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Analysis of Kasur Reclaimed Soil for the Toxicity of Heavy Metals

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ABSTRACT

The agriculture in practice in the soil of Kasur reclaimed after drainage of tannery wastewater by installation of pretreatment plant poses a danger that the crops produced may not translate into entry of toxic heavy metals in the food chain Thus the analysis of the affected soil was due. .This article reports analysis of the reclaimed soil for toxic heavy metals such as Cr, Cd and Cu. The concentrations of total heavy metals were determined by standard methods of analysis and results were computed and compared with various international standards for agriculture recommended by international organizations, groups of experts and or individual researchers. The results revealed that the concentrations of total heavy metals (Cr, Cd and Cu) in agricultural soil are within permissible limits. Thus, it may be concluded that the reclaimed land area around Kasur tanneries is appropriate for agricultural practices.

Keywords: Analysis, Kasur, Reclaimed, Soil, Heavy Metals.

INTRODUCTION

Soil pollution by tannery wastewater has become a major subject of concern in all industrialized areas of different countries. The developing countries in particular have a common practice of disposing the effluents produced by tanning industries on the nearby land area or in big lagoons without any treatment of wastewater or any prescribed procedure of its disposal [1]. The deleterious substances from these effluents penetrate into the soil, leaving it unfit for agriculture [2]. The constant seepage of these effluents into the soil also leads to the pollution of groundwater reservoirs [3].

Kasur, a district of the Punjab in Pakistan has long standing tradition of tanning. A cluster of more than 240 tanneries in its suburbs produce a huge amount of wastewater and solid waste that contain different obnoxious heavy metal compounds such as those containing Cr, a carcinogenic metal [4-5].The tannery wastewater flooded more than 400 acre of land in the vicinity of the tannery cluster [6]. After the installation of the wastewater pretreatment plant to dispose of wastewater, the land has been reclaimed but there yet exists the danger that the heavy metal contaminants accumulated in the soil may ultimately become a part of the food chain because of the agricultural practices being carried out in the area [7].

There are several reports in literature about the deleterious effects of harmful pollutants on nature of the soil. The source of all the pollutants whether organic or inorganic is the discharge of the industrial wastewaters [8]. The goal of this study is to evaluate the reclaimed soil for suitability of agricultural practices with respect to total heavy metal content (Cr, Cd and Cu) by comparing with specified international standards.

MATERIALS AND METHODS

Study Area: The present study deals with approximately 400 acres of land area contaminated with tannery waste water in Kasur district, Pakistan. The areas along Deepalpur Road, Mangal Mandi Road, Ali Garh, Deen Garh and Tannery Wastewater Pre-treatment Plant, Kasur were covered as shown in

