Abstract—an experiment was carried out to study the effects of cadmium and organic matter on soil pH, electrical conductivity, and cadmium availability as a factorial treatment arrangement in a completely randomized design with three replications. Treatments consisted of four levels of cow manure (0%, 0.75%, 1.5% and 3%) and five levels of cadmium (0, 2, 5, 10 and 20 mg kg$^{-1}$soil) filling pots of 2 kg soil. The results indicated that addition of cow manure to soil can reduce the soil pH and increase the electrical conductivity resulting in cadmium availability increase.

Keywords— Cadmium Availability, Cow Manure, pH.

I. INTRODUCTION

NOWADAYS, content of heavy metals in agricultural soils is increasing due to industrial wastes from various factories. High mobility and dynamism of cadmium (Cd) in soils as well as high uptake, significant toxicity and biological half-life of about 20 years establish it as a significant element among heavy metallic elements. Cadmium can cause complications such as hepatic and renal failure in humans [16]. Sources of cadmium in contaminated soils include the application of cadmium-rich phosphate fertilizers, sewage sludge, runoff and also leaching from land mines and metals deposition of metal smelters [22]. Adsorption of heavy metals is largely dependent to soil mixtures containing silicate clay, organic matter, and oxides of iron, aluminum and manganese [17].

Farm animal manures are considered as a good source of nutrients and also are used as an organic fertilizer to improve soil physical and chemical properties. Along with providing nutrients, organic fertilizers also affect the solubility of metallic elements in the soil [5]. Due to the presence of high affinity ligands or functional groups, soil organic matter highly associates with metallic cations [9]. Organic materials generally have diverse effects on the mobility and availability of heavy metals in soil which are largely dependent on the solubility of organic matters [10]. Almas et al. (2000) reported that addition of organic matter to soil increased the solubility of cadmium and zinc complexes formed by metal-organic matter [2]. Consequently, the use of organic matter can boost the solubility of these metals leading to acceleration of their leaching into groundwater.

Continuation of farm-animal-fertilizers utilization in calcareous soils can bring about the soil pH reduction [15]. Adsorption of heavy metallic elements is extremely reliant on soil pH [8,17]. Alloway (1990) reported that absorption and desorption of cadmium and zinc have shown more sensitivity to soil pH compared with copper and lead. Approximately, 10 to 50 percent of absorbed cadmium and zinc are exchangeable. Cadmium adsorption is increased threefold with each unit of pH from 4 to 7.7 [1]. Luo et al. (2010) observed that application of compost lessened the exchangeable Cadmium about 70% and was also effective in reducing the toxicity of it [14]. As the soil pH elevates, Hydrogen ion (H$^+$) is released from functional groups such as carboxyl, phenolic, hydroxyl and carbonyl. Then it causes metal cation binding [3]. Karca (2004) conducted a study of the effect of organic residues on soil extractable Cd. They found that soil pH reduced significantly during embedding on the soil. Also, application of tobacco dust significantly increased the DTPA-extractable Cd content in soil [12].

Effects of Cadmium and Organic Matter on Soil pH, Electrical Conductivity and their Roles in Cadmium Availability in Soil

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Organic matter can influence soil electrical conductivity through changing the pH level leading to changing of cadmium availability in the soil. Pirdshti et al. (2010) observed that increasing vermicompost quantity from 30 to 45 tons per hectare created a considerable increase in soil electrical conductivity. As stated by results, 45 tons of vermicompost per hectare (with and without chemical manure) was reported undesired for bean as a legume plant and relatively sensitive to salinity [19]. However, consensus has not been reached among researchers regarding the effects of organic matter on availability of cadmium. According to various effects of organic matter on availability of heavy metals in different conditions and also extent of soil contamination with cadmium, this study aimed to investigate the effects of organic matter on soil electrical conductivity and consequently availability of cadmium in soil.

