the previous state, but also upon the state of the local neighborhood (Eastman, 2001). Cellular automata (CA) are discrete dynamic systems whose behavior is completely specified in terms of a local relation. They are composed of four elements: cells, states, neighborhood rules and transition rules. *Cells* are objects in any dimensional space that manifest some adjacency or proximity to one another. Each cell can take on only one *state* at any one time from a set of states that define the attributes of the system. The state of any cell depends on the states of other cells in the *neighborhood* of that cell, the neighborhood being the immediately adjacent set of cells that are 'next' to the cell in question. And, finally, there are *transition rules* that drive changes of state in each cell as some function of what exists or is happening in the neighborhood of the cell (Batty and Xie, 1997).
According to Dietzel and Clarke (2006), of all the CA models available, SLEUTH may be the most appropriate because it is a hybrid of the two schools in CA modeling—it has the ability to model only urban growth and incorporate detailed land use data. Reasons attributed to choosing this model are: (1) the shareware availability means that any researcher could perform a similar application or experiment at no cost given they have the data; (2) the model is portable so that it can be applied to any geographic system at any extent or spatial resolution; (3) the presence of a well-established internet discussion board to

support any problems and provide insight into the model's application; (4) a well documented history in geographic modeling literature that documents both theory and application of the model; and (5) the ability of the model to project urban growth based on historical trends with urban/non-urban data.

The main component of the SLEUTH is the Clarke Urban Growth Model (UGM) which drives a second component, the Deltatron land cover model. SLEUTH is the evolutionary product of the Clarke Urban Growth Model that uses cellular automata, terrain mapping and land cover deltatron modeling to address urban growth. The name SLEUTH was derived from the simple image input requirements of the model: Slope, Land cover, Exclusion, Urbanization, Transportation, and Hillshade.

In order to run the model, one usually prepares the data required, verifies the model functions, calibrates the model, predicts the change and builds the products. The user can implement SLEUTH modeling in different modes. The test mode is intended to give the user an easy way to execute a single run on a data set to confirm that the model is performing correctly, or produce output files for a specific set of coefficients.

In calibration mode, the large number of possible coefficient sets is narrowed down to a reasonable estimate of best fit values using brute force calibration methods. Typically the calibration of SLEUTH is a three-step process. In the first step which is a coarse calibration, a variety of spatial metrics are produced, the most common being the Lee–Sallee metric. The Lee–Sallee metric describes the degree of spatial matching between the simulated data and the input historical data, and is a rigorous measure of the ability of a parameter set to replicate historical urban growth patterns. The tested parameter sets are sorted based on their goodness of fit, and the parameter values are narrowed to values around the parameter set that produced the best fit between the historical and simulated data.

In the fine calibration step, the narrowed range of parameters from the previous step is used to simulate the historical growth patterns. Results of these simulations are evaluated using spatial metrics of fit, and the range of parameters is narrowed one last time. Finally, the historical data is simulated one last time using the re-narrowed set of parameters, and the one that best recreates the urban growth is then used in model forecasting. After calibration, a set of five parameters or coefficients are produced that describe the historical growth patterns of the system over time based on a fixed set of transition rules. Five coefficients (with values 0 to 100) control the behavior of the system, and are predetermined by the user at the onset of every model run (Clarke et al., 1998). These parameters are diffusion that determines the overall dispersiveness nature of the outward distribution, breed coefficient which is the likelihood that a newly generated detached settlement will start on its own growth cycle. Spread coefficient is another parameter that controls how much contagion diffusion radiates from existing settlements. Slope resistance factor influences the likelihood of development on steep slopes, and finally road gravity that is produced to show the attraction roads create in drawing new settlements towards and along them. These parameters drive the transition rules that simulate four types of urban growth. These are spontaneous growth showing the urbanization of land that is of suitable slope, yet not adjacent to preexisting urban areas, diffusive growth when newly established urban areas begin to transform the land around them from other uses into urban land cover, organic growth at the urban fringe and as infill within areas that may not have fully made the transition from another land use to urban. Road influenced growth is another type of growth that takes into account the influence of roads over urbanization and land use change while prediction growth type is a collection of Monte Carlo simulations.

The prediction mode of the SLEUTH model uses the best fit growth rule parameters from the calibration to begin the process of ''growing'' urban settlements, starting at the most recent urban data layer. The resulting forecast of future urban growth is a probabilistic map where each grid cell has the chance of being urbanized at some future date, assuming the same unique ''urban growth signature'' is still in effect as it was in the past, while allowing some system feedbacks termed self-modification (Herold *et al.*, 2003). Due to its scientific appeal, availability and relative ease of use, we adopted the SLEUTH for modeling Gorgan City change through time, a first time event in Iran.

