Effect of Industrial and Municipal Effluent On Soil, Water, and Plants in Isfahan

Hamid Reza Rahmani

Scientific Member of Soil and Water Institute of Iran.

P.O. Box 81785-199, Isfahan, Iran., E-mail: hr.rahmanii@yahoo.com

Abstract:

Utilization of none-prime waters in arid regions is necessary to supplemental water resources. The municipal EW from the Esfahan Northern Water Treatment Plant, and industrial EW from Zob-Ahan, Fold-Mobarekeh (iron foundries), Polyacril (Petrochemical Plant) and, Zohreh (dyeing plant) were selected and its effect on soil, water resources, and plant were studied.

The result shows that for municipal EW the COD, BOD, TSS and, for industrial EW $So4^{2-}$, Cl^-, Hco_3^-, BOD, COD, N-NO3, TDS, TSS, SAR and heavy metals concentrations of Cu, Mn, Cr, Co, Cd and Zn are the limiting factor and exceed the standard for agricultural land irrigation.

In soil in land irrigated with municipal EW, the organic matter content, total nitrogen, available phosphorous and Potassium and selected heavy metals were higher than well-water irrigated lands. In soils irrigated with industrial EW the concentration of Mn, Zn, Cd and, Cu exceeded the normal levels, and were in critical range. The concentration of Fe, Zn, Cu and Zn in the wheat roots irrigated with EW were higher than wheat root irrigated with well-water and the wheat grain concentration of Mn and Zn where higher than wheat grain check fields irrigated with well-water. In land irrigated with industrial EW Cu concentration was higher than normal and Fe concentration were higher than sufficient range.

Also, Zn and Cu grain concentration increased, and Fe grain concentrations decreased compare with leaf and shoot concentration in wheat. In alfalfa, plant Cu and Zn concentration were in critical range, and Cu, Fe, and Zn concentration exceeded the sufficient range.

Keywords: Municipal, Effluent Water, Heavy Metals, Permissible, Critical

Introduction:

The contamination and quality of irrigation water is of the main concern especially in the regions with limited water resources. In such region not only, the water resources should wisely be utilized at the same time should be prevented from contamination. The industrial and municipal effluents water (EW) are among the most important sources of soil and water contamination. The EW usually contains high level of hazardous material, which removal of them may not possible with routine treatments. EW in case of entrance into the soil, surface and ground water, cause pollutions and poison food chain. Additionally, due to limitation of fresh water and increasing population treatment and recycling of industrial and municipal EW is needed (Abbaspour, 1992). Unregulated discharge and mixing of raw EW with the fresh water resources causes irreversible damage to environment and agricultural lands.

Environmental contaminations by EW due to presence of heavy metals are among the main cause of environmental pollutant. In Iran, the concentrations of heavy metals in soil treated with EW have been studied (Torabian and Baghuri, 1996). For several plants, species in southern part of Tehran City the Cd concentration in EW treteated area were 1.5 to 2 times higher than the none-pollutant ones. Also, in several studies the soil Cd concentration has been high. Soils and plant in south part of Tehran contain high Cd level (Torabian and Baghuri, 1996). The plant highest Cd concentration has been reported in Taiwan in brown rice contaminated soil (Chen et al., 1994).

Heavy metals have adverse effect on plant growth. The budding rate and growth of trees has been decreased by increasing Cd and Pb concentration in EW used for irrigation (Bazargan, 1988). The Pb concentration in EW of selected industries in City of Yazd was less than 0.01 mg $liter^{-1}$ (Rahmani, 1997). In Bahrain Pb concentration in plants were from 9 to 240, in Canada from 100 to 300 in France from 50 to 400, in England from 100 to 700 and in Iran 50 to 400 mg kg^{-1} (Rahmani, 1995; Rahmani, 2001).

In Hamedan, the application of municipal EW has increased the soil surface organic mater, available P, and k, and concentration of Cu and Zn. Application of municipal EW for table vegetable crop production increased the concentration of Cu and Zn above the critical range(Asadi and Azari,2003).

The Zn, Mn, Cu and Fe in land irrigated with EW were higher then land irrigated with well-water, but the difference were not significant ($P<0.05$). Corn Fe and Mn concentration, wheat grain and straw Mn and Zn concentration, tomato Fe, Zn and, Cu concentration in land irrigated with EW were higher than land irrigated with well-water(Feizi,2001).

In Iran, the volume of non-prime water resources such as industrial and municipal EW was about $3.36*10^9$ cubic meter in 1996, which $2.5*10^9$ cubic meters are from municipal swage. The volume of EW in 2001 is $4.5 *10^9$ cubic meter, and 2011 will rise to $7*10^9$ cubic meter. Therefore, it is necessary to set plan to study the long-term affects application of EW on environment, food chain and, human health.

