http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet

Asian Network for Scientific Information

308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 10 (10): 1649-1654, 2007
ISSN 1028-8880

Assessment of Change in Soil Water Content Properties Irrigated with Industrial Sugar Beet Wastewater

[1]Sayyed Hassan Tabatabaei, [2]Payam Najafi and [3]Hussein Amini
[1]Department of Water Engineering, Faculty of Agriculture,
Shahrekord University, Shahrekord, Iran
[2]Department of Soil Science, Faculty of Agriculture,
Khorasgan Azad University, Isfahan, Iran

Abstract: In this research the effect of industrial sugar beet wastewater has been assessed on the soil water content properties in summer 2005. The evaluated parameters were the soil water content points such as Saturation Percent (SP), Field Capacity (FC), Permanent Wilting Point (PWP), gravitational water and Total Available Water (TAW). The pilot design was fully randomized with three replications and three treatments. The three treatments were: 1-normal water, 2-industrial sugar beet wastewater (50%) and normal water (50%) and 3-sugar beet wastewater (100%). The experiments have been carried out in the field, in 21 columns with the diameter 110 mm and the height of 400 mm. The soil was irrigated using surface irrigation method for 12 events with a constant volume and period. Based on the result, the SP, FC and PWP initial value were 46.5, 35 and 15%, respectively for all the treatments. At the end of the period, the values changed to 47, 36.6 and 17.5% for T_2. They are also increased significantly to 48.5, 37 and 18.7% for T_3 at the end of the period. The increasing of soil Organic Matter (OM) during the period is expected to be the main factor for this change. The result shows that although the FC and PWP parameters are increased during the period but TAW decreased significantly from the 20 to 18.5%. The other effects of wastewater on soil and leached water quality should be evaluated too.

Key words: Irrigation, industry wastewater, sugar beet factory, soil water content, FC, PWP, TAW

INTRODUCTION

The first use of wastewater was reported in Banzelo, Germany, in 1531 and in Edinburgh, Scotland in 1650. In the early of the 20th century most of the countries started to use wastewater. In Palestine more than 70 percent of wastewater was used for agricultural irrigation (Abedi and Najafi, 2001). Nearly, 60 percent of total volume of wastewater in California (432 Mm^3) was used for agricultural irrigation too (Tavakoli and Tabatabaei, 1999). In many cities of Iran, municipal wastewater is used for agricultural irrigation. For instance, the water of the Firuzabad canal in Tehran in which a significant part of the municipal and industrial waste is disposed, widely used for irrigation of fruit and vegetables. Of the 9700 hectares of the cultivable lands of Tehran, almost 6900 hectares (nearly 70%) are irrigates with wastewater. It has been reported that in Shiraz, in arid seasons the main discharge of the river is wastewater which is ultimately used in agriculture. In Tabriz, municipal and industrial wastewater enters the Ajichai River and is ultimately used for agricultural irrigation. (Tabatabaei and Liaghat, 2004). Wastewater sludge is also uses as a fertilizer in agricultural lands. The application of wastewater and sludge in agricultural land generates numerous sanitary problems (Abedi and Najafi, 2001). Czyzyk (1996) in his research reported that wastewater irrigation has a significant effect on the groundwater contamination level. Lauver (2000) has evaluated nitrate contamination of the groundwater of Arizona using volume balance approach in the agricultural lands in which wastewater is used for irrigation. He reported that the quality of groundwater contamination potential is increased when uncontrolled amount of wastewater is used for irrigation. Sharmasarkar *et al.* (2000) has evaluated the nitrate plume in the soil of the sugar beet filed irrigated by wastewater.

When wastewater is continuously used for irrigation, some changes are expected to happen in soil infiltration. The most important index for evaluation of the change are Sodium Adsorption Ratio (SAR), Electrical Conductivity (EC) and Total Dissolved Solid (TDS). Tavakoli and Tabatabaei (1999) reported that the three indexes should

Corresponding Author: Sayyed Hassan Tabatabaei, Department of Water Engineering, Faculty of Agriculture, Shahrekord University, P.O. Box 115, Shahrekord, Iran Fax: +98-381-442-4428

be considered synchronal in evaluation of soil infiltration change. The acceptable range of SAR and EC in the irrigation with wastewater is presented by world health organization (WHO) in 1989. In general, irrigation water salinity makes the soil saline and hard and decreases crop yield. So the salinity effect must be considered in advance base on the sort of the soil, climate and crop (Tavakoli and Tabatabaei, 1999). Zadhoush (1998) evaluates the effect of wastewater both on physical and chemical properties of the soil and on the crop of the lands in northern parts of Isfahan.

