Cumhuriyet Üniversitesi Fen Fakültesi
Fen Bilimleri Dergisi (CFD), Cilt:36, No: 3 Özel Sayı (2015)
ISSN: 1300-1949

Cumhuriyet University Faculty of Science
Science Journal (CSJ), Vol. 36, No: 3 Special Issue (2015)
ISSN: 1300-1949

The Effect of Compost on Release and Transport of Heavy Metals (Zn, Cu) in Soil

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Received: 01.02.2015; Accepted: 05.05.2015

Abstract. The present study is aimed to examine the effect of consuming compost on transportation of copper and zinc in soil. There were four compost treatments and heavy metals (zinc and copper) and two control treatments (one compost soil and other compost-free soil) as a completely random design. The runoff every time was taken and determined the concentrations of copper and zinc, EC and pH. The results show that the concentration of zinc and copper during 12 times of leaching showed significant difference at %1. The treatment No.4 has the maximum Zn concentration in output runoff (3.3 mg/lit) having the highest added zinc in compare with the other treatments. The control treatment No.2 had the maximum copper concentration (0.1 mg/lit). The treatment No.1 had the minimum copper concentration, and despite the added copper (290 mg/lit) to the mixture of soil and compost, little copper transported in soil. Also pH and EC have significant difference (%1) during 12 times of leaching.

Key words: Zinc, Copper, Concentration, Runoff

1. INTRODUCTION

Soil as an irreplaceable natural resource is being destroyed and this process ultimately has been led to decrease in agricultural productions [12]. Contamination of soil resources is very important as it is close relationship with human nutrition and its direct interference in production in terms of environment and community health aspects [2]. Improper uses of water and soil resources are amongst major environmental issues in present era. The contaminants are considered as environmental destructives, and amongst them, heavy metals have been considerable due to their non-degradable and physiological effects on organism at low concentrations[11]. The main effect of heavy metals is their role in lowering soil quality. Reduced microbial biomass, decreasing the number of viable bacteria, preventing mineralization of soil organic matter and weakening soil decomposition are amongst the effects of heavy metals[4].Composting is an effective way to recycle solid organic wastes to nutrient-rich fertilizers. Many wastes such as straw, leaves, mud, agricultural fertilizers, animal waste and alike are suitable for composting. Since biological compost is more suitable for plants and soils and has more compatibility than chemical fertilizers, in fact, it is a perfect choice for processing solid waste[3]. Widespread distribution of heavy metals in soil, water and atmosphere has caused the raw materials used to produce compost as plant straw, animal manure, sewage sludge, home waste and agricultural fertilizers to be sources of heavy metal pollution. The contents of heavy metals in compost change in parts per million issue due to intense development of agriculture and industry in many parts of the world[13]. The results of a study

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Special Issue: The Second National Conference on Applied Research in Science and Technology

show that the surface absorption of copper and has less association with the amount of clay and organic matter[8]. Many factors could affect the movement or concentration of heavy metals. The movement of heavy metals is limited in lime soils and soils with high Fe and AL. Ionic exchange between heavy metals and soil particles could lead to change in pH which could affect the movement of heavy metals. Dissolved organic matter in the soil or compost is an important factor which affects the movement of heavy metals. Polarity change in dissolved organic matter could lead to high leaching of heavy metals or avoiding the movement of heavy metals in soil [3]. Numerous properties such as pH, CEC, amount of organic matter, nature and clay all affect the chemical behavior of metals in soil [1]. Mismanagement of sewage and compost discharge in different targets in soil has undesirable consequences such as contamination of water sources especially ground waters, soil and plant [5]. The present research is aimed to examine the effect of consuming composite organic fertilizer on release and transfer of zinc and copper in soil and ground water and determine the amount of leaching and examine the pH changes and EC in leaching runoff of soil columns.

