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Review

Effect of urban wastewater usage and problems of accumulation of heavy metals in agricultural lands (south of Tehran)

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Cultivation of plants as sources of human food and livestock around the big cities like Tehran is common. In some of these areas, untreated raw sewage and urban wastewaters are used for irrigation of these plants. In Southern Tehran, the long-term irrigation of plants with waste water is produced by urban activities, regardless of the increase of soil fertility and the provision of macro and micro nutrients, such as nitrogen, phosphorus, iron, zinc and manganese. Also, it increased soil organic matter and heavy metals accumulation, such as lead, cadmium, nickel and chromium in those plants which are irrigated by wastewaters. The total amount and absorbable concentration of the mentioned elements are increased in irrigated soils, plants and finally, in edible parts of plants. Maximum accumulation of heavy metals was observed in roots, shoots and seeds, respectively. Also, the highest amount of uptake and accumulation was observed in glandular products. A study on element accumulation and defined standards shows that it is not possible to produce crops under these areas or at least it could be possible only for the production of some of the crops that their economic parts are not directly consumed by humans or are useable after some processes. Currently, the dominant regional pattern of cultivation is maize - wheat whose final product is directly and indirectly consumed by humans or livestock. Accumulation of heavy metals in corn and wheat plant is dangerously close to the threshold. In addition, in other plants grown in these regions, accumulation of heavy metals in plant economic organs is more than normal restriction and toxicity threshold for humans and livestock. Considering these problems and hazardous effects of waste water consumption, it is necessary to monitor the cultivation patterns and limit cultivation of those plants which have high level of heavy metal absorption and transport into economic and edible parts. It is suggested that these areas are suitable for wood production and orchards' establishment.

Key words: Urban waste water, heavy metal, south of Tehran, agricultural products.

INTRODUCTION

About 18.6 million ha of the countries' land are under agricultural activity, in which 10.5 million ha are allocated to irrigated and rain fed agriculture and the rest are fallow or waiting to be used for cultivation. One of the most important economic and social policies of government after the revolution is the optimal use of renewable resources, especially soil and water resources. It is predicted that in 1400, more than 10 billion m^3 of water per year will be used in urban, rural and industrial sections. There is 60 to 70% of recycling coefficient, thus about 6 to 7 billion m^3 of water as effluent will be entered into the agricultural land. Brace et al. (1995) reported that application of this rich source in agricultural production is current in most parts of the world and is used in a wide scale. This source is rich with macro nutrients, such as nitrogen, potassium, phosphorus and magnesium, and

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trace elements like iron, zinc and manganese (Elsokary and Sharaf, 1996; Jafarzadeh, 1996; Kabata- pendias and Padias, 1992; Valmis et al., 1985). Smith (1996) showed that there are other unexpected factors, such as heavy metals, which lead to changes in natural ecosystem balance, agricultural lands and changes in structure and characteristics of plants and animals fed by wastewater through contaminated food chain (Alloway, 1995). Heavy metals are entered into the food chain and are dangerous for humans and livestock; therefore, the study on heavy metal accumulation in different parts of crops irrigated with wastewater is very important (Salardini and Mojtahedi, 1988). In Tehran, a huge volume of melted snow from Alborz range flows into urban canals; simultaneously, urban and industrial wastewater are added into them and finally without any infiltration process, they enter into fields in the south of Tehran and about 50,000 ha of agricultural lands are irrigated by this water. Currently, the dominant crops in Southern Tehran during summer season are forage corn, squash, celery, rice and some fresh vegetables. These crops are rotated with winter crops, such as wheat, canola and turnip (Lavado, 2001). Winter precipitation increases wastewater expansion in Tehran so that in some years, it occurs severally than the normal mode. Obviously, with regard to climate conditions and limited water resources in Iran, use of water sources and especially urban wastewater in agriculture is inevitable and justifiable. Also, considering the health risks of wastewater in agriculture and the necessity conservation of human and animal health, adverse effects of wastewater must be examined continuously. One of the objectives of this study is to identify positive and negative impacts of wastewater in agriculture.

