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（Summary）

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In Pakistan, tannery industry is one of the major revenue generating sectors after textile. Large number of tannery units is in operation throughout the country and are contributing to the economy of country. But on the other hand these industries are releasing the untreated hazardous effluent to the environment which poses a serious health risk to the people living in that area. Tannery effluents are ranked as the highest pollutants among all industrial wastes as tanneries are major source of chromium contamination. In this back ground Kasur tannery area was selected so as to investigate the environmental situation. With the basic objective to characterize the site regarding the source identification and to determine the extent of total chromium in entire area, this research work was conducted. Kasur research site, constituting of different components like wastewater carrying drains, stagnant ponds and tannery units, was thoroughly investigated in order to define the existing environmental condition regarding solid waste management and effluent discharge. Improper tannery effluent waste disposal resulted in the formation of huge stagnant ponds adjacent to the tannery area which persisted for long duration consequently becoming a major source of creating mass flux into the soil along with infiltration. There were different Phases of the research, mainly divided into preliminary and confirmatory phases. During these phases, the soil and groundwater samples were taken covering a wide range of area. The basic purpose of the analysis was to understand the spatial variation of the contaminant, which was chromium in this research. In order to investigate the seepage concentration in soil detailed field experimentations were conducted. Health survey was also conducted in the localities adjacent to the tannery areas and drains in order to observe the effect of contaminated groundwater on health. As a supporting data information random groundwater sampling was also conducted which showed extremely high concentrations of groundwater in tannery area up to 90 mg/L and 10 mg/L of concentration was also observed on farther distances. On the basis of these results detailed investigations regarding wastewater carrying drains, soils in the surrounding areas and groundwater was done. These drains carried huge amounts of discharge and large volumes of wastewater which overflowed from these drains. It further caused stagnant pond like impact and became a continuous source of seepage into the soil. Wastewater samples from drains showed extremely higher concentrations of not only total chromium but other chemical parameters as well. There were four drains in the research area which were analyzed on seasonal basis to observe the yearly variations of chromium concentrations in these drains. Chromium concentrations in wastewater samples as high as 2,050 mg/L posed a potential risk of soil and groundwater contamination. Due to inefficient treatment plant immense quantities of wastewater were left untreated and diverted into other drains for further carriage up to farther distances. Thus not addressing the alarming situation of spreading of contaminants rather shifting the contamination from one site to other.

Surface soil samples were collected from wide spread range in order to observe the possible effect of wastewater overflowing from the drains. Considering high concentrations of total chromium in wastewaters, the downstream side of drains was focused to carry further intensive investigations. In this regard it was found surface soil samples showed higher concentrations up to 180 mg/kg in the areas adjacent to Drain 3, which had shown immense overflows. Surface soil from other areas showed no significant results even up to distance of 10 kilometers on downstream side. Furthermore in order to investigate the effect of seepage from the unlined drain coming from the center of city along with effect of overflow from Drain 3, soil bores were conducted on downstream side. These eight (8) soil bores were sampled at every depth of 1.5 meters up to 30 meters with the purpose to observe chromium concentration variation at every depth and to find out the soil texture beneath the soil. The soil samples were analyzed for leaching capability of soil and total content retention for both total chromium and hexavalent chromium. It was observed that higher the silt and clay proportions higher the retention of total chromium. However no significant concentrations were found at any depth for both leaching and retention tests. It depicted that seepage effect was cluster based due to wastewater intrusions into soil and then groundwater however it percolated up to considerable depth of soils as higher concentrations up to 91.2 mg/kg for total chromium and 16.1 mg/kg for hexavalent chromium as observed at depth of about 17 meters. Groundwater was also monitored periodically by installing eight (8) monitoring wells in the downstream area in order to find out the concentration trend of total chromium in groundwater. The results obtained did not show any significant concentrations in the groundwater with maximum level up to 0.04 mg/L. However seasonal trend of variation in groundwater samples was observed. FEMWATER model was used in order to conduct contaminant transport simulations in the area. Three main scenarios were developed in order to simulate the site for contaminant movement. First scenario was considered with adverse condition with untreated wastewater discharged into open fields converting them into stagnant ponds adjacent to tannery area with no treatment plant and drains in the area and this scenario was considered for duration of 20 years from 1980 to 2000. Second scenario was for no contaminant release into the environment due to properly collected wastewater systems and treatment plant while third scenario was due to improper handling of wastewater resulting in the overflow of wastewater in immense amounts. The result of simulation showed very slow movement of contaminant plume indicating that stagnant pond in the tannery area has not affected the downstream side however with the passage of time contamination may spread downward. The findings of health hazard studies described the potential threat to health of the residents of surrounding areas of tannery units due to drinking of untreated groundwater which is contaminated by the improper tannery effluent management and its treatment. Finally, based on the findings and conclusion of the research work, recommendations were made to cope with the adverse environmental conditions at site. Natural attenuation was proposed to be the most viable option in order to reduce the contaminant levels in the soil and groundwater.