II. MATERIALS AND METHOD

The experiment was conducted to the effects of cadmium and organic matter on soil pH and electrical conductivity as well as roles of these factors in availability of cadmium. A Completely Randomized Design (CRD) was performed in a factorial arrangement with three replications under greenhouse condition at Ferdowsi University of Mashhad, Mashhad, Iran. Desirable soil was collected from surface horizons (0 to 30 cm) of the research farm of Ferdowsi University of Mashhad. After air drying and passing of soil through a 2 mm metal sieve, some physical and chemical characteristics of it were analysed (Table I). Organic matter was also sieved with finer than 2 mm and then analyse for chemical properties (Table II). Cow manure was used as organic material in this experiment. Treatments consisted of five levels of cadmium Cd0=0, Cd1=2, Cd2=5, Cd3=10 and Cd4=20 mg Cd / kg soil, and four levels of organic matter OM0=0%, OM1=0.75%, OM2=1.5% and OM3=3% of cow manure. Organic matters were added to the soil containing field capacity moisture and then incubated at 22-25 °C for 35 days. Then CdSO4.8H2O was dissolved in distilled water and sprayed evenly to the soil. Once incubation period was completed, 60 pots were filled up with 2 Kg of the soil. After 65 days, soil samples were taken from each pot, air-dried and sieved through a 2 mm. Soil samples were measured for pH and electrical conductivity of the saturation extract by JENWAY conductivity meter 4310. Available cadmium in the soils was determined according to Lindsay and Norvell (1978) using extract DTPA-TEA by atomic absorption spectroscopy (Shimadzu AA-670) [13]. The results were analysed by ANOVA and considered significance by Duncan's multiple range test at level of 5%. Statistical tests were carried out using the SAS system 9.1 (SAS Institute Inc., 2003). Microsoft software Excel 2007 was used to plot graphs.

### Table I- soil properties before treatment

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil textures</td>
<td></td>
<td>Loam</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>7.85</td>
</tr>
<tr>
<td>EC</td>
<td>dS m⁻¹</td>
<td>1.60</td>
</tr>
<tr>
<td>OC</td>
<td>%</td>
<td>0.50</td>
</tr>
<tr>
<td>Nl</td>
<td>%</td>
<td>0.10</td>
</tr>
<tr>
<td>Pava</td>
<td>mg kg⁻¹</td>
<td>20</td>
</tr>
<tr>
<td>Cd ава</td>
<td>mg kg⁻¹</td>
<td>0.03</td>
</tr>
</tbody>
</table>

### Table II- properties of cow manure

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>pH(1:5)</th>
<th>Pt</th>
<th>OC (%)</th>
<th>C/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>dS m⁻¹</td>
<td>11</td>
<td>8.1</td>
<td>0.72</td>
<td>40</td>
<td>22.7</td>
</tr>
</tbody>
</table>

III. RESULTS AND DISCUSSIONS

A. Interaction of cadmium and organic matter with soil electrical conductivity

Organic matter influenced soil electrical conductivity significantly in all treatments containing 0.75%, 1.5% and 3% organic matter. Result indicated that electrical conductivity increased accompanied by organic matter volume (Fig. 1).
B. Interaction of cadmium and organic matter with soil pH

Fig. 2 indicates that increasing the level of cadmium had no significant effect on soil pH. But, the soil pH was significantly decreased in all cadmium treatments containing organic matter from zero to 3%.

In this study, pH lessened as salinity increased probably due to application of manure in the soil.

The mechanism of this increase can be explained by accumulating of cations in the soil solution as a result of salinity increase. The hydrogen ion (H⁺) positioned on the surface of colloids can be exchanged in the soil solution, consequently, declined the soil pH. Studies have displayed that decomposition of organic matter in soil, produces organic acids such as citric acid and malic acid causing the soil pH to drop and thereby increase in availability of nutrients [18].

C. Interaction of cadmium and organic matter on cadmium availability

Availability of cadmium significantly increased as content of total cadmium increased in the soil. According to Fig. 3, application of 20 mg Cd kg⁻¹ with 1.5% and 3% organic matter significantly increased the available cadmium levels compared with zero percent organic matter. However, application of organic matter containing other cadmium levels did not significantly change the cadmium availability. Del Castilho et al. (1993) reported that the solubility of zinc and cadmium increased hundred fold in a loamy soil treated with cow manure. Soil pH reduction was reasoned for this increase [5].

IV. CONCLUSION

The results indicate that application of cow manure in soil could increase the availability of cadmium content as a result of soil pH and electrical conductivity reductions. Perhaps the main reason for the increase is high producing levels of electrical conductivity of the manure in the soil. Mineral content of farm animal manures can be related to special reasons such as animal nutrition and diet. In addition, one reason for the reduction in pH can be referred to soil microbial activity resulting from addition of organic matter to soil as the soil CO₂ increases and consequently leads to decrease in pH value. The treatment Cd4OM3 showed the highest cadmium availability among all treatments. The reasons for this can be related to reduce the pH leading to increase in cadmium availability in soil. Existence of the highest electrical conductivity could be also another factor which was probably caused by application of high levels of cow manure. Accompanied by soil salinity, ionic strength of soil solution raised about 1.6 fold in the treatment with 3% organic matter compared with the zero percent. Thus, cations greatly increased in the soil solution. Replacement of the exchangeable cadmium on the surface of soil colloids with other cations present in solution, such as calcium, could accordingly induce more cadmium release into soil solution leading to increase in availability of this element in the soil.

REFERENCES