EFFLUENTS APPLICATION IN AGRICULTURAL LAND IN SOUTH OF TEHRAN

Effluent is a diluted solution which covers all surplus water from human activities and environment and includes produced extra water due to health and industrial expenditures. Although the main usage of this water resource is in agriculture, produced crops in these lands are not noteworthy by final consumers because of hazardous agents, such as: microbes and pathogens, heavy metals, organic matter, dissolved salts and suspended solids. On the other hand, regarding high level of nutritious elements such as phosphorus, potassium and nitrogen, and micronutrients such as iron, zinc and manganese that are effective in increase of yield, farmers are eager to make use of this wastewater in their agricultural lands (Kirkham, 1985). It is reported that in 50 countries of the world, at least 20 million ha of agricultural ecosystems, close to the cities, are irrigated with urban wastewater. In China, more than 36 million ha of agricultural land are irrigated with raw and untreated sewage that are 7.3% of the total agricultural land in this country (Brace et al., 1995; Gigolity et al., 1966).

Soil samples were collected from different regions of Tehran and chemically analysed. Results are shown in Table 1.

In Tehran as a metropolis, the produced water resources by snow melting from Alborz heights pass through it via urban canals and receive the produced wastewater by public activities and then flow into farms located in the south of the city. The first study was performed in 1973 on the effects of sewage on crop production in the south of Tehran. The arsenic concentration in the well water was investigated from the north of Tehran to the south of Tehran. The results showed that arsenic concentration was increasing in well water, so 62% of the samples arsenic concentration was more than the critical level (Arbab, 1995). Another report showed that the average concentration of cadmium in well water in Tehran is close to the maximum allowable (Bazargan, 1988; Bingham et al., 1975), and in some regions like Nazi Abad, Koshtargah and Dolatabad, cadmium concentration in soil was more than the reported amounts when compared with other countries. Torabian and Baghory (1994) investigated the total and absorbable amount of some elements such as cadmium, zinc, copper, lead, chromium and nickel in the southern part of Tehran, which were irrigated by urban wastewater. They showed that the amount of the mentioned elements was increased in soil and plants. Tofighi and Salmasi (1999) and Williams (1987) studied heavy metals movement in soils. They showed that the highest amount of nickel, cadmium and lead was accumulated in upper layers of the soil. Harati (2003), during a study of wastewater effects on corn, concluded that macro (N, P and K) and micro elements in the wastewater improve growth and yield of maize, while accumulation of heavy metals such as cadmium and lead in corn was more than the standard limits and critical step for animal feeding. Effects of wastewater in south of Tehran on vegetables and crops were investigated by Hariri et al. (1995) and Akbari (1995). They concluded that in some of these plants, heavy metals are accumulated in the roots and they are not transported into the shoots. The amount of some heavy metals, particularly lead, cadmium and nickel reached the critical level for man and livestock.

Soil status in agricultural land in south of Tehran

Use of wastewater in agricultural lands in south of Tehran increased organic matter and nutritional elements in soils of the area. Also, due to continuous use of sewage, there are physicochemical changes in soil structure, especially in terms of soil permeability, percent organic matter, macro and micro elements concentration which was

Table 1. Soil characteristics of some regions in south of Tehran.

Factor	Village/region			Standard range
	Saleh Abad	Taleb Abad	Firooz Abad	Plant growth
PH	7.8	7.6	7.9	-
EC	3.35	6.69	-	-
Soil texture	Silty Clay Loam	Silty Clay Loam	-	-
N	0.01	0.08	-	-
P	1.5	2.3	-	-
K	383	270	-	-
Cu	-	30.5	-	-
Fe	13.1	10	12.7	-
Zn	16.5	12.4	7	150-200
Pb	40	35.3	38.7	10-30
Cd	1.9	2.8	1.3	5-10
Mn	6.2	4.1	3.9	-
Cr	2	2	0.5	1-2
Ni	10	10	9	20-30