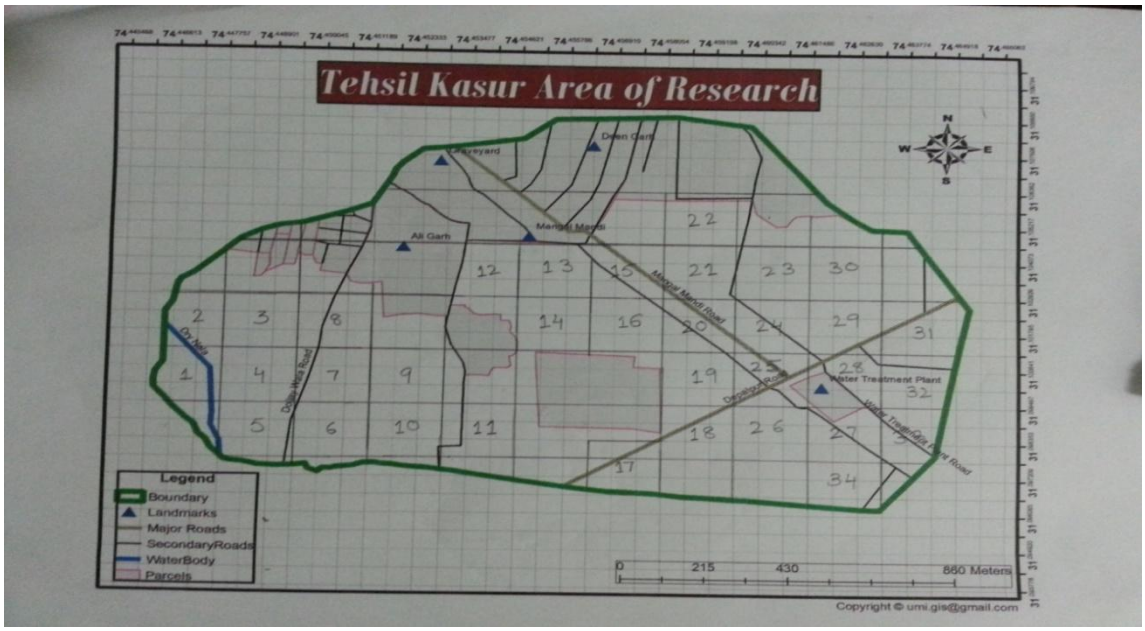

Fig.1. Map of reclaimed areas and tannery wastewater pre-treatment Plant, Kasur showing sampling points on grid.

Soil Sampling: Total 34 soil samples were collected from each grid (one grid covered an area of 9 acres). The sample was collected in a clean polythene bag. Because the chemical preservation of solids is generally not recommended and; the samples were kept at room temperature and the **b**ag was labeled with the specifications. Every sample was labeled with sample type, date, time, sample identification number, and grid number. Sampling was carried out according to the guidelines given in US-EPA Field Sampling Guidance Document #1205. Decontaminated equipment was used to collect the soil samples. Grab samples were collected using an auger which was transferred into an appropriate sample homogenization container. The sample was, mixed thoroughly and impurities like roots, stones, pebbles and gravels were removed. Bulk was reduced to about half to one kilogram.

Total Metal Content Analysis by ICP-MS: The total metal content of three metals Copper, Cadmium and Chromium was determined by ICP-MS (Inductively Coupled Plasma Mass Spectrometry). Acid digestion of the soil samples for ICP spectroscopy was accomplished with a mixture of perchloric acid and nitric acid (1:2). Acid digestion method was used for multi-elemental analysis because it is preferably used

for flame emission spectrophotometer. 5.0 g of soil was weighed and17.5 mL of double acid mixture was added. Brown fumes appeared in the glass digestion tube and the color of contents in the tubes became light yellow. The tubes were placed n a hot plate and heating was continued at 175˚C till clear transparent solution with white dense fumes was formed at the end. These copious white fumes were the indication of complete digestion process. However, this clear solution may have slight amber to yellowish tint which usually disappears when distilled water is added. Digestion tubes were cooled Using a volumetric flask the volume was made to 50 ml with distilled water or as desired when contents in the digestion tubes were still warm/ All samples were then filtered using Whatman No.42 filter paper. The filtrates was transferred to plastic bottles and stored in a refrigerator. The digests were then directly run on ICP-MS for analysis. Care was taken that samples were not dried on hot plate during digestion.The total metal concentration for chromium (Cr mg/kg), Copper (Cu mg/kg) and Cadmium (Cd mg kg^{-1}) were determined in all reclaimed soil samples from all the grids and compared with four different standards [9-12].

Statistical Analysis: To interpret the data descriptive statistics was applied which included mean and standard deviation (± SD).

RESULTS AND DISCUSSION

The results of chemical analysis of soil samples of Kasur reclaimed soil are exhibited in fig.2 which shows variability in concentrations of heavy metals.