Material and Methods:

The quality of municipal and industrial EW of Esfahan Northern Water Treatment plan, and industrial EW of Zob-Ahan, Folad-Mobarkeh(Iron foundries), Polyacril(chemical plant) and Zohrah (dyeing plant) and its impact on soil, plants and water resources (well-water) was studied for two years. The EW were sampled, seasonally every 6 hours during 24 hours periods and, well-water from an area irrigated with EW were sampled seasonally.

During a two-year study, in area using municipal EW, four farms were selected (3 Irrigated with EW and one irrigated with Well-water). In area irrigated with industrial EW two zone were selected, one irrigated with industrial EW from Zob-Ahan and one irrigated With EW from Folad-Mobrakeh.

In each zone, 3 farms of approximately 0.5 ha were selected. In each farm, composite soil sample from three fields from 0-30 cm, were collected in three replicates. In fields irrigated with industrial EW water the soil, plant, and check filed were sampled. In fields irrigated with municipal EW, wheat root, shoot, and grains and in fields irrigated with industrial EW Wheat grain and shoot, and alfalfa were sampled.

The EW and well-water were analyzed for pH, EC, TDS, TSS, $N\text{-}No_3$, cations, anions, BOD, COD, and the concentration of heavy metals including Cu, Zn, Mn, Ni, Co, Cd, Fe, Pb and Cr. The soil samples were analyzed for pH, EC, texture, organic matter, cations, anions and concentration of heavy metals including Cu, Cd, Zn, Fe, Mn and, Pb. The plants samples were analyzed for percent dray matter content and the same heavy metals as soil samples. The results were compared with permissible concentration levels.

Result and Discussions

Municipal EW properties and effect of on soil, water and plant:

Table 1 shows the mean and range of chemical properties of the northern Esfahan municipal EW and, the local well-water. The results show that the concentration of heavy metals in well-water and EW are very low and do not exceed the permissible levels. The EC of well-water and EW for irrigation utilization are very limiting and not limiting, respectively. The BOD, COD, TSS, of EW for irrigation application are limiting.

Soil samples irrigated with well-water, and few of the soil samples irrigated with EW were saline ($EC>4$ $dS\ m^{-1}$), due to saline well-water and long-term utilization of EW. In all soil samples collected from the land irrigated with EW (table 2)the percent organic matter, total N, available P and K and heavy metals were higher than soil irrigated with well water, and the difference between them were significant ($P<0.05$). Concentration of Fe, Zn, Cu, and, Cd in wheat roots irrigated with EW were higher than wheat roots irrigated with well water. The grain and shoot Mn and, Zn irrigated with EW were significantly ($P<0.05$) higher than well-water. The effect of irrigation water sources on root Pb was not significant ($P<0.05$).

Even though the heavy metals concentration in EW do not exceed the permissible levels the concentration of heavy metal in soil and plants irrigated with EW have increased compare with control. The result shows the long-term heavy metal accumulation in soil. The result of EW application in agricultural land show that EW heavy metal content are not harmful, but other reports that EW may increase soil heavy metal concentration more than permissible levels(Ellioti and Stevenson,1986).

Industrial EW biological and chemical properties and effect of on soil, water and, plant:

The range of chemicals properties and concentration of heavy metals in industrial EW and the well-water located in area irrigated with them are given in table 3. The comparison of the results with permissible level shows that BOD, COD, TSS, TDS, N-No_3, Cl^-, $So4^{2-}$ and heavy metal concentration of Zn, are limited for discharge into surface water and, disposal into absorption wells and heavy metal concentration of Cd, Cr, Co, Cu, Mn, and Zn for utilization as the irrigation water.

The limiting chemicals properties in well-water for discharge into surface water are N-No3, Cl^-, $So4^{2-}$, and heavy metal concentration of Fe (in one well-water). For irrigation of agricultural land the heavy metal concentration of Fe, Co, Cu, exceeded the permissible levels.

According to table 4, the available concentration of heavy metal in soil samples are higher than control. In addition, the concentration of Cd, Mn, Cu, and Zn heavy metals exceed normal concentration level and are in the critical range. Similar results have been reported by numerous researches (Chen, 2000; Elliott and Stevenson, 1986; Webber and Singh, 1994). The results show the accumulation of heavy metals in soil due to long term application of EW.

Comparison of the result in table 5, with the permissible level show that the concentration of heavy metals except Zn and Fe do not exceed the permissible level in wheat shoot and grain. The Cu concentration is higher than sufficiency range in shoot and Fe concentration is higher than sufficiency rang in wheat grain. In alfalfa plant the concentrations of Cu and, Zn are in critical range and the concentration of Zn, Fe and, Cu are higher than sufficiency range. The wheat plant has the tendency to accumulate more Zn and, cu and less Fe in the root compare with the shoot. The concentration of Cd and, Pb in wheat and alfalfa were very low.