## MATERIALS & METHODS

Gorgan is the capital city of the Golestan Province in the north east of Iran. The economic growth in the area in the recent past has led to a large increase in population, driving dramatic urban expansion and land use change.

We used the SLEUTH modeling method to simulate and project the change in the area of the city. SLEUTH requires an input of five types of image files (six if land use is being analyzed). For all layers, zero is a nonexistent or null value, while values greater than zero and less than 255 represent a live cell.

We geo-registered and re-sampled a 10 meter DEM of the area obtained from National Cartographic Center of Iran to 20 meters resolution using Idrisi 32 software (Eastman, 2001). Then, we derived the slope and hillshade layers from the DEM layer. Landsat TM and ETM+ scenes of the Gorgan City covering around 1316 $Km^2$ were selected for this study. The scenes which dated July 1987, September 1988, July 2000 and 2001 were imported into Idrisi 32 software (Eastman, 2001), geo-registered to the other layers and re-sampled to 20 meters resolution. Then the scenes were classified using knowledge from the area and Maximum Likelihood supervised classification method. We identified seven classes: water, agriculture, fallow lands, built-up areas, dense broad-leaved forest, thin forest, pastures and needle-leaved woodlands. A post-classification comparison was conducted to detect the change in land use and land cover of the area. The urban extent was derived through reclassification of these detailed land cover classifications into a binary urban / non-urban map (Fig. 1)

For deriving the transportation and excluded layers, we used visual image interpretation and on-screen digitizing to generate individual vector layers that were transformed into raster layers with 20 meters resolution. We ensured that all data layers followed the naming protocol for SLEUTH, were in grayscale GIF format and had the same projection, map extent, and resolution.

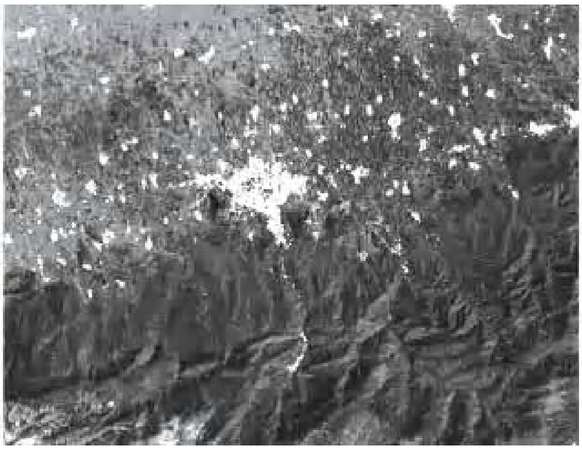


**Fig. 1. Gray scale color composite image of the study area, bands 2, 3, and 4 of ETM+ sensor of Landsat satellite, 30th July 2001, with lighter spots showing the residential areas**

Model calibration was conducted in three phases: coarse, fine and final calibration. The algorithm for narrowing the many runs for calibration is an area of continuous discussion among users, and so far no definitive “right” way has been agreed upon. Examples of approaches used thus far include: sorting on all metrics equally, weighting some metrics more heavily than others, and sorting only on one metric. In this investigation, the last method, namely sorting on one metric, was applied. Simulations were scored on their performance for the spatial match, using Lee-Sallee metric.

Adopting the procedure used by Leao *et al.*, (2001 and 2004) and Mahiny (2003) we devised two different urban growth scenarios for model prediction. One scenario described the city as growing following historical trends, according to the parameters calibrated based on historical data. The second scenario described a more compact growth as a response to hypothetical policies and the shortage of land to reduce urban spreading. This was done by manipulating the value of some of the calibrated growth parameters. In the historical growth scenario, when the final calibration process was completed, the best selected parameters were run through the historical data many times and their finishing values were averaged considering the self-modification parameters. In the simulation for a compact city, the spread and road-gravity coefficients were reduced to half of the calibrated and averaged best values were derived in the process.