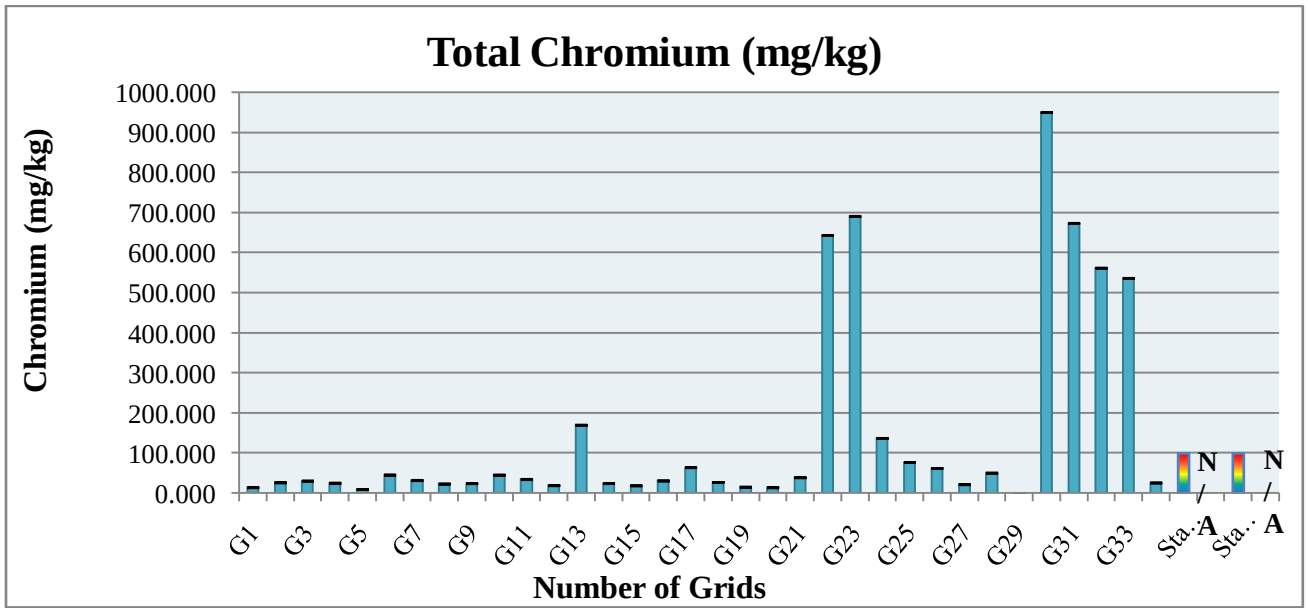

Fig. 2: Graph illustrating the mean values of Total Chromium for soil samples from all grids and their comparison with the proposed permissible limits of Total Chromium in soil by *Standard 1, **Standard 2, ***Standard 3 and ****Standard 4

*Standard 1: International Agricultural Soil Standards (Alloway, 1990), **Standard 2: Indian Standards of Soil (Awasthi,2000), ***Standard 3: Permissible limits of heavy metals in soil given by European Community Commission (ECC, 1986), ****Standard 4: Permissible limits of heavy metals in soil given by Rowell, 1994

Fig.2 shows that the highest mean value of total Cr is observed at G_{30} which is 950.687± 0.035 (mg kg^{-1}). The lowest mean value is observed at G_6 which is 9.987± 0.065 (mg kg^{-1}). According to standard 1 and standard 3 the permissible limit is 100 (mg/kg). Most of the result values are in permissible limit with

these standards except for grids G_{13}, G_{22}, G_{23}, G_{24}, G_{30}, G_{31}, G_{32} and G_{33}. The results could not be compared with standard 2 and 4 (Ref) because there is no permissible limit given by these standards. The reported Cr concentration in tannery contaminated soil of Peshawar is 0.810 - 100.2 mg kg^{-1} [13], and the same is the result observed in the analyzed soil samples except a few.

Fig 3 shows the lowest mean value of total Cu with ± SD at grid G_1 which is 12.42± 0.03 (mg kg^{-1}). The highest mean value with ± SD is observed at grid G_6 which is 63.847 ± 0.064 (mg kg^{-1}). All the result values are below permissible limits according to standard 1, standard 2 and standard 3 which are 100 (mg kg^{-1}), 135-270 (mg kg^{-1}) and 50-140 (mg kg^{-1}), respectively. According to standard 4 only grid G_1, G_2, G_{11}, G_{20}, G_{21} G_{23}, G_{24}, G_{25}, G_{26}, G_{27}, G_{28}, G_{29}, G_{31}, are in permissible limit which is 20 (mg kg^{-1}).