Plants uptake of heavy metals has increased by long-term utilization of industrial EW in agricultural land. Presently the quality of EW plays an important role in contamination of soil, plant, and water resources. The long-term application of EW may lead to serious contamination and accumulation of heavy metals exceeding the permissible ranges.

Conclusion:

Utilization of the none-prime water resources especially industrial and municipal effluent water in the arid region for agricultural land is needed. However due to chemical and biological limitation of EW, regarding the heavy metal concentration and it's introduction into human food chain it is recommended 1- To fully treat before discharge into environment, 2-It is used for plant with low tendency to accumulate heavy metals 3- Monitor water resources and take the necessary steps to prevent contamination of underground water resources.

Table 1- The mean and range of chemical properties and heavy metal concentration of well-water and effluent water(Moyen et étendue de concentrations en métaux lourds et les caractéristiques chimiques d'eau de puit et d'effluent).

.

Parameter	Well-Water		Effluent	
	Range	Mean	Range	Mean

pH	6.6-6.7	6.6	7.2-7.55	7.4
EC (dS m^{-1})	6.27-11	8.36	-----	1.49
BOD (mg l^{-1})	-----	----	145-246	178.7
COD (mg l^{-1})	-----	----	192-352	248
TSS (mg l^{-1})	-----	----	70-124	88.7
Fe (mg l^{-1})	<LOD*	<LOD	-----	0.12
Cu (mg l^{-1})	<LOD	<LOD	-----	<LOD
Zn (mg l^{-1})	<LOD	<LOD	-----	<LOD
Mn (mg l^{-1})	<LOD	<LOD	-----	<LOD
Cd (mg l^{-1})	<LOD	<LOD	-----	0.05
Pb (mg l^{-1})	<LOD	<LOD	-----	<LOD

* Less than detection level

Table 2- The mean and range of heavy metal concentration and chemical properties of soil irrigated with industrial and municipal effluent water(Moyen et étendue de concentrations en métaux lourds et les caractéristiques chimiques des sols irrigués avec l'eau d'effluent municipal et industriel).

Parameter	Well-Water		Effluent	
	Mean	Range	Mean	Range
pH	7.19	7-7.5	7.2	7.1-7.3
EC, (dS m^{-1})	4.44	2.01-6.17	9.85	7.85-11.84
OC, (%)	1.6	1.2-1.8	1.03	0.97-1.08
N, (%)	0.16	0.12-0.18	0.103	0.097-0.108
Available P, (mg kg^{-1})	67.3	43.4-82.3	8.7	5.3-12
Available K, (mg kg^{-1})	752	393.7-961	243.5	220-267
Mn, (mg kg^{-1})	28.99	15.56-41.50	16.9	15.96-16.41
Cu, (mg kg^{-1})	2.17	1.40-2.85	1.35	1.23-1.47
Cd, (mg kg^{-1})	<LOD	<LOD	<LOD	<LOD
Zn, (mg kg^{-1})	1.98	1.09-2.49	0.71	0.63-0.79
Fe, (mg kg^{-1})	11.9	7.27-20.67	5.6	5.49-5.71
Pb, (mg kg^{-1})	3.24	2.97-3.75	2.05	2.02-2.07

Etendue de la teneur en métaux lourds disponibles et totaux dans les sols traités avec l'eau d'effluent et de puit(temoin).

Table 3- The range of chemical properties of effluent and well-water(Etendue de caractéristiques chimiques d'eau d'effluents et de puit).

Parameter	Range	
	Effluent-Water	Well- Water
pH	6.5-8	6.8-7.6
EC (dS m^{-1})	0.57-30.6	2.04-25.0
$N-NO_3$	0.7-165.8	0.80-118

Hardness	200-2800	350-3400
TDS(mg/l)	364.8-19584	1280-14784
TSS (mg /l)	28-138	---
BOD(mg /l)	6-123	---
COD(mg /l)	31-517.2	---
Co (mg /l)	0.039-0.095	0.107-0.200
Cr (mg /l)	0.013-0.129	<LOD-0.252
Cd (mg /l)	<LOD-0.068	<LOD
Pb (mg /l)	<LOD-0.068	0.096-0.130
Zn (mg /l)	0.17-2.143	0.192-0.248
Cu (mg /l)	0.06-0.129	0.099-0.125
Ni(mg /l)	0.014-0.055	0.018-0.175
Hco_3^- (meq/l)	0-7.6	0-4.4
Cl^-(meq/l)	3.2-2000	13-1600
So_4^{2-} (meq/l)	0-47	0-69
Na^+(meq/l))	1.84-83	14-85
Ca^{2+}+Mg^{2+} (meq/l))	4-56	2-68
SAR	1.06-38.68	4.48-30.05

Table 4- The range of available and total concentration of heavy metals in soil treated with effluent water and check fields (well-water)(Etendue de la teneur en métaux lourds disponibles et totaux dans les sols traités avec l'eau d'effluent et de puit(temoin).