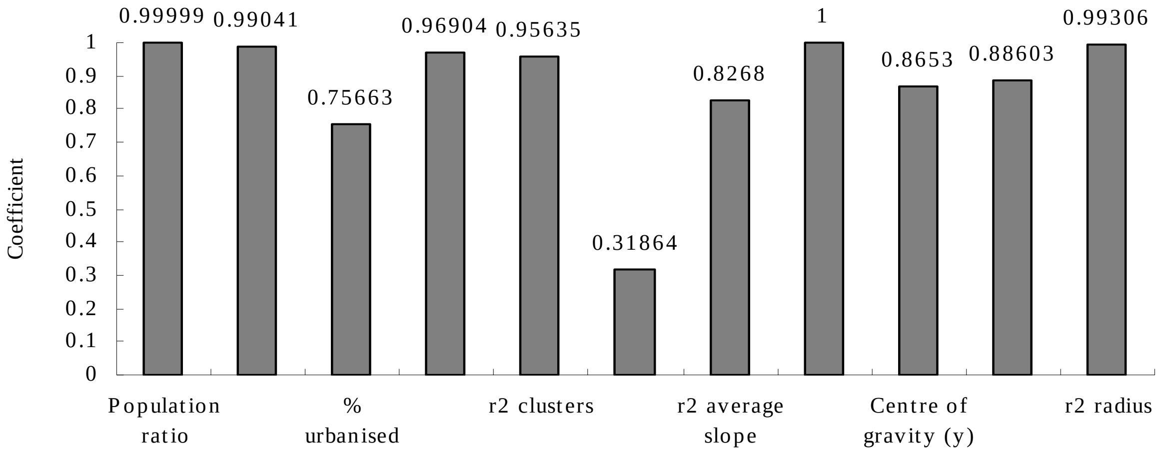



**Fig. 2. Statistics of the best fit parameters for modeling Gorgan City Expansion**

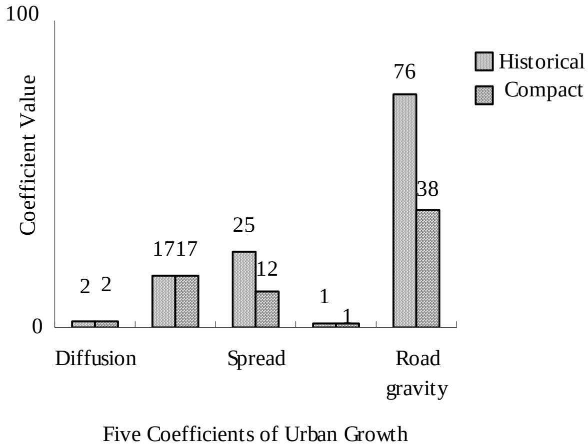



**Fig. 3. Best fit parameters for final calibration.**

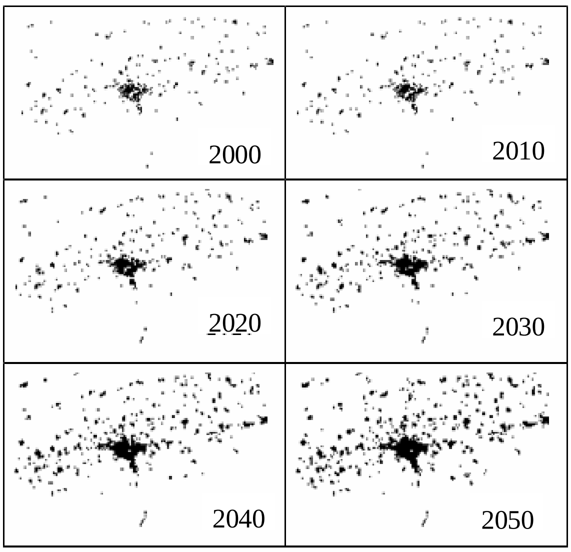



**Fig. 4. Simulated urban growth of Gorgan in historical scenario**

During final calibration, statistics were produced for best fit parameters for the Gorgan City. Some of the statistics are related to the 'amount' of growth experienced in the region (number of cells urbanized). These include the indexes *population ratio, $r^2$ population* and *%urbanized*. Other indices are mainly related to the 'shape' of the growth simulated by the model, such as *$r^2$edges*, *$r^2$clusters* and the *Lee-Sallee* index.

The resulting forecast of future urban growth was produced as a probabilistic map. In the map, each grid cell will be urbanized at some future date, assuming the same unique "urban growth signature" is still in effect as it was in the past, while allowing some system feedbacks termed self-modification. For both the back-cast and projected urban layers, a probability over 70% (given 100 Monte Carlo simulations) was used to consider a grid cell as likely to become urbanized. The final results of the model application were annual layers of urban extent for the historical time frame (1987–2001) and projected future urban growth (2002–2050).