2. METHODS

The present research implemented in the Research Greenhouse of Agriculture School of Khorasgan Islamic Azad University, 20 km far from northeast of Isfahan within 51˚40´ E longitude and 32˚40´ N altitude. The area had dry and hot weather, average annual rainfall of 100 mm and annual evaporation of 2000 mm. The samples were collected from Heydarabad area, 10 km east of Isfahan, south Baraan (Zayanderud riverbank) (ppm) or parts per thousand (ppt) sizes[3]. Soil contamination has been turned to an environmental lead had more associated with the alkaline saturation percentage of soil and then it has and average association with pH and cation exchange capacity and There were four treatments of organic fertilizers of compost, zinc and copper used in the present research as follow:

Treatment 1: Compost with 290 mg/kg copper soil

Treatment 2: Compost with 1160 mg/kg copper soil

Treatment 3: Compost with 290 mg/kg copper and zinc soil Treatment 4: Compost with 1160 mg/kg copper and zinc soil And there were also two control treatments one was soil with compost and the other soil without compost carried out in three tries to determine the effect of consuming compost organic fertilizer on different zinc and copper forms in soil as a completely random statistical plan.

3. IMPLEMENTATION

For testing, as Fig (1) shows, in total 18 high pressure propylene columns were provided (100 mm internal diameter and 600 mm height) and metal tables were used to erect and stabilize the columns. Also a pore (1 cm in diameter) was chosen in order to prevent obstruction of the distal part of the column. It was used plastic nets with pores (20 microns in diameter) to avoid losing soil particles and compost during leaching [3].

Figure 1. Propylene pipes.

A pit (0.8 sq. m area and 1 m depth) provided to fill in the soil columns in the given area. After sampling three depths (0-20 cm), (20-40 cm) and (40-60 cm), the samples was first air-dried and then passed through a sieve (having pores 2mm in diameter). Separating too large particles provides greater uniformity of soil. Too large pores also provide the preferential flow in soil columns then the soil required to fill the columns was calculated in natural conditions considering the bulk density of soil and was added without any special dense operations. It was poured about 5 cm of sand at the end of columns before the addition of soil.

The compost mixed with the soil surface was considered about 5% soil surface volume. First the compost was air-dried and crashed in 20 mm pieces with a plastic granulator. The mass of compost added to soil surface (considering the bulk density) was 47.1 gram. With compost weight at 47.1 gr per column, specific amount of zinc and copper were added in four treatments. Heavy metals were sprayed to compost as Cu (NO3)2 and Zn (NO3)2 which is the most reliable way to mix metals with compost uniformly. Once the metals was added to compost, the contaminated.

4. RESULTS AND DISCUSSION

Compost was maintained for one week to form clot in lab environment and then mixed with 5 cm of soil surface. Demineralized distilled water was used in leaching test as simulated rainfall (pH=6.5 and electric conduction = 1.07 dS/cm) and 1.8 lit water was calculated required for flooding soil considering the total soil volume. The water divided into six equal parts to pass the uniform volume of water through all the columns and was given to the columns in each leaching time and runoff samples gathered and transferred to the lab for chemical analysis. Leaching was carried out within 25 days every other day.Concentration of copper and zinc was measured in the soil solution. The concentration of metals was measured in specific wavelength of each element by Perkin Elmer's atomic absorption measurement. Parameters such as pH and EC were measured at the soil solution part. The soil pH in 2:1 soil and water suspensions so that first the pH meter model 262 calibrated with buffer solutions and then the pH samples were measured (methods of soil analysis). The Electric Conduction (EC) in 2:1 soil and water

Tables 1,2. Show the results of chemical analysis of soil and compost before leaching.