The effect of wastewater on soil, subsurface water and plants completely depend on the type of the wastewater and its content. Industrial sugar beet wastewater has special effects on soil because of its special content.

There is no reference evaluating the effect of the wastewater in irrigation on the physical properties of the soil. A large number of lands in the eastern parts of Isfahan are irrigated with a large amount of industrial sugar beet wastewater. Several years ago, farmers started to use industrial wastewater for irrigation because of the drought season and scarcity of water. The crops of these lands were Alfalfa, grass and sugar beet.

The objective of this research is evaluation of the change in the important content properties of the soil irrigated with industrial sugar beet wastewater. These properties are Saturation Percent (SP), Field Capacity (FC), Permanent Wilting Point (PWP), Gravitational Water Content (GWC) and Total Available Moisture (TAM).

MATERIALS AND METHODS

Material: To evaluate the effect of the industrial sugar beet waste water on the physical properties of the soil water content, an experiment was carried out in Khorasgan Azad University in Isfahan, Iran in the summer 2005. The soil texture was clay-loam and the soil initial conditions were measured as Table 1. The irrigation water analysis is presented in Table 1, too.

The experiment was conducted in 21 columns of soil as shown in Fig. 1. The columns made by PVC with the diameter of 110 and the height of 400 for each. The first 50 mm part of the column in the lower part was filled with a sand filter, the next 250 mm with soil and the next 50 mm with sand filter. The other remained 50 mm was used for irrigation. The columns of soil are exposed to wastewater using the surface irrigation method during seven interval days. The total numbers of irrigation events was 12 and the volume of the wastewater irrigation was 1.2 L.

The experiment is statistically designed fully randomized with three treatments and three replications. The three treatments were T_1, T_2 and T_3. Soil and water analysis were conducted in three steps of irrigation. Table 2 shows the treatment description and sampling time.

Table 1: Soil properties of the experiment filed

Soil texture	$CaCO_3$	SAR (%)	Organic matter (%)	pH (%)	EC (dS m^{-1})	Bulk density (g cm^{-3})
Clay-loam	67.36	4.35	0.93	7.87	2.63	1.38
Irrigation water	-	1.25	-	8.68	0.65	-
Sugar beet	-		-			-
Waste water		7.85		7.84	2.95	

Table 2: Treatment description and sampling time

	Sampling time			
Treatments	1	(Irrigation event 1)	2 (Irrigation event 6)	3 (Irrigation event 12)
Irrigation water (T_1)	T_1	T_{11}	T_{12}	T_{13}
50% water + 50% wastewater (T_2)	T_2	T_{21}	T_{22}	T_{23}
100% wastewater (T_3)	T_3	T_{31}	T_{32}	T_{33}

Table 3: Physical and chemical analysis of soil and chemical analysis of water

Row	Test name	Analysis methods	Classification	Test references
1	Soil texture	Hydrometery	Physical test	(Lee and Bauder, 1986)
2	Bulk density	Clod	Physical test	(Klute, 1986)
3	Aggregate stability	Flotation	Physical test	(Baybordi, 1996)
4	Saturation percent	Saturation method	Physical test	(Lee and Bauder, 1986)
5	Filed capacity	Pressure plate	Physical test	(Lee and Bauder, 1986)
6	Permanent wilting point	Pressure plate	Physical test	(Lee and Bauder, 1986)
7	Electrical conductivity	EC meter	Chemical test	(Page, 1991)
8	Organic matter	Cold oxidation	Chemical test	(Nelson and Sommers, 1987)
9	pH	pH meter	Chemical test	(Page, 1991)
10	$CaCo_3$	Titration with HCl	Chemical test	(Zarrin-Kafsh, 1995)
10	Mg	Titration with EDTA	-	(Klute, 1986)
10	Na	Flame Photometer	-	(Page, 1991)
10	Ca	Titration with EDTA	-	(Klute, 1986)