## RESULTS & DISCUSSION

We conducted 5 Monte Carlo iterations for the coarse calibration of the model in 3124 runs which took around 15 hours on a Pentium 4 with 2 GHz CPU speed. For fine calibration, 8 iterations in 6479 runs were conducted taking around 15 hours on the same computer. The final calibration was done using 10 iterations in 2999 runs on the same computer that took around 9 hr.

Most of the statistics for best fit parameters of the simulation results of Gorgan present high values of fit, indicating the ability of the model to reliably replicate past growth (Fig 2). This suggests that future growth predictions can also be used with confidence. There was a high match for the amount of urban cells and clusters and the shape of urban edges between the simulated and control years (Fig. 2). It can be seen in Figure 2 that the slope has a low coefficient, translating into a small effect on the possibility of area becoming urban.

For the simulation of Gorgan city expansion, the final averaged parameters used in the prediction phase are presented in Figure 3. Each parameter in Figure 3 reflects a type of spatial growth. For Gorgan City, the diffusion coefficient is very low, which reflects a low likelihood of dispersive growth. The low value for the breed coefficient reinforces it, given low probability of growth of new detached urban settlements. The spread coefficient stimulates growth outwards of existing and consolidated urban areas. The high value of the road gravity coefficient denotes that the growth is also highly influenced by the transportation network, occurring along the main roads. Slope resistance affects the influence of slope to urbanization. In Gorgan area, topography was shown to have a very small effect in controlling the urban development, where even the hilly areas are likely to urbanize (Fig. 3). This was also clear in Figure 2 where the statistic of the parameter was found to be low. Inspection of the newly developed areas in the Gorgan City proved this to be reality.

Fig. 4 .illustrates the future urban form and extent of Gorgan City area according to the model simulation using the historical scenario. Looking at the Figure 4, managers and decision makers can easily find the locations where the city may increase and their corresponding intensities. This information is of great importance, as it gives the managers an upper hand in controlling the unwanted situations from happening.

Fig. 5. shows the extent of urban development over time for the two growth scenarios. Quite expectedly, the compact city scenario predicts a smaller increase for the future as compared to the historical scenario. However, the choices are open to the users to construct different scenarios and immediately assess their effects on the fate of the city. Modification of the driving parameters of city change, as defined in this study, can help in defining the best method for preventive measure in terms of feasibility and economy.

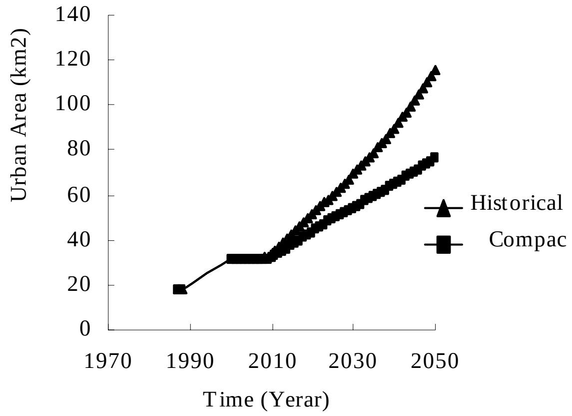



**Fig. 5. The area of city expansion for the two scenarios**

## CONCLUSION

Planning and management are based on generic problem solving. They begin with problem definition and description, and then turn to various forms of analysis, which might include simulation and modeling, and finally move to prediction and thence to prescription or design, which often involves the evaluation of alternative solutions to the problem (Batty and Densham, 1996). According to Rubenstein-Montano and Zandi (2000) modeling tools form the majority of approaches developed to assist decision-makers with planning activities and according to Leao *et al.*, (2001 and 2004), spatial modeling of urban growth permits systematic and formal studies of *possible future worlds* and provides a basis for the preparation and evaluation of urban policies.

Models allow the simulation of the real system, thus allowing the user to get a better insight into the actual decision domain and particular decision situations. They also allow the user to forecast alternative and comparable future states, and thus constitute an instrument to investigate the likelihood of a desired situation through experimentation. Spatial models of urban growth have the ability to play an important role in the planning process; if not in aiding in policy decisions, then in processes such as visioning, storytelling, and scenario evaluation (Dietzel and Clarke, 2006).