Heavy metal concentration (ppm); macro nutrients (N, P, K) (%) (Harati, 2003; Hariri, 2005; Molahoseini, 2002; Akbari, 1995).

confirmed by Boggess et al. (1978) and Koeppe (1977). The effects were observed at a depth of 40 cm on root zone and elements absorption zone. Study on accumulation of heavy metals in some soils of south Tehran shows that the accumulation of heavy metals, except lead and chromium, is not hazardous for crop production (Hariri et al., 2005). Status of lead accumulation in soil samples showed that concentration of this element is more than the standard level for cultivation and breeding of plants. One of the most important reasons for lead accumulation in soil is high concentration of lead in fuels. However, lead will be transferred via canals and then transferred to agricultural lands.

Chemical properties of wastewater in south of Tehran

The main sources of wastewater in south of Tehran is supplied by three main canals. These canals transfer melted snow from north to south. During this transfer, the sewage from sanitary water consumption in houses and residential wastewater from factories and workshop activities with suspended pollutants in the air which are deposited in canals, will find ways into the south of the city. This sewage during transfer will be polluted more and more and when it is close to the south of Tehran, it becomes dark in color and denser. Urban wastewater in agricultural lands in the south of Tehran will be transferred to the fields by using the main and secondary canals, after which it will then irrigate the crops. This irrigation source leads to gradual increase in nutrients and it improves plant growth when compared with application of these materials as fertilizer which is used normally, one or two times during plant growth stages. The most important materials in sewage are organic matter, nitrogen, phosphorus, carbon, calcium, magnesium, sulfate, chloride, carbonate and heavy metals. Increase of some elements such as iodine and chloride causes soil salinity and reduce crop production. Chemical composition and nutrient elements in sewage, especially macro and micro nutrients can be effective in plant growth. On the other hand, there is gradual increase in soil nutrients. Although in the early years, it can increase crop yield, there is high possibility of soil poisoning. It should be noted that the use of wastewater has adverse effects on physicochemical structure of soil, including increased soil organic matter, reduced soil infiltration, gradual change in the population of beneficial microorganisms and soil biological community, especially the rapid increase in the population of nematodes, increased soil salinity and acidity, reduce evaporation from soil, etc. Generally, effluent contains 2 to 7% nitrogen and 1 to 5% phosphorus, which is equivalent to 2 to 10% phosphorus fertilizer as P_2O_5. Both nitrate and ammonia in the sewage water is absorbable by plants and it affects plant growth (Sidle and Kardos, 1979). While sewages are poor in respect to potassium, small amounts of this element are accessible in sewages. Therefore, application of chemical fertilizers containing potassium is necessary, especially for corn and potato when wastewater is used at the same time. Thus, selection of crop and adjustment of element concentrations in sewage is very important in management of those kinds of lands which are irrigated by sewages (Garcia et al., 1981).

Table 2. Sewage characteristics of some main canals in south of Tehran.

Factor	Sorkhe Hesar	Firooz Abad	Shoor river	Ghale no	Well water	Agricultural standard
PH	-	-	-	7.5	-	-
EC	-	-	-	1.4	-	-
N	-	-	-	6	-	-
P	-	-	-	1.65	-	-
K	-	-	-	-	-	-
Cu	-	-	-	0.05	0.04	0.2
Fe	0.4	0.25	0.6	-	-	5
Zn	0.77	0.02	0.008	0.005	0	2
Pb	2.25	1.5	1.9	0.06	-	0.5
Cd	0.015	0.015	0.018	0.08	0.05	0.01
Mn	0.06	0.012	0.007	-	-	0.2
Cr	0.007	0.01	0.009	-	-	0.1
Ni	0.075	0.05	0.1	0.08	0.05	-

Heavy metal concentration (ppm); macro nutrients (N, P, K) (%) (Harati, 2003; Hariri, 2005; Molahoseini, 2002; Akbari, 1995).