Element	Available Concentration (mg kg^{-1})		Total Concentration (mg kg^{-1})
	Effluent Water	Check	Effluent Water
Pb	1.6-12.2	1.1-1.4	51.3-57.7
Cd	<LOD-1.4	<LOD	10. 3-12.8
Zn	13.9-45.9	1.8-2.9	60.3-74.4
Mn	18.0-20.6	11.7-12.3	509.0-551.3
Cu	3.6-8.3	0.66-1.1	28.2-38.4
Fe	45.0-65.1	4.8-9.0	NM*

*** not measured**

Table 5- The range of concentration of heavy metals in Wheat and Alfalfa(Tableau 5: Etendue de la teneur en métaux lourds de blé et de luzerne.

Element	(mg kg-1 dry weight)		
	Wheat(shoot)	Wheat(grain)	Alfalfa(shoot)
Pb	<LOD	<LOD	<LOD
Cd	<LOD	<LOD	<LOD
Cu	6.1-7.1	4.6-10.8	26.7-52.5
Zn	6.1-8.6	15.9-50	51.7-66.7
Fe	145.5-158.1	90.5-93.6	291.7-297.5
Mn	NM*	NM*	18.3-39.2

*** not measured**

References:

[1] - Abbaspour, M., 1992. Environmental Engineering (In Farsi). Vol. 1. IAU Publication, Iran 550 pp.

[2] - Asadi M, K. Azari, 2003. Investigation of intensity and extend of soil and plants contaminations with Heavy metals, and concentration of heavy metals in table vegetable in Hamedan. The 8Th congress soil science of Iran.

[3] - Bazargan, N., 1988. Utilization of Nhar-Firoz-Abad swage effluent for irrigation of agricultural land, and the fate of heavy metals (In Farsi). M.S. Thesis. University of Tehran, Health Department.

[4] - Chen, Z.S. 2000. *Relationship between heavy metal concentrations in soils of Taiwan and uptake by crops, Department of Agricultural Chemistry, National Taiwan University*, Taipei 106, Taiwan, Roc.

[5] - Chen Z.S., S.L. Lo, and H.C. Wu., 1994. Summary analysis and assessments of rural soil contaminated with Cd in Taiwan. Project report of Scientific Technology Advisor Group (STAG), executive yaan, Taipei, Taiwan.

[6] - Elliott . L.F. and F.J. Stevenson. 1986. *Soils for management of organic waste and waste water*. Second printing, Soil. Sci. Am. Madison. Wisconsin, USA. pp. 650.

[7] - EPA/ ROC. 1998. *Environmental information of Taiwan, ROC*, Environmental Protection Agency (EPA), Taipei, Taiwan, ROC.

[8] - Feizi. M., 2001. Effect of application of municipal waste water on soil and plant in north area of Esfahan, The 7Th Congress Soil Science of Iran.

[9] - Mollahosseini. H. 2003. Investigation effects of application of municipal waste water on Maze. The 8Th congress soil science of Iran.

[10] - Rahmani H.R., 1997. Investigation of Pb, Cd, Ni, concentration in effluent water of selected industrials factory in city of Yazd. (In Farsi). The Research Deputy of Yazd University.

[11] - Rahmani H.R.1995. The soil leads pollution by on road vehicles in some highways of Iran (In Farsi). M.S. Thesis. Isfahan University of Technology, 140 PP.

[12] - Rahmani, H.R., 2001. The plant leads pollutions by on road vehicles in some highways of Iran (In Farsi). Ecology. No. 26 P: 77-83.

[13] - Rahmani, H.R. 2001. *The pollutant sources of soil, water and, plant in Yazd Province*. The final report. Approved National Scientific Iranian Government Board Proposal. Yazd University, Iran.

[14] - Rahmani, H.R. 2003. The optimum utilization of industrial effluent in agriculture. The final report of Esfahan Province for development. Planning and administration organization of Esfahan Province.

[15] - Torabian A. and S. Baghuri. 1996. Investigation of contaminations of untreated effluent municipal and industrial water in agricultural land in south Tehran (In Farsi). Ecology. Vol:22 No. 18 PP:33-45.

[16] - Webber M.D and S.S. Singh, 1994, Contamination of agricultural soils, Chapter 9, Soil health, Agriculture and Agric-Food Canada.