We successfully modeled the change in the extent of the Gorgan City using the SLEUTH method for the first time in Iran. The process was found feasible, considering the time, facilities and the background knowledge it requires. The results, although not tested thoroughly, were found very useful in terms of providing insight into the process of city change to the managers and decision makers. Using this information, the authorities can take preventive measures for controlling negative effects of the predicted change. They can also use the information for preparing the infrastructure required in near future and mitigate the unwanted changes through possible means. Using a combination of the past, present and future city sizes and their impact on the surrounding land use and land cover, information can be also compiled for other studies such as a proper cumulative effects assessment in the area.

## ACKNOWLEDGMENTS

We extend our appreciation for the support provided by the authorities of the Tarbiat university in funding the study and presenting its results at the International Journal of Environmental Research (IJER). Details of this research can be found in the website of University of California Santa Barbara with URL: http://www.ncgia.ucsb.edu/projects/gig/v2/About/gorgan_iran.htm

## REFERENCES

Acevedo, W., Foresman, T. W. and Buchanan, J. T., (1996). Origins and philosophy of building a temporal database to examine human transformation processes. Proceedings,ASPRS/ACSM Annual Convention and Exhibition, Baltimore, MD, **I**, 148–161.

Barredo, I. J., Kasanko, M., McCormick, N. and Lavalle, C., (2003). Modeling dynamic spatial processes: simulation of urban future scenarios through cellular automata. Landscape and Urban Planning, **64**, 145-160.

Batty, M., Longley, P. and Fotheringham, S., (1989). Urban growth and form: scaling, fractal geometry, and difusion-limited aggregation. Environ. Plan. A., **21**, 1447–1472.

Batty, M., Xie, Y. and Sun, Z., (1999). Modeling urban dynamics through GIS-based cellular automata. Computers, Environment and Urban Systems, **23**, 205-233.

Batty, M., (1994). A Chronicle of Scientific Planning: the Anglo-American Modelling Experience. J. Am. Plan. Assoc., **60** (1), 7–16.

Batty, M. and Densham, P. J., (1996). Decision support, GIS, and urban planning. Available at: http://www.geog.ucl.ac.uk/~pdensham/SDSS/s_t_paper.html

Batty, M. and Xie, Y., (1997). Possible urban automata. Environ. Plan., B., **24**,175-192.

Cecchini, A., (1996). Urban modelling by means of cellular automata: generalised urban automata with help on-line (AUGH) model. Environ. Plan. B., **23**, 721-732.

Clarke, K., Gaydos, L. and Hoppen, S., (1997). A self-modifying cellular automaton model of historical urbanisation in the San Francisco Bay area. Environ. Plann. B., **24**, 247-261.

Clarke, K. and Gaydos, L., (1998). Loose-coupling a cellular automaton model and GIS: longterm urban growth prediction for San Francisco and Washington/ Baltimore. Int. J. Geo. Inform. Sci., **12**(7), 699-714.

Dietzel, C. and Clarke, K., (2006). The effect of disaggregating land use categories in cellular automata during model calibration and forecasting. Computers, Environ. Urban Sys., **30**, 78-101.

Eastman, R. J., (2001). Guide to GIS and Image processing, Vo.2. Clark university, USA. 144.

Eastman, R. J., (2001). Idrisi 32, Release 2. Tutorial. Clark university, USA. 237.

Engelen, G., White, R., Uljee, I. and Drazan, P., (1995). Using cellular automata for integrated modelling of socio-environmental systems. Environ. Monitor. Assess., **34**, 203-214.

Engelen, G., White, R. and Uljee, I., (1997). Integrating constrained cellular automata models, GIS and decision support tools for urban planning and policy-making. Available at: http://www.citeseer.ist.psu.edu/371266.html

Herold, M., Goldstein, N. C. and Clarke, K. C., (2003). The spatiotemporal form of urban growth: measurement, analysis and modeling. Remote Sens. Environ., **86**, 286-302.

Leao, S., Bishop, I. and Evans, D., (2001). Assessing the demand of solid waste disposal in urban region by urban dynamics modeling in a GIS environment. Resources, Conservation and Recycling, **33**, 289-313.

Leao, S., Bishop, I. and Evans, D., (2004). Simulating urban growth in a developing nation's region using a CA-based model. Journal of Urban Planning and Development, **130**(3), 145-158.

Leao, S., Bishop, I. and Evans, D., (2004). Spatial-Temporal model for demand and allocation of waste landfills in growing urban region. Computers, Environ. Urban Sys., **28**, 353-385.

Lee, D., (1973). Requiem for large-scale models. J. Am. Inst. Plan., **39**, 163-178.