Results of several wastewater samples collected from the south of Tehran are shown in Table 2. These samples are mainly obtained from the main canals which transfer wastewater to fields in the south of Tehran. The results show that lead concentration, in wastewater obtained from Shoor river, Firoozabad and Sorkhehesar which are main canals in the south of Tehran, is more than the standard level for irrigation of lands (Hariri et al., 2005). It was observed that nitrogen and phosphorus concatenation was 6 and 1.65%, respectively.

EFFECTS OF WASTEWATER ON PLANTS GROWN IN SOUTH OF TEHRAN

Plants as the lowest level in food chain play an important role in human and animal diet and due to direct and indirect consumption they are the main factors in heavy metals transfer to other levels of food chain. Thus, they should be more considered than other dietary levels. According to Environmental Protection Agency's standards in Iran, application of wastewater to irrigation of some crops has been limited. For example, planting some grain crops, such as wheat and barley that are not directly used, has not been restricted while there are limitations in corn and sorghum cultivation, because they are used in animal diet directly (Gaui, 1997). Cultivation of glandular industrial plants like sugar beet is not recommended due to direct contact with soil. In contrast, there is no limitation in cultivation of cotton and madder, because their products are consumed by humans after some processes. Productions of fruit, especially those fruits which are used freshly, are not recommended due to probable contact with soil. Nut fruits, such as walnuts, almonds, pistachios and hazelnuts can be grown and produced. In addition, there is no limitation about wastewater application for irrigation of woody trees, like pine, spruce and oak and we can irrigate them easily and safely by wastewater. Ability of plants to absorb and accumulate heavy metals from soil and water is different and it depends on plant species and type of elements. Legume and grass plants have less ability to accumulate cadmium in their leaves when compared with leafy vegetables like spinach and lettuce. On the other hand, tomato has high ability to accumulate cadmium when compared with barley, bean, carrot and cabbage.

In order to study heavy metal accumulation in plants grown in the south of Tehran, several studies were done (Harati, 2003; Hariri, 2005; Molahosein, 2002; Akbari, 1995). Results of heavy metals accumulation in crops grown in south of Tehran are shown in Table 3. During these experiments or research projects, the crops were cultivated in greenhouses or laboratories under simulated conditions in respect to soil and water quality. At the end of plant growth or after physiological maturity, plant organs were separated according to the economic (those parts of the plant which are consumed by humans or animals directly) and non-economic (those parts of the plant which are not consumed by humans or animals and which will be returned to the soil after harvesting) parts of the plant (Davis and Beckett, 1978). Although in many cases these parts of the plant were used for feeding animals, after some processes, heavy metal accumulation was measured Table 4. Results indicated that there was an increase in heavy metal concentration in economic and non-economic parts of the plant. Also, it was shown about some crops that it is necessary to lay down new policies, and even the cultivation and production of some products should be hindered.

Table 3. Heavy metal accumulation in some plants in south of Tehran (Taleb Abad village- Dah Kheyr region and Saleh Abad).