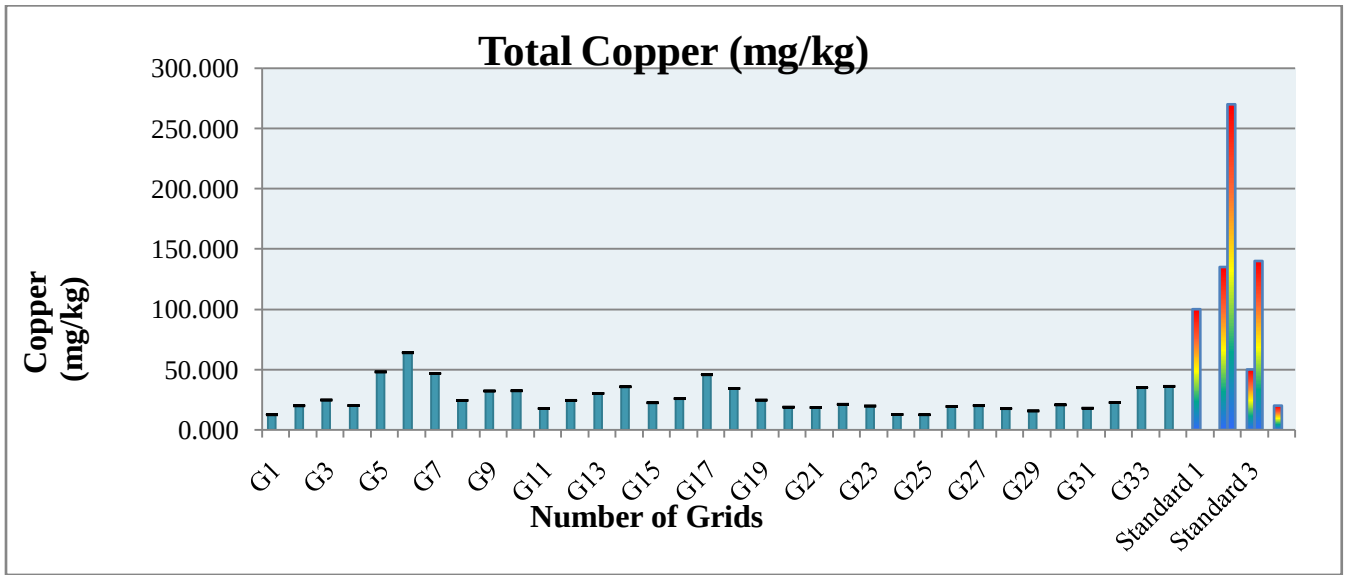

Fig. 3: Graph illustrating the mean values of Total Copper for soil samples from all grids and their comparison with the proposed permissible limits of Total Copper in soil by *Standard 1, **Standard 2, ***Standard 3 and ****Standard 4, Standrds1,2,3,4 are above

Fig. 4 shows the total the greatest mean value with ± SD Cd at grid G_{33} which is 6.843± 0.1 (mg kg^{-1}). The lowest mean value with ± SD is observed at grid G_{14} which is 0.13± 0.03 (mg kg^{-1}). In standard 1 the permissible limit for total Cd is 1.0 (mg kg^{-1}), in standard 2 the permissible limit is 3-6 (mg kg^{-1}), in standard 3 the permissible limit is defined as 1-3 (mg/kg) while in standard 4, the permissible limit is given as 0.5 (mg/kg). According to standard 1 very few values are in permissible limit which include grid G_1, G_2, G_3, G_4, G_7, G_8, G_{11}, G_{12}, G_{13} and G_{16}. With respect to standard 2, only G_{22}, G_{32} and G_{33} exceed the permissible limit. According to standard 3, grid G_{22}, G_{29}, G_{31}, G_{32}, G_{33} and G_{34} only exceed the permissible limit. Grid G_2, G_3 and G_4 are only in permissible limit when the present study was compared with the standard 4.

The concentrations of heavy metals in Kasur soil were reported in previous studies as Cd (2- 3.4 mg kg^{-1}), Cr (54.1-210.2 mg kg^{-1}), and Cu (31.2-60.8 mg kg^{-1}) [14], which resemble the values determined here with some variations. In preceding study the findings for total heavy metal concentrations in the soils of tannery adjacent to Ejersa area of East Shoa, Ethopia which are Cr (92.86 – 126.17 mg kg^{-1}), Cd (0.19 – 0.74 mg kg^{-1}) and Cu (10.12 – 17.64 mg kg^{-1}) [15] are similar to the current findings.