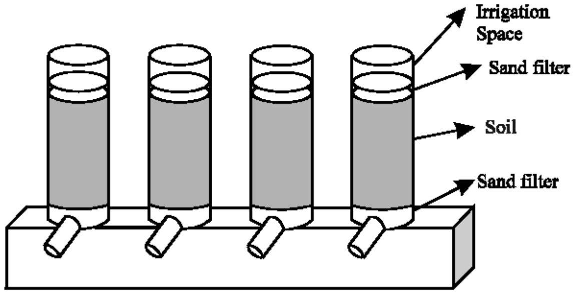

Fig. 1: Setup of the experiments

Method: In any sampling time of the research (Table 2), both physical and chemical analyses were conducted on soil and just chemical analysis was conducted on the wastewater. The list and analyses of the physical and chemical properties of the soil analysis are presented in Table 3. Table 3 shows the chemical analysis of the wastewater, too.

The first three columns of soil are selected randomly for the tests of the initial condition. Other nine columns are used for the second steps of the analysis. Other remained columns are also used for final tests. The analysis of the soil is conducted on the disturbed soil.

RESULTS AND DISCUSSION

This research has been carried out to evaluate the effect of industrial sugar beet wastewater on the content properties to the soil during 12 events of irrigation. Figure 2 shows the Saturation Percent (SP) in three steps and three treatments. The SP value in the beginning of the test was 46% and it was the same for all the treatment, because the tests are carried out in the same condition. The SP value is increased during the irrigations events for all of the treatments. Table 4 shows the statistical analysis of the data in the initial conditions compared with the final conditions using a t-test value and a Duncan test. Table 4 shows that there no significant difference of SP value (less than 5%) between all the treatments. All the treatments are categorized in one group in Duncan test.

In the chemical analysis of the soil such as SAR, pH, EC, there is no significant variation during irrigation events (Table 4). It means that the change of SP may not affected by the soil chemical properties. The Organic Matter (OM) of the soil is also tested because it can affect the properties of the soil. Figure 3 shows the OM value in the test.

The analysis of the wastewater shows that there is OM existing in the wastewater which can increases the OM in the soil. Table 4 shows that OM is not increased significantly during the test period. It can conclude that the experiment period (12 events) should be longer to

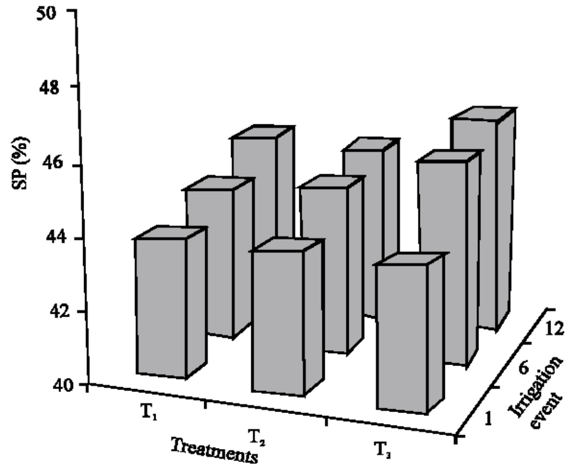

Fig. 2: Saturation Percent (SP) in the treatments of experiment (%)

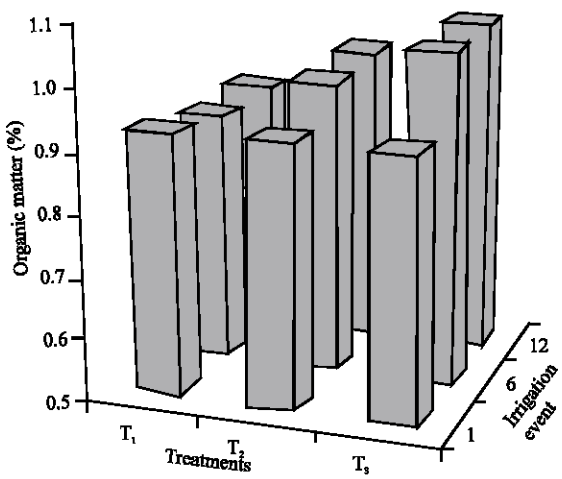

Fig. 3: Organic Matter (OM) in the treatments of experiment (%)

make the variation significant. So in case that the numbers of events is increased the level of significantly will be decreased. It means that if irrigation with the wastewater continues for more than several years, it will cause some significant changes in the OM of the soil and probably in the SP. The Bulk Density (BD) is also evaluated as another parameter which is illustrated in Fig. 4. There is no considerable in BD during the irrigation period. Although no change was observed in T_3 and it was constant during the irrigation. Tabatabaei *et al.* (2004) report that irrigation will also increases BD. It can be concluded that in T_3 increasing of OM has prevented increasing of BD in the soil.