Volum every each layer of soil(gr)	Cu(mg/kg)	Zn(mg/kg)	EC(ds/m)	PH	Om%	BD(gr/cm^3)	Clay(%)	Silt(%)	Send(%)	Soil texture(%)	FC	Porosity(%)	depth
2182	28.1	69.6	1.69	7.73	0	1.39	14.1	20.9	65	Sandy Loam	11.43	47.5	0-20
2229	22.5	60.7	1.89	8.12	0	1.42	7.5	30.8	61	Sandy Loam	9.29	46.4	20-40
2009	35.4	80.9	1.82	7.74	0	1.28	34.1	37.5	28.4	Sandy Loam	27.41	51.6	40-60

	Cu(mg/kg)	Zn(mg/kg)	EC(ds/m)	PH	OC(%)	Om(%)	BD(gr/cm^3)
compost	**135**	**355**	**7.82**	**7.95**	**13.6**	**23.44**	**0.6**

The effects of treatments on total concentration of zinc in leaching runoff: Chart (1) shows leaching of heavy metals (zinc) in artificial rainfall conditions. The release of heavy metals at the beginning of leaching is low and then reaches its peak continuing the leaching process. The maximum leaching at all treatments (treatment 1: compost plus 290 mg/kg copper soil; treatment 2: compost plus 1160 mg/kg copper soil; treatment 3: compost plus 290 mg/kg copper and zinc soil; treatment 4: compost plus 1160 mg/kg copper and zinc soil; control treatment 1: soil with compost; control treatment 2: soil without compost) carried out at the eighth leaching. Maximum Zn concentration was at the runoff of treatment 4 having maximum added zinc in compare with the other treatments and soil is the minimum at the control treatment 2. The treatment 4, in compare with other treatments, had the highest release of zinc in runoff of soil column indicating that compost plays a role in releasing zinc in compare with the other treatments [3]. In column studies on red soil showed that zinc in compost escapes easier than copper in soil column and the highest concentration of zinc in the runoff from processed compost contaminated with the highest zinc and copper[3].

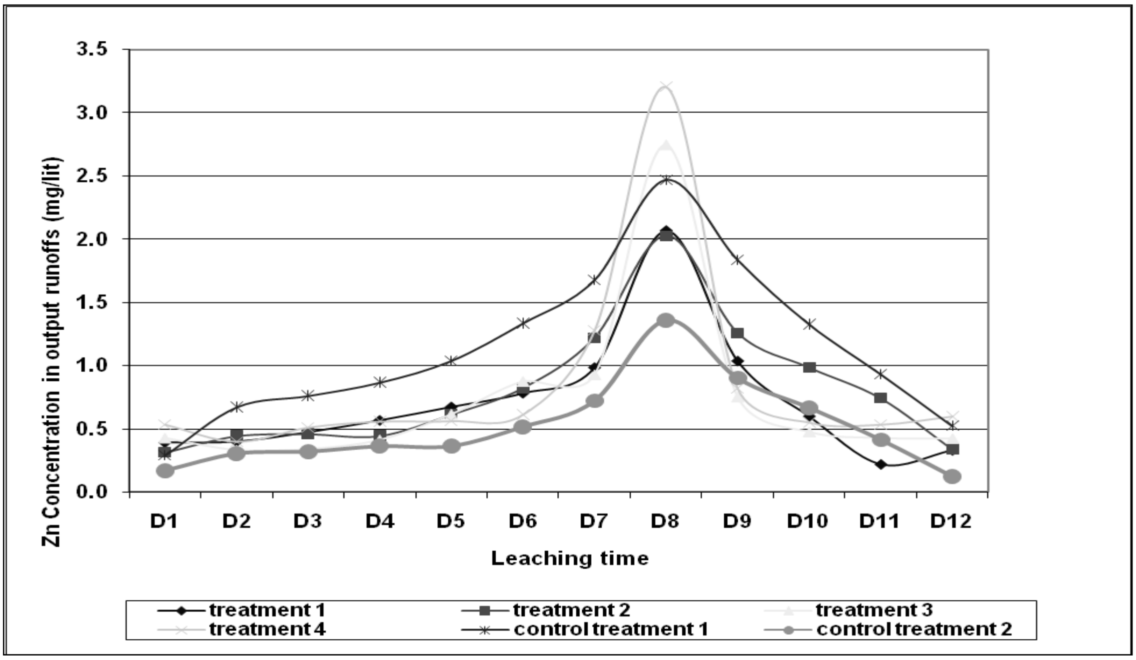

Chart 1. Concentration changes of zinc during 12 times of leaching in output runoffs