Plant		Element							
		Cu	Fe	Zn	Cd	Cr	Mn	Pb	Ni
Corn	Root		646.9	70.2	0.7	9.8	55.3	25	4.5
	Shoot		177.6	72.1	0.72	12	39	34.8	5
	Ear		54	75.6	1.1	2.8	29.1	12.2	2.5
	Seed		49.76	65.63	3.22	22.84	9.95	23.08	7.69
Wheat	Plant	7.3	-	32.4	0.56	-	-	2.5	-
Alfalfa	Shoot		328	72.2	4.9	10.4	52.2	1.8	2.7
Lettuce	Leaf		740.8	96.6	2.8	8.3	60.3	9.9	7.3
Radish	Leaf		527.9	96.2	1.9	6.3	166.8	3.4	7.2
	Root		462.5	95	1.4	24.3	43.3	10.6	7.9
Bean	Plant		257.37	102.08	1.60	17.95	80.13	29.65	3.04
	Pod		88.9	69.3	0.48	1.9	13.5	1.4	5
	Seed		97.6	100.9	1.6	1.4	57.6	10.1	4.8
	Root		850.6	74	0.96	20	2.64	21.6	6.5
Cotton	Plant		231.4	85.5	2.9	35.4	57.2	5.2	4.6
	Seed cotton		256	117.3	Trace	11.5	73	35.5	22.1
	Root		166.1	40.4	1.1	4.5	14.2	3.5	4
Mung bean	Plant		123.3	72	4.2	8.4	67.7	13.1	3.5
	Root		132.6	71.4	0.4	5	20.1	16.6	3.9
	Seed		1.5	16.5	53.5	14.7	1.1	94.5	183.9
Sunflower	Plant		270.3	103.6	3.7	4.5	46.1	27.6	3.3
	Root		258.6	60.3	0.9	3.2	35	39.7	3
	Seed		43.5	113.7	0.48	2.2	19.2	3.3	2.8
Squash	Plant		557.4	103.2	11.1	6.9	30.1	15.5	1.2
	Root		415.5	105.5	6.2	7.9	23.1	13.9	20.7
	Fruit		108.6	116.5	1.5	8.3/3	57.8	4.72	19.7
Spinach	Leaf		347.5	125	1.3	2.4	66.2	8.4	3.8
	Root		369.8	97.2	-	7.7	46	9.6	3.2
Turnip	Plant		469.7	100.9	1.2	1.9	93.5	-	3.1
	Tuber		151.1	101.9	1.1	3	22.5	8.9	2.8
Cress	Leaf		309.3	121.6	1.9	16	52.7	9.7	5.6
	Root		309.3	121.6	1.9	16	52.7	9.7	5.6
Leak	Leaf		216.35	79.81	0.96	3.85	32.69	10.1	4.81
Scallion	Leaf		272.12	77.4	0.96	5.29	31.25	10.1	2.4

Heavy metal concentration (ppm); macro nutrients (N, P, K) (%) (Harati, 2003; Hariri, 2005; Molahoseini, 2002; Akbari, 1995).

Table 4. Heavy metal accumulation in economic and non-economic parts of the plants.

Plant	Allowable to use	Unallowable to use	More than standard	Recommend
Corn	Leaf and stem	Root and seed	Cd ,Pb, Ni	Prevention of fresh use and silage
lettuce	-	Leaf	Ni , Mn	Seed production
Bean	-	Root and leaf	Cr, Fe	Do not cultivate
Cotton	Yarn and seed	Oil and meal	Ni ,Pb ,Cr	Seed production and industrial oil
Radish	-	Leaf and root	Ni و Pb, Fe	Do not cultivate
Alfalfa	Leaf stem and seed	Root	Cd, Mn, Fe	Dangerous
Squash	-	Fruit	FeوCd, Ni	Do not cultivate
Sunflower	Stem and leaf	Seed and oil	Cd	Do not cultivate
Spinach	-	Leaf	Zn و Mn, Ni	Dangerous
Turnip	Leaf	Tuber	PbوCd	Do not cultivate
Cress	-	-	Cr, Pb	Do not cultivate

Heavy metal concentration (ppm) (Harati, 2003; Hariri, 2005; Molahoseini, 2002; Akbari, 1995).

Corn

In corn, as a dominant forage crop in this region, lead and cadmium accumulation increased up to the toxic range for animal feeding even when it was not suitable for silage. However, in some cases, corn was consumed by humans directly (Cahney, 1973; Iwai, 1975; FAO, 1998; Sheila and Ross, 1996).

Wheat

Wheat is not consumed by humans directly, in that there are some processes before its consumption; thus wheat production is recommended. Accumulation of heavy metals in wheat is less than the dangerous range for humans.

Leafy vegetables

Irrigation of vegetables by sewage has some health problems because these plants are consumed by humans directly.

Bean

In these plants, heavy metals, especially chromium and lead, are transferred to pods and seeds. Thus, if these crops are consumed as fresh crops, their cultivation is not recommended.

Glandular plants

Cultivation of glandular and root plants such as turnips and glandular, radish and scallion, and other products such as carrot, beet, garlic and potatoes, in south of Tehran, is not recommended. It is reported that in the major glandular plants, the amounts of heavy metals in roots, tubers and underground organs are 10 times higher than shoot and grain.