Figure 5 and 6 show Field Capacity (FC) and Permanent Wilting Point (PWP) of the soil, respectively. The FC and PWP is seen to be greater in

Table 4: Statistical analysis of data base on T and Duncan test

Parameter	SP	EC	pH	SAR	OM	Bd	FC	PWP	SP-FC	FC-PWP
Initial value	43.87	2.63	7.87	4.35	0.93		34.95	15.00	8.92	19.95
T_{11}	0.99[a]	0.98[a]	0.99[a]	0.42[a]	0.90[a]	*	1.00[a]	1.00[a]	0.99[a]	1.00[a]
T_{12}	0.66[a]	0.82[a]	0.97[a]	0.41[a]	0.75[a]	*	0.225[a]	0.049[b]	0.71[a]	0.025[b]
T_{13}	0.39[a]	0.77[a]	0.97[a]	0.39[a]	0.66[a]	*	0.049[b]	0.023[b]	0.46[a]	0.019[b]
T_{21}	0.99[a]	0.98[a]	0.99[a]	0.42[a]	0.90[a]	*	1.00[a]	1.00[a]	0.99[a]	1.00[a]
T_{22}	0.24[a]	0.70[a]	0.70[a]	0.39[a]	0.45[a]	*	0.002[b]	0.002[b]	0.71[a]	0.006[b]
T_{23}	0.15[a]	0.70[a]	0.79[a]	0.42[a]	0.29[a]	*	0.029[b]	0.000[b]	0.54[a]	0.105[b]
T_{31}	0.99[a]	0.98[a]	0.99[a]	0.42[a]	0.90[a]	*	1.00[a]	1.00[a]	0.99[a]	1.00[a]
T_{32}	0.11[a]	0.99[a]	0.66[a]	0.44[a]	0.27[a]	*	0.002[b]	0.003[b]	0.61[a]	0.019[b]
T_{33}	0.018[a]	0.86[a]	0.55[a]	0.48[a]	0.22[a]	*	0.005[b]	0.001[b]	0.90[a]	0.025[b]

*no replication; [a,b]Duncan level

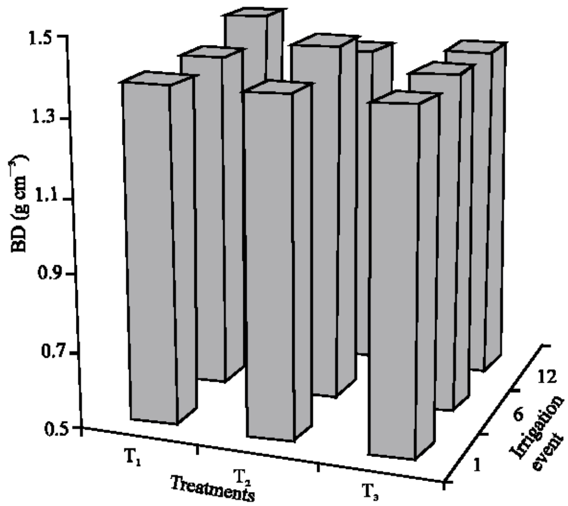

Fig. 4: Bulk Density (BD) in the treatments of experiment (g cm^{-3})

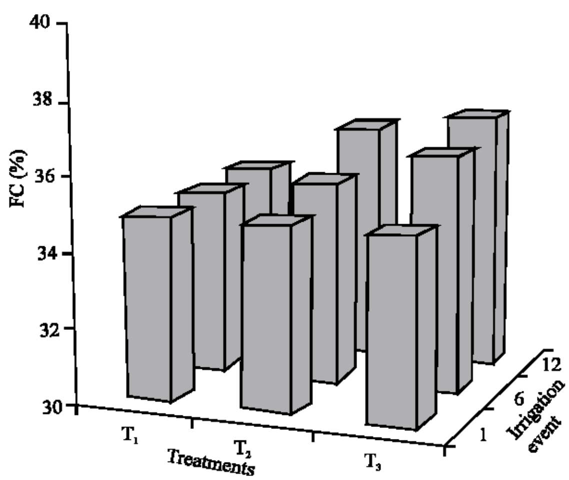

Fig. 5: Filed Capacity (FC) in the treatments of experiment (%)