Finally Duncan-Test shows that leaching at the first and twelfth leaching times have been significant, in fact, leaching has been influenced the concentration of zinc in leaching runoff under rainfall conditions.

Table 3. Duncan -Test for 12 times of leaching at four measurement parameters.

	Series difference		Release rate	T	Significance level	
	Average	Error Average				
First series Zn-Zn12	-0.05967	0.02825	17	-2.11204	%5	*
Second series Cu1-Cu12	-0.07156	0.00311	17	- 22.99741	%1	**
Third series pH1-pH12	0.39550	0.05804	17	6.81456	%1	**
Fourth series EC1-EC12	0.38889	0.04536	17	8.57357	%1	**

* Significant at %5 and ** significant at %1

Studies show that soils having very complicated environmental, chemical and physical properties could show well remove and refine pollutants such as pollutants in sewage[6]. The results could also indicate that soils with these properties, despite having high added zinc to compost, have decreased concentration of zinc in column runoff and ultimately reducing the amount of groundwater contamination. To improve the quality of sewage and avoid groundwater contamination during discharging sewage in soil, the longer time of sewage passing through soil particles less possible of pollutants to transport deep in soil due to more contact and consequently more impact of chemical and biological processes of soil on its quality[16], thus longer time of leaching could reduce zinc transfer to output runoff.

The effect of treatments on total concentration of copper in leaching runoff under similar rainfall conditions: Chart (2) shows leaching of heavy metals in artificial rainfall conditions. The release of heavy metals at the beginning of leaching is low and then reaches its peak continuing the leaching process. The maximum leaching at all treatments carried out at the eighth leaching. The control treatment 2 (soil treatment) has the maximum concentration of copper and the treatment 1 has the minimum concentration of copper, despite 290 mg/lit of added copper to the mix of soil and compost of which only a little copper transported to the output runoff indicating the role of compost in stabilizing copper in compare with other control treatments. Pedrot (et. 2008) showed that formation of stable composition between organic matter in compost and copper reduces copper transportation of copper in compost. High copper absorption by iron and aluminum oxides reduces copper in soil column runoff [3].