Lee, D., (1994). Retrospective on Large-Scale Models. J. Am. Inst. Plan., **60**(1), 35–44.

Li, X. and Yeh, A. G. O., (2000). Modelling sustainable urban development by integration of constrained cellular automata and GIS. Int. J. Geo. Info. Sci., **14**(2), 131-152.

Mahiny, A. S., (2003). A modeling approach to cumulative effects assessment for rehabilitation of remnant vegetation, PhD Thesis, SRES, ANU, Australia.

Phipps, M. and Langlois, A., (1997). Spatial dynamics, cellular automata, and parallel processing computers. Environ. Plan. B., **24**, 193-204.

Rubenstein-Montano, B. and Zandi, I., (2000). An evaluative tool for solid waste management. J. Urban Plan. Develop., **126**(3), 119-135.

Sembolini, F., (1997). An urban and regional model based on cellular automata. Environ. Plan. B., **24**, 589-612.

White, R. and Engelen, G., (1993). Cellular automata and fractal urban form: a cellular modelling approach to the evolution of urban land-use patterns. Environ. Plan. A., **25**, 1175-1199.

White, R. and Engelen, G., (1994). Cellular dynamics and GIS: Modelling spatial complexity.Geo. Sys., **1**(2), 237-253.

White, R. and Engelen, G., (1997). Cellular automata as the basis of integrated dynamic regional modelling. Environ. Plan. B., **24**, 235-246.

White, R., Engelen, G. and Uljee, I., (1997). The use of constrained cellular automata for highresolution modelling of urban land use dynamics. Environ. Plan. B., **24**, 323-343.

Wu, F., (1998). SimLand: a prototype to simulate land conversion through the integrated GIS and CA with AHP-derived transition rules. Int. J. Geo. Info. Sci., **12**(1), 63-82.

***Aims & Scopes***

*International Journal of Environmental Research* is a multidisciplinary journal concerned with all aspects of environment. In pursuit of these, environmentalist disciplines are invited to contribute their knowledge and experience. *International Journal of Environmental Research* publishes original research papers, research notes and reviews across the broad field of environment. These include but are not limited to environmental science, environmental engineering, environmental management and planning and environmental design, urban and regional landscape design and natural disaster management. Thus high quality research papers or reviews dealing with any aspect of environment are welcomed. Papers may be theoretical, interpretative or experimental.

# Instructions to Authors

## *Manuscript Submission*

Authors are requested to download the Copyright form and Covering letter web site http://ijer.ut.ac.ir/ Please send a completed and signed form either by mail or fax to the *International Journal of Environmental Research* Office. Manuscripts should be emailed to: ijer@ut.ac.ir. It should be noted that normal time for reviewing the submitted papers is about four weeks.

***Language***

The journal's language is English. British English or American English spelling and terminology may be used. We appreciate any efforts that you make to ensure that the language is corrected before submission. This will greatly improve the legibility of your paper if English is not your first language.

***Manuscript Presentation***

Manuscripts should be typewritten on A4 paper, with a font Times New Roman of 11 pt, one side only, leaving adequate margins on all sides to allow reviewers' remarks. Please double space all material. Number the pages consecutively with the first page containing:

**Running head (shortened title)**
**Title**
**Author(s)**
**Affiliation(s)**
**Full address** for correspondence, including telephone number, fax number and e-mail address.

***Text***

The text should include: Title, author(s) name and address, an abstract, key words, introduction, materials and methods, results and discussions, conclusion, acknowledgement and references.

***Abstract***

Please provide a short abstract of 100 to 250 words. The abstract should not contain any undefined abbreviations or references.

***Key words***

Please provide 5 to 7 key words.

***Notes***

Please avoid notes, but if any, use footnotes rather than endnotes. Notes should be indicated by consecutive superscript numbers in the text.

***Acknowledgements***

Acknowledgements of people, grants, funds, etc. should be placed in a separate section before the References.

***References***

All publication cited in the text should be presented in the list of references following the text of the manuscript. In the text refer to the authors' name (without initials) and year of publication (e. g. Williams, 2004). For three or more autours use the first autour followed by *"et al.,"* in the last. The list of references at the end of the manuscript should be arranged alphabetically authors' names and chronologically per author: The list of references should be given in the following style:

**1. Journal article:**

Karbassi, A. R. & Amirnezhad, R. (2004). Geochemistry of heavy metals and sedimentation rate in a bay adjacent to the Caspian Sea. Int. J. Environ. Sci. Tech., v.1, No.3, pp. 199-206.