Cotton

Although cotton irrigation with sewage leads to chromium accumulation in leaves and bolls, actually the root of cotton accumulates the lowest concentration of heavy metals. In cotton, there are different mechanisms that absorb heavy metals from soil and then transfer them to shoots, especially seeds that are fiber.

There is no problem with the use of cotton yarn considering heavy metal accumulation, but the extracted oil and produced meal is dangerous for human and livestock consumption. It has been reported that heavy metal concentration in these products are increased due to the concentrate. Therefore, it is recommended that cotton production with sewage water should be permitted only for fiber production, and the produced seed should be allocated to the industry.

Alfalfa

Production of alfalfa with sewage in south of Tehran has serious problems. As a result of the direct contact of plants with sewage and the possibility of diseases, this crop is not suitable for forage production in this area. Lucrative business of alfalfa seed production is a good opportunity for seed production in this region.

Squash

Heavy metals accumulation in the roots of this plant is more than the fruits. As such, squash production is not recommended due to direct contact with sewage water.

Sunflower

Heavy metal accumulation in seeds is less than other parts, but it is close to the critical range for human and animal consumption. Therefore, possibility of oil production should be investigated.

Wastewater impacts on groundwater resources

If sewage is used for plant irrigation, there is the possibility of ground water pollution occurrence (Fazeli, 1998). Application of urban wastewater contaminates groundwater resources, especially in sandy soils. Soil layers, especially clay layers can act as a buffer and hinder groundwater contamination. Therefore, sewages must not be used in sandy soils or those regions where the water table is close to the surface, or in the ground waters used for drinking.

CHALLENGES OF WASTEWATER USE IN SOUTH OF TEHRAN

Application of raw sewage for irrigation of agricultural land is not acceptable. In addition, there is undesirable effect on soil, such as decrease of quantity and quality of crops, heavy metal accumulation in plants and gradual reduction in soil infiltration. Furthermore, heavy metal accumulation and microbial contamination are menaces to the society's health.

SUMMARY AND RECOMMENDATIONS

1. The status of heavy metals accumulation in plants grown in this region shows that there is a heterogeneous trend in absorption and transmission of elements to economic organs of plants. Also, the results showed that the major heavy metals were accumulated in roots and the lowest amount was transferred into the seeds; but in some cases, accumulation in seeds was close to the critical range for human diet or in some other cases, heavy metal accumulation was more than the critical range for human and livestock consumption. According to serious health problems and consequences of these elements on human and animal health, as well as on the ecosystem, it is necessary to change the cultivation pattern. In addition, development and production of woody trees would have been placed on the agenda;
2. Currently, there is no comprehensive research on effects of sewages on human and animal health and especially its effects on soil ecology; thus, a long-term research is needed;
3. Increase of control and precision supervision on sewage application in agriculture and assessment of quality should be performed frequently;
4. The most suitable conditions, in terms of environment health, will be made when application of wastewater is under supervision and control in certain areas. Moreover, these sources should not be provided for common farmers. It should be noted that in future planning of wastewater application, it is necessary to concentrate on climate, social and economic points;
5. Although the gradual increase of soil nutrients in the early years increases final yield, there is still the possibility of soil poisoning. Therefore, selection of crop, cultivation pattern and monitoring of soil and water are very important.