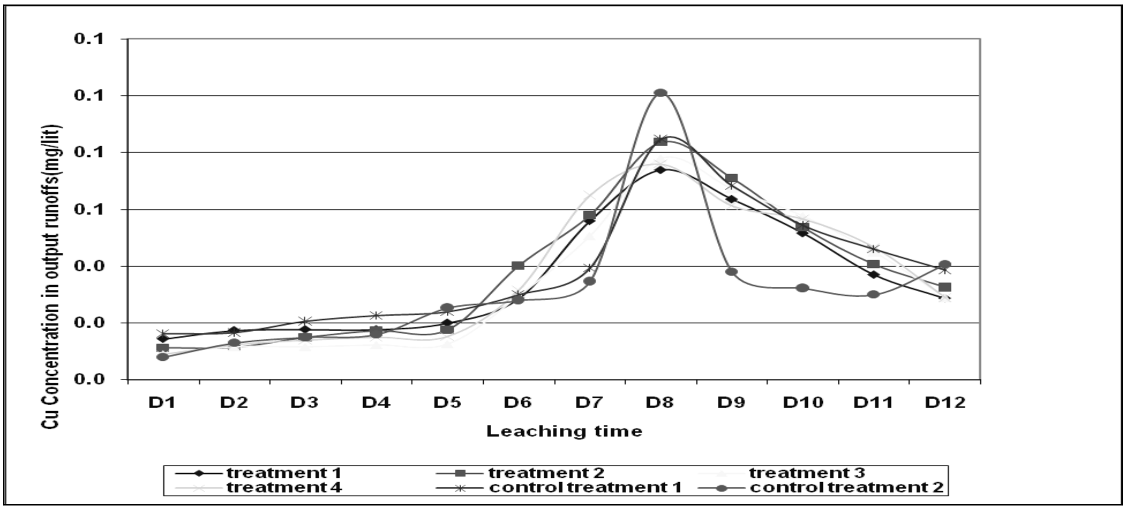

Chart.2. Concentration changes of copper during 12 times of leaching in output runoff

Finally carrying out Duncan-Test (according to the Table3) shows that leaching has affected the concentration changes of copper in leaching runoff under rainfall conditions. The studies show that when heavy metals-contaminated compost was added to red soil a little copper and more than half of zinc was removed from soil column [3]. In the present study also the zinc came out more from copper. In another study (Gove et. 2009) comparing copper and zinc leaching in sand soils or sandy loam showed that copper and zinc in compost, zinc is removed more from soil column.

The effects of treatments on pH changes of output runoff under similar rainfall conditions: Chart (3) shows the pH changes under artificial rainfall conditions. pH changes had a soft raise trend at the beginning of leaching and then it has started to fall since the tenth time of leaching. The treatment 2 has the minimum pH containing compost and copper. pH changes could be related to ion exchange between soil particles and heavy metals in soil columns.

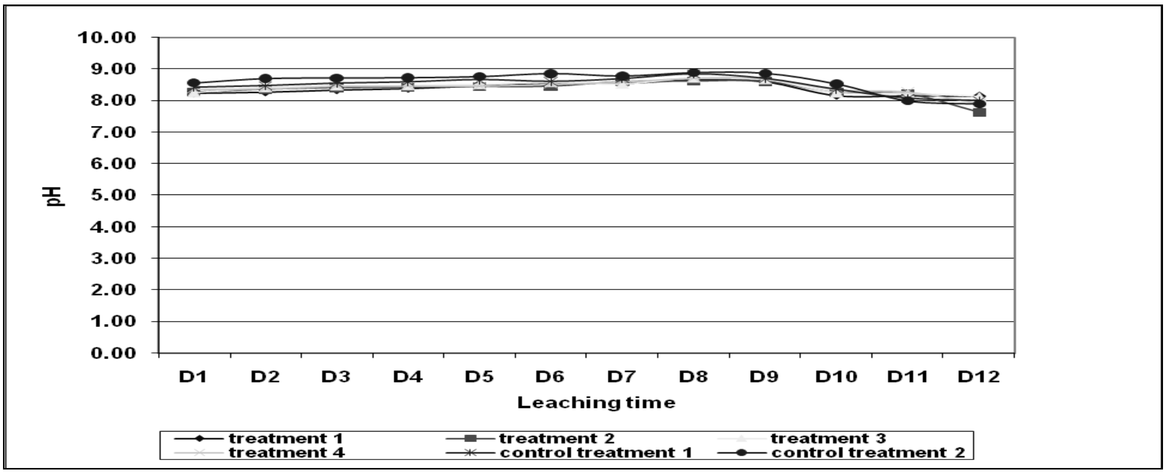

Chart 3. PH Changes during the twelve times of leaching

Finally Duncan-Test (Table3) shows that leaching at the first and twelfth leaching times have been significant (%5), in fact, leaching has been influenced the pH changes in leaching runoff from soil column under rainfall conditions and led to pH reduction. The maximum pH reduction is seen in copper-contaminated processed compost and then copper and zinc contaminated processed compost [3]. Ion exchange between soil particles and heavy metals causes changes in pH[14].