**2. Book chapter:**

Cutrona, C. E. & Russell, D. (1990). Type of social support and specific stress: Towards a theory of optimum matching. (In I.G. Sarason, B. R. Sarason, & G. Pierce (Eds.), Social support: An interactional view (pp. 341-366). New York: Wiley.)

**3. Book, authored:**

Capland, G. (1964). Principles of preventive psychiatry. (New York: Basic Books)

**4. Book, edited:**

Felner, R. D., Jason, L. A., Moritsugu, J. N. & Farber, S. S. (Eds.) (1983). Preventive psychology: Theory, research and practice. (New York: Pergamon Press)

**5. Paper presented at a conference:**

Phelan, J. C., Link, B. G., Stueve, A. & Pescosolido, B. A. (1996, November). Have public conceptions of mental health changed in the past half century? Does it matter? (Paper presented at the 124$^{th.}$ Annual Meeting of the American Public Health Association, New York)

**6. Dissertation:**

Trent, J.W. (1975) Experimental acute renal failure. Dissertation, University of California

**7. Internet publication/Online document**

**7.1. Internet articles based on a print source**

VandenBos, G., Knapp, S. & Doe, J. (2001). Role of reference elements in the selection of resources by psychology undergraduates [Electronic version]. J. Bibliog. Res., 5, 117-123.

VandenBos, G., Knapp, S., & Doe, J. (2001). Role of reference elements in the selection of resources by psychology undergraduates. J. Bibliog. Res., 5, 117-123. Retrieved October 13, 2001, from http://jbr.org/articles.html

**7.2. Article in an Internet-only journal**

Fredrickson, B. L. (2000, March 7). Cultivating positive emotions to optimize health and well-being. Prevention & Treatment, 3, Article 0001a. Retrieved November 20, 2000, from http://journals.apa.org/prevent/vol3/pre03.html.

***Figures***

All photographs, graphs and diagrams should be referred to as a 'Figure' and they should be numbered consecutively (1, 2, etc.). Multipart figures ought to be labeled with lower case letters (a, b, etc.). Please insert keys and scale bars directly in the figures. Provide a detailed legend (without abbreviations) to each figure, refer to the figure in the text and note its approximate location in the margin. Only black and white figures must be submitted. The resolution of figure must at least be 300 dpi. Figures that are prepared by excel should be send along with their source of data.

***Tables***

Each table should be numbered consecutively (1, 2, etc.). In tables, footnotes are preferable to long explanatory material in either the heading or body of the table. Such explanatory footnotes, identified by superscript letters, should be placed immediately below the table. Please provide a caption (without abbreviations) to each table, refer to the table in the text and note its approximate location in the margin. The same data should not be presented simultaneously in tables and figures.

***Proofs***

Proofs will be sent to the corresponding author by e-mail (if no email address is available or appears to be out of order, proofs will be sent by regular mail). Your response, with or without corrections, should be sent within 72 hours.

***Copyright***

Authors will be asked, upon acceptance of an article, to transfer copyright of the article to the Publisher. This will ensure the widest possible dissemination of information under copyright laws.

The submitted materials may be considered for inclusion but can not be returned.

***Additional Information***

Additional information can be obtained from:

*International Journal of Environmental Research*

P.O. Box: 14155-6135
University of Tehran
Graduate Faculty of Environment
E-mail: ijer@ut.ac.ir
http://ijer.ut.ac.ir
Tel: +9821 61113188
Fax: +9821 66407719

# Copyright Transfer Agreement

**1-Parties of the Agreement**

**Author (Co-authors)**

---

Title of the manuscript

---

(hereinafter referred to as the “Materials”),
**Journal title**

“International Journal of Environmental Research (IJER) ”

**2. Subject of the Agreement**

**A.Copyright**
**1**. The Author (and each Co-author) shall transfer and sell to the Publisher for the length of the copyright starting from the moment the present Agreement comes into force the exclusive rights to the Materials, including the rights to translate, reproduce, transfer, distribute or otherwise use the Materials or parts (fragments) contained therein, for publication in scientific, academic, technical or professional journals or other periodicals and in derivative works thereof, worldwide, in English, in print and electronic editions of such journals, periodicals and derivative works in all media or formats now existing or that may exist in the future, as well as the right to license (or give permission to) third parties to use the Materials for publication in such journals, periodicals and derivative works worldwide.
The transfer under this Agreement includes the right to adapt the presentation of the Materials for use in conjunction with computer systems and programs, reproduction or publication in machine-readable format and incorporation into retrieval systems.
**2**. Reproduction, placement, transfer or any other distribution or use of the Materials, or any parts of the Materials contained therein, in any way permitted under this Agreement, shall be accompanied by reference to the Journal and mention of the Publisher, namely: the title of the article, the name of the Author (Co-authors), the name of the Journal, volume/number, copyright of the publisher.