REFERENCES

Akbari, G, Hariri N, Harati M, Foghi B (1995). Study on effect of irrigation with urban sewage and well water and heavy metal accumulation in plants in south of Tehran. Final report, research project, Tehran University and environment protection organization.
Alloway BJ (1995) Heavy metal in soils. Blackie academic press, New York.
Arbab DP (1995). Study on arsenic composition in 60 wells in north and south of Tehran. Thesis. Faculty of Sanitation. Tehran University.
Bazargan N (1988). Firooz Abad sewage application in agriculture and heavy metal destination. Thesis. Faculty of Sanitation. Tehran University
Bingham FT, Page AL, Mahler RJ, Ganje TJ (1975). Growth and cadmium accumulation of plants grown on a soil treated with a cadmium – enriched sewage sludge. J. Environ. Qual., 4: 207-11.
Boggess SF, Willavize S, Kooppe DE (1978). Differental response of soybean varities to soil cadmium . Agron. J., 70: 756-60.
Brace HB, Abdellah AR (1995). Recycling nutrient from municipal wastewater. Elsevier Science.
Chaney RL (1973). Crop and food chain effects of toxic elements in sludge and effluents. In proc. Of joint conf. on recycling municipal sludges and effluents on land. National association of state universities and land grant collages, Washington, D.C., pp. 129-41.
Davis RD, Beckett PHT (1978). The use of young plants to detect metal accumulations in soil. Water Pollut. Control, 77: 193-210.
Elsokary TH, Sharaf AL (1996). Enrichment of soils and plants irrigated by wastewater by zinc and calcium.Fourth Nat. Congress Poll. control Agric. Environ. Egyptian J. Soil Sci., 36(1-4): 219-232.
Food and agriculture organization, FAO (1998). Animal feeding and food softy. Food and nutrition paper69: Food and agriculture of the united state nations.
Fazeli MS (1998). Enrichment of heavy metals in paddy crops irrigated by paper mill effluents near Nanjangud, Mysore District, Karnatake, IndiaEnvironmental. Geology, pp. 4-34
Garcia WJ, Blessin CW, Inglell GE, Kwolek WF (1981). Metal accumulation and crop yield for a variety of edible crops grown in diverse soil media amended with sewage sludge. Environ. Sci. Technol., 15(7): 793-804.
Gigliotti G, Daniela B, Giusquiani PL (1966). Trace metals uptake and distribution in crop plants grown on a 6- years urban waste compost amended soil.
Gaui FN, Basta T, Ram WR (1997). Wheat grain cadmium as a effected by long term fertilization and soil acidity. J. Environ. Qual., 29: 265-271.
Harati M (2003). Study on heavy metal accumulation in different parts of corn irrigated by sewage in south of Tehran. Msc Thesis. Tehran University.
Hariri N, Akbari G, Harati M, Foghi B (2005). Study on effects different concentration of urban sewage on vegetative and reproductive

traits,yield, yield componenets of plants in south of Tehran. Final report, research project, Tehran University and environment protection organization.

Iwai I, Hara T, Sonoda y (1975). Factors affecting Cd uptake by corn plants. Soil Sci. Plant Nutr., 21(1): 37-49.

Jafarzadeh HN (1996). Effect of Shiraz sewage on heavy metal accumulation in soil in some crops. Second congress on water and soil problems.

Kabata-pendias A, pendias H (1992). Trace elements in soil and plants. CRC. Press. Boca rattan,fl.

Kirkham MB (1985). Agricultral use of phosphorus in sewage sludge. Adv. Agron., 35: 129-161.

Koeppe DE (1977). The uptake, distribution and effect of cadmium and lead in plants. Sci. Total Environ., 7: 197-206

Lavado SR, Porcelli CA, Alvarez R (2001). Nutrient and heavy metal concentration and distribution in corn, soybean, wheat as affected by different tillage systems in the argentine pampas. Elsevier science. Soil Till. Res., 62: 55-60

Molahoseini H (2002). Study on intensity and expansion of heavy metal soil contamination and determine of heavy metal concentration in irrigated plants with sewage. Final report, pp. 81-365

Salardini A, Mojtahedi M (1988). Fundamental of plant nutrition. Center for Academic Publications.

Shiela M, Ross M (1996). Toxic metals in soils plant system. John Wily & sons, inc. newyork.

Sidle RC, Kardos LT (1979). Nitrate leaching in a sludge treated forest soil. Soil Sci. Soc. Am. J., 43: 278-82.

Smith SR (1996) agricultural recycling of sewage sludge and the environment. Biddlesltd, Guildford.