T_3 rather than in T_2 and T_1 and it is same for SP. Table 4 shows that the variation of FC and PWP is significant during 12 irrigations in 1% level. It can also be concluded that increasing of OM in the soil also

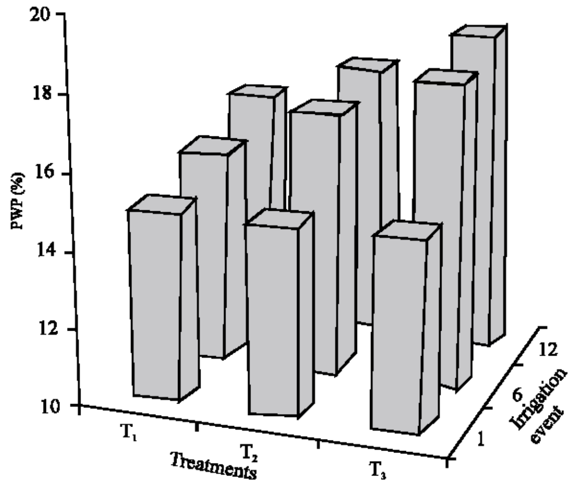

Fig. 6: Permanent Wilting Point (PWP) in the treatments of experiment (%)

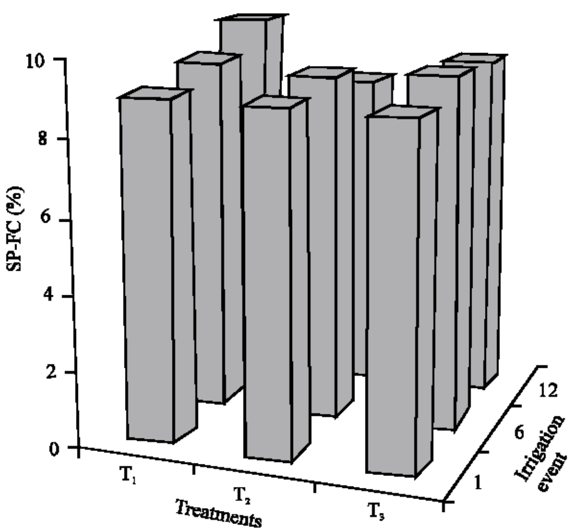

Fig. 7: Gravitational water (GW or SP-FC) in the treatments of experiment (%)

increases the FC and PWP, because of irrigation with the wastewater. As the rate of FC and PWP is low in the

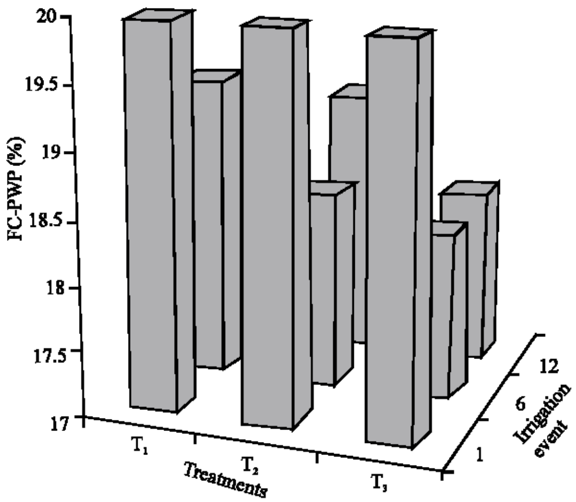

Fig. 8: Total available water (TAW or FC-PWP) in the treatments of experiment (%)

light soils (sandy, sandy-loam) irrigation with the wastewater will improve soil water content properties in these points.

During irrigation, the SP of the soil is increased at first and then it starts to be decrease. FC is also increased. Figure 7 shows the GW in the T_1, T_2 and T_3. Table 4 shows that the GW isn't varied significantly during the experiment time, although the FC changes significantly. The Duncan test shows that the GW is categorized in one group and confirms the least result.