**B.Reserved Rights**
The Author (Co-authors) or the employer of the Author (Co-authors) of the Materials shall retain all proprietary rights (with the exception of the rights transferred to the Publisher under the present Agreement).

**C.Author’s Guarantee**
The Author (Co-authors) guarantees that the Materials are an original work, submitted only to IJER, and have not been published previously.
In case the Materials were written jointly with Co-authors, the Author guarantees that he has informed them of the terms of this Agreement and obtained their signatures or written permission to sign on their behalf.
The Author guarantees as well that:
The Materials do not contain libelous statements.
The Materials do not infringe on other persons’ rights (including without limitation copyrights, patent rights and the trademark right).
The Materials do not contain facts or instructions that can cause damage or injury to third parties and their publication does not cause the disclosure of any secret or confidential information.

## AUTHOR

---

(Last Name, First Name, Official Position)
Correspondence Address ______________________________________________________
Phone ______________________________
E-mail ______________________________

______________________________ ________________
(Signature) (Date)

**ON BEHALF OF THE PUBLISHER**
Graduate Faculty of Environment, University of Tehran
No. 23, Ghods St, Enghelab Ave., Tehran-Iran
P.O.BOX.14155-6135
Tel: +98 21 61113188 Fax: +98 21 66407719
E-mail: ijer@ut.ac.ir
Web: http://ijer.ut.ac.ir

---

**(Last Name, First Name, Official Position)**

**Accepted for publication**

**(Signature)** **(Date)**

---

**INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESERACH (IJER)**
**is indexed and abstracted in the bibliographical databases including:**

Index Copernicus (IC); Poland
http://www.indexcopernicus.com/index.php

IC Journals is a journal indexing, ranking and abstracting site. This service helps a journal to grow from a local level to a global one as well as providing complete web-based solution for small editorial teams. IC Journals helps to professionally manage your journal from your location and automatically delivers XML files to Medline. This service accepts, peer-review and tracks manuscripts online and builds up relations with authors, reviewers and readers as well as increasing the international awareness of a journal.

Bioline international; Canada
http://www.bioline.org

Bioline International is a not-for-profit electronic publishing service committed to providing open access to quality research journals published in developing countries. BI's goal of reducing the South to North knowledge gap is crucial to a global understanding of health (tropical medicine, infectious diseases, epidemiology, emerging new diseases), biodiversity, the environment, conservation and international development. With peer-reviewed journals from Brazil, Cuba, India, Indonesia, Kenya, South Africa, Uganda, Zimbabwe and more to come, BI provides a unique service by making bioscience information generated in these countries available to the international research community world-wide.

Cambridge Scientific Abstracts (CSA); USA
http://www.csa.com

CSA is a worldwide information company, serving as a guide to researchers to help them be more effective in their work by enabling and expediting discovery, aiding the management and organization of quality information and providing tools to assist in its subsequent dissemination. CSA specializes in publishing and distributing, in print and electronically, 100 bibliographic and full-text databases and journals in four primary editorial areas: natural sciences, social sciences, arts & humanities, and technology. A privately held company, CSA is headquartered in Bethesda, Maryland, with offices throughout the U.S., as well as in Australia, Hong Kong, Japan, Europe, Latin America and the United Kingdom. Researchers in more than 4,000 institutions worldwide use CSA information resources, and CSA's print journals are used in more than 80 countries. CSA has been a leader in publishing and providing quality abstracts and indexes and an innovator in the information field for over 30 years.

Magiran; Iran
http://www.magiran.com

MagIran.com is the one site for all Iranian magazines. Find your favorite magazines and view published numbers, table of contents and papers.

Scientific Information Database (SID); Iran
http://www.sid.ir

Regarding the every day enhancement of the requirements for research , the growth of scientific production at universities and research center of Iran , and the necessity of instant access to scientific source , it is tangible to develop scientific database in Iran. Accordingly, Scientific Information Database (SID) of Academic Center for Education, Culture and Research in August 7, 2004, was commenced. SID intends to provide intensive resource for university professors, students and researchers.