The effects of treatments on EC changes of output runoff under similar rainfall conditions: Chart (4) shows the EC changes under artificial rainfall conditions. EC changes at the beginning of leaching are low and then reach their peak continuing the leaching process. All treatments reach the maximum EC at the seventh leaching time (before maximum leaching if heavy metals carried out in the eighth leaching time). The treatment 3 (copper and zinc contaminated treatment) has the maximum EC and ion exchange and movement of soluble ions may caused increasing in EC.

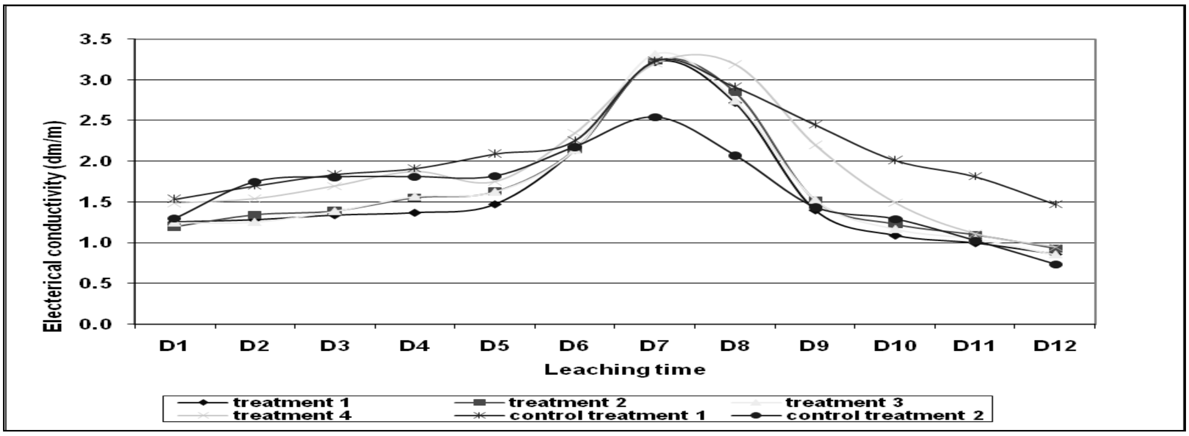

Chart.4. EC changes during twelve leaching times

Finally Duncan-Test (Table3) shows that leaching from the first to twelfth leaching times have been significant (%1), in fact, leaching has been influenced the EC changes in leaching runoff from soil column under rainfall conditions and led to pH reduction. In general, increased heavy metals lead to increase electric conduction. Also ion exchange at this stage between heavy metals in compost and soil particles leads to increase in EC. Movement of exchangeable ions is also useful in this process. The maximum EC is seen in copper and zinc contaminated processed compost[3]. In the present study, the treatment 4 also has the maximum EC having the maximum copper and zinc contamination (1160 mg/kg copper and zinc soil) along with the treatment 3 (290 mg/kg copper and zinc soil). The remaining organic fertilizers (municipal sewage compost and cow manure) increase soil salinity in compare with the control[14]. Movement of soluble ions could increase EC[10]. Soil has played a useful role in improvement the quality of sewage so that the average salinity after passing soil column is less than the transportation of sewage to soil column[9]. EC also, at the present study, gradually decreases after the EC leaching stages.

4. CONCLUSIONS

The results of compost on release and transport of heavy metals (zinc and copper) in soil show the organic fertilizer could increase the possibility of leaching heavy metals in soil which is seen in connection with zinc but, for copper, compost plays more than a stabilizer and also, in general, concentration of heavy metals decreases during passing through soil column. The results of compost on EC and pH changes during leaching occur under similar rainfall conditions. pH decreases during leaching of heavy metals and also we saw the maximum electrical conduction before leaching of heavy metals which is due to the interaction of ion exchange during leaching. It is recommended that to consume organic compost fertilizer considering the quantity of metals within as well as soil specifications (texture, pH, EC…) and the maximum authorized concentration of these metals in different soils are determined. The results of the present study should be approved in future studies at a long-term examination period under farm conditions.