A very important soil water content parameter is Total Available Water (TAW). This parameter is different from FC and PWP. Figure 8 shows the TAW value in the experiment. The TAW is decreased during the experiment significantly in T_2 and T_3. Actually it is not like FC and PWP, because their values have been increased but TAW is decreased. It can be conclude that although the FC and PWP has been increased but the rate of increasing in PWP was greater than FC. It means the increasing of OM level in the soil has changed the soil moisture characteristic curve.

In brief irrigation with the wastewater decreases the available water for the plants. Consequently irrigation with the wastewater decreases the irrigation intervals and farmers must irrigate the farm in more events for the same yield. This could be considered as an undesirable effect of the wastewater irrigation. It is clear that the other effects of the wastewater on soil should be evaluated.

ACKNOWLEDGMENT

We would like to express our appreciation to Khorasgan Azad University for financial support of this research project. The authors wish to thank Mr. Karimzadeh, Mr. Massoudi and Mr. Shahnavazi for their assistant in the filed work.

REFERENCES

Abedi, M. and P. Najafi, 2001. Use of Treated Wastewater for Irrigation. Iranian National Committee on Irrigation and Drainage Press.

Baybordi, M., 1996. Soil Physics. 5th Edn. Tehran University Press.

Czyzyk, F., 1996. Effect of long-term irrigation with municipal wastes on subterranean. Zeszyty-Naukowe-Akademii-Rolniczey-We-Wroclawiu.-Konferencye (Poland), 293: 33-41.

Klute, A., 1986. Methods of Soil Analysis, Part I. Physical and Mineralogical Methods. (2nd Edn.), Agro. Monger. 9, ASA and SSSA, Madison, WS, USA. pp: 1189.

Lauver, L., 2000. Nitrogen mass balance for municipal wastewater. Practice periodical of Hazardous, Toxic and Radioactive Waste Manage., 4: 36-38.

Lee, G.W. and J.W. Bauder., 1986. Particle Size Analysis. In: Methods of Soil Analysis, A. Klute (Ed). Part 1 (2nd Edn.) Agro. Monger. 9, ASA and SSSA, Madison, WS, USA., pp: 383-411.

Nelson, D.W. and L.E. Sommers, 1987. Total Carbon, Organic Carbon and Organic Matter. In: Methods of Soil Analysis. Page, A.L., R.H. Miller and D.R. Keeney (Eds.). Part 2- Chemical and Microbiological Properties (2nd Edn.), Agronomy, 9: 539-577.

Page, A.L, 1991. Methods of Soil Analysis. (2nd Edn.), ASA and SSSA, Madison, WS, USA.

Sharmasarkar, S., F. Cassel, R. Zhang, G.F. Vance, S.D. Miller and M.J. Reddy, 2000. Modeling Nitrate Movement in sugar beet soil under flood and Drip Irrigation. ICID J., 49: 43-54.

Tabatabaei, S.H. and A. Liaghat, 2004. Use of Zeolite to control heavy metals in municipal wastewater applied for irrigation. Japanese J. Ion Exchange, Japanese Association of Ion Exchange Press Vol. 15, No. 2 (http://www.jaie.gr.jp/index.html).

Tabatabaei, S.H., H. Fardad, M.R. Neyshabory and A. Liaghat, 2004. Simulation model for seasonal variation of infiltration equation in heavy soils with two crop residue managements, International Soil Congress (ISC) on Natural Resource Management for Sustainable Development to be held in Erzurum-Turkey, in June 7-10, 2004 (http://www.toprak.org.tr).

Tavakoli, M. and M. Tabatabaei, 1999. Irrigation with treated wastewater. Proceeding of the Conference on Environmental Effect of Using Wastewater on Irrigation, Iranian National Committee on Irrigation and Drainage Press, No. 28.

WHO., 1989. Health guideline for the use of wastewater in agriculture. Technical report No. 778, WHO, Geneva. Italy.

Zadhoush, A., 1998. Evaluation of irrigation with north Isfahan wastewater treatment plant on agricultural crop, M.Sc. Thesis, Department of Irrigation, Faculty of Agriculture, University of Tehran.

Zarrin-Kafsh, M., 1995. Applied Soil Science, Tehran University Press.