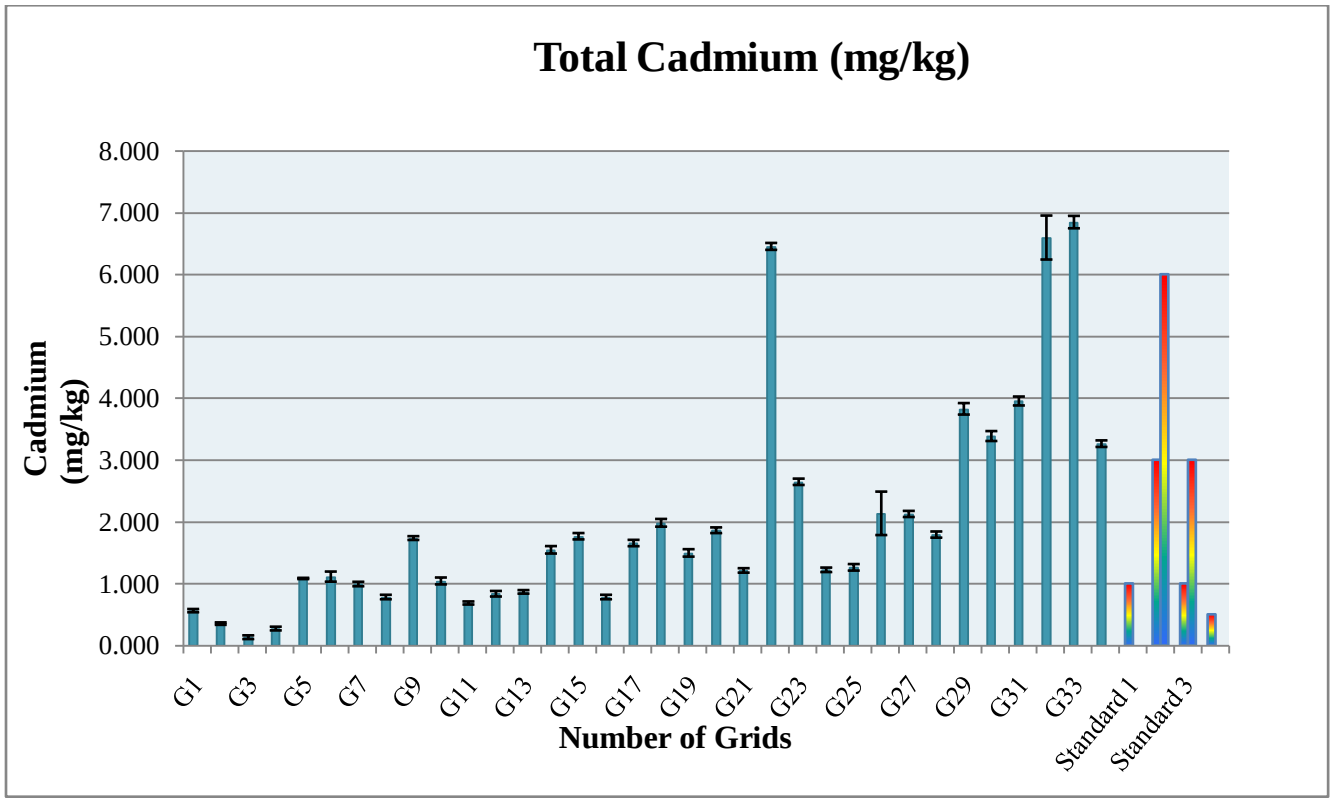

Fig. 4: Graph illustrating the mean values of Total Cadmium for soil samples from all grids and their comparison with the proposed permissible limits of Total Cadmium in soil by *Standard 1, **Standard 2, ***Standard 3 and ****Standard 4, Standrds1,2,3,4 are above

APPLICATIONS

The work reported in this article is of great applied value because it provides farmers of the tannery wastewater polluted area o Kasur to undertake agricultural practices in the soil polluted by tannery wastewater subsequently reclaimed by installation of tannery wastewater pretreatment plant without hesitation except some pieces of land where they can do so after its treatment with phytoremediation.

CONCLUSIONS

From the foregoing discussion, it may be concluded that the reclaimed land area around Kasur tanneries is almost appropriate for agriculture practices. In most of the samples, the mean values of total metal concentrations of all the heavy metals (Cr, Cd, and Cu) in the studied agricultural soil are within permissible limits prescribed by most of the compared standards with very few samples exceeding limits. As cultivation is harmful in few areas where heavy metal concentration is exceeding, phyto-remediation should be considered to bring the exceeding limits of metals within permissible limit.

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