ACKNOWLEDGMENT

It is to appreciate professors, authorities of Research Greenhouse at the Agriculture School as well as the Pedology Lab at Islamic Azad University, Khorasgan Branch who provide us with facilities to study.

REFERENCES

[1] Alloway,W.J.,1995.Soil processes and the behavior of heavy metal in soils, Blachie Academic and professional , London, PP.11-35.
[2] Baybourdi, M, 1998. Soil Physics. Tehran University Publication
[3] Chen,G., G. Zeng, C. Du, D. Huomg, L. Tang, L. Wang, and G. Shen. 2010. Transfer of heavy metals from compost to red soil and groundwater under simulated rainfall conditions.Journal of Hazardous Materials, 181: 211- 216.
[4] Delijani, F, Gh. A. Kazemi, Parvinnia and M. Khakshoor. 2009. Distribution and enrichment of heavy metals in soils of South Pars Special Economic Zone (Assaluye). Eighth International Congress on Civil Engineering, Shiraz University.
[5] Gohil, M.B.,2000. Land Treatment of wastewater. New Age International Ltd., Pubishers, New Dehli.
[6] Gong, C., R.J. Donahoe. 1997. An experimental study of heavy metal attenuation and mobility in sandy loam soils. Applied Geochemistry, 12: 243- 254.
[7] Gove, L., C.M. Cooke, F.A. Nicholson, and A.J. Beck. 2009. Movement of water and heavy metals (Zn, Cu, Pb and Ni) through sand and sandy loam amended with biosolids under steady- state hydrological conditions, Bioresour. Technol, 78: 171- 179.

[8] Harter, R. D., 1974. Adsorption of copper and lead by Ap and Bs horizon of several northeastern United states sails. Soil Sci. Soc. Am. 43: 679-683.
[9] Hosseinpoor, A, Gh. H. Haghpanah, A. Alizadeh and A. Fotovat. 2009. Changes in chemical quality of raw sewage and urban wastewaters due to passing through soil columns. Soil and Water Magazine (Agricultural Industries and Sciences), Vol. 23, Issue 3.
[10] Kaschl, A., V. Romheld, and Y. Chen. 2002. The influence of soluble organic mather from municipal soild waste compost on trace metal leaching in calcareous soils, Sci. Total Envtion. 291: 45-57.
[11] Khosravi Dehkordi, A, A. R. Safyanian and M. Afyuni. 2008. Spatial distribution of heavy metals in agricultural soils, urban and Isfahan, thesis of M.Sc. in Environment
[12] Karbasi, A. R., F. Moatar, M. Monavari and S. S. Mosibi. 2009. Air pollution on concentration of heavy elements in Park Mellat’s soil. Environment technology and Sciences, 10th Edition, Issue 4.
[13] Luo, C. L., Z. G. Shen, A. J. M. Baker, and X. D. Li. 2006a. A Novel Strategy using biodegradable EDDS for the chemically enhanced phyoextraction of Soils contaminated with heavy metals. Plant and soil, 285: 67-80.
[14] Tang, L., G.M. Zeng, F. Nour bakhsh, and G.L. Shen. 2009. Artificial neural network approach for predicting cation exchange capavity in soil based on physico- chemical properties, Environ. Eng. Sci, 26: 137- 146.
[15] Pedrot, M., A. Dia, M. Davranche, M. Bouhnik-le coz,O. Henina, and G. Gruaua. 2008. Insights into colloid- mediated trace element release at the soil/ water interface. J. Colloid Interface Sci, 325: 187- 197.
[16] Van Cuyk, S., R. Siegrist, A. Logan, S. Masson, E. Fischer, and L. Figueroa. 2001. Hydraulic and purification behaviors and their interactions during wastewater treatment is soil infiltration systems. Water Rese. Vol. 35, Issue 4: 953-964.