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Determination of Soil and Water Contamination around an Industrialized Town, Kazanli, Mersin, Turkey

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In this study, concentrations of selected metals, namely chromium and nickel, in groundwater and soil were investigated. It was found that extensive chromium and nickel levels in soil that had been used for building materials and this could probably impair public and environmental health, such as in sea turtles, in the area. Toxicological risk assessment from water quality criteria indicated that aquatic toxicity from both acute and chronic nickel and chromium does not exceed estimated ecotoxicology levels.

Key Words: Kazanli, Mersin, Turkey, Chromium, Nickel, Groundwater, Soil contamination.

INTRODUCTION

Kazanli (population 10,812 in 2000) is located between Adana and Mersin provinces in Turkey. Both beach sediments and industrial solid wastes have been blamed to contaminate groundwater and soil around the district.

Chromium(VI) is remarkably dangerous to living organisms due to its highly oxidizing properties; therefore, permissible chromium content in water is regulated tightly. Chromium(VI) acting as electron acceptor is only needed in trace amounts for genetic growth of living beings[1]. Hexavalent chromium and nickel are noted to act as sensitizers responsible from the pathophysiological point of view[2]. Among inorganic carcinogens, both chromium(III) and nickel are potential creature carcinogens.[3] Kara *et al.*[4] noted that retired volcanic fields have more nickel concentrations than normal soils and heavy fertilizer use affects metal levels in agricultural soils. It is estimated that worldwide average total chromium level of soil is 37 mg/kg. Similarly, La Grega *et al.*[3] gave mean nickel concentration in soil as 40 mg/kg. As one of the TCLP (Toxicity Characteristics Leaching Procedure) metals, maximum chromium level in TCLP extract[3] should not be more than 5 mg/L.

Kazanli, which has notable industrial plants, has more than 1600 people

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working in the industrial sector. In early 2005, some people living within the district declared that they suffer from serious diseases (such as cancer) and blamed industrial plants causing these diseases. In late 2004, some waste from settlement tanks of an industrial plant accidentally spilled from the tanks. In a short time period, the failure was solved. This study was designated to illustrate the metal pollution in the district. This study does not intend directly to blame the industrial plants as contamination sources due to the fact that hazardous waste materials management law has a remarkably short past (15 years) in Turkey. The industrial plants in Kazanli have been operational since the 1930's.

EXPERIMENTAL

Five different soil and groundwater samples from Kazanli were obtained by the principal author of this paper. The representative samples were stored in sterile sampling containers until their transport to Mustafa Kemal University Scientific Research Center (MKUFAM) Central Laboratory. The samples were taken on January 10, 2005 and all the analyses were completed on January 13, 2005. The metal levels were read using Varian® Liberty Series II inductively coupled plasma atomic emission spectrometer (ICP-AES) equipment. Total five reference points were chosen prior to determination of metal concentrations and at least 99.5% correlation was achieved.

Acute and chronic metal toxicities were estimated using the following equations given by La Grega *et al.*[3]

$$\text{Acute Cr(III)} = e^{[0.819 \times \ln(\text{hardness}) + 3.688]}$$
$$\text{Chronic Cr(III)} = e^{[0.819 \times \ln(\text{hardness}) + 1.561]}$$
$$\text{Acute Ni} = e^{[0.846 \times \ln(\text{hardness}) + 3.3612]}$$
$$\text{Chronic Ni} = e^{[0.846 \times \ln(\text{hardness}) + 1.1645]}$$

RESULTS AND DISCUSSION

Fig. 1 shows the location of the district of Kazanli. It is located next to the Mediterranean sand beach which is used by sea turtles to lay their eggs and alluvial material around the town is the dominant soil structure. Two fill materials used in a rainwater discharge (drainage) canal and in basement floor of a residential place, a soil sample near the road asphalt plant, an empty space close to an apartment site and an agricultural field were examined to determine the levels of chromium and nickel in the area.

In Fig. 2 average element concentrations, namely hexavalent chromium, total chromium and total nickel, are illustrated (regardless of sampling depth). As shown, empty space from the apartment site has a notable metal contamination in soil.

Fig. 3 illustrates metal levels in soil as a function of sample depth. The sample taken from empty space of the apartment site is not shown on the same graph due to the fact that large total (4451, 2473 and 1156 mg/kg, respectively, on 15, 45 and 75 cm depths) and hexavalent chromium (2.12, 1.35 and 1.27 mg/kg respectively) as well as total nickel concentrations (196, 360 and 446 mg/kg with respect to sampling depth) were detected on this sample.

Chromium should not exceed 100 mg/kg and nickel should not exceed 50 mg/kg as acceptable and maximum values in soil. In south-west Louisiana[5], coastal sediments were found to include 10–30 mg/kg chromium. Only one sample examined in Kazanli (near municipal asphalt plant) was found to have

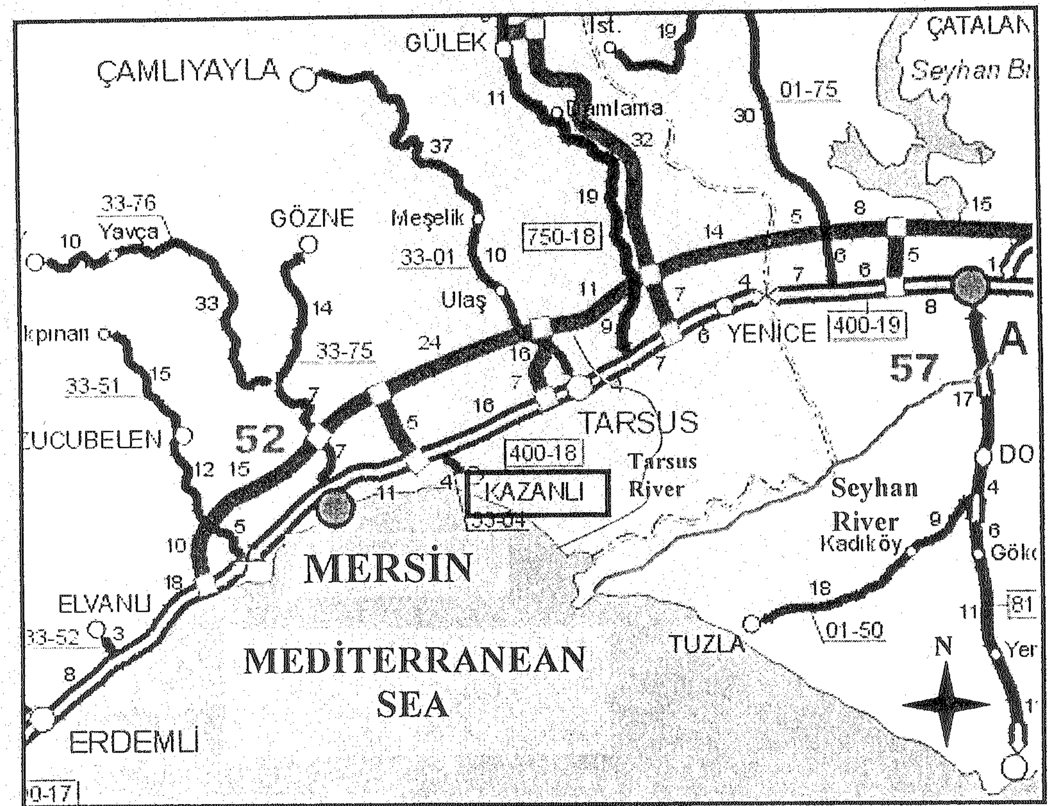

Fig. 1. Map of Kazanli and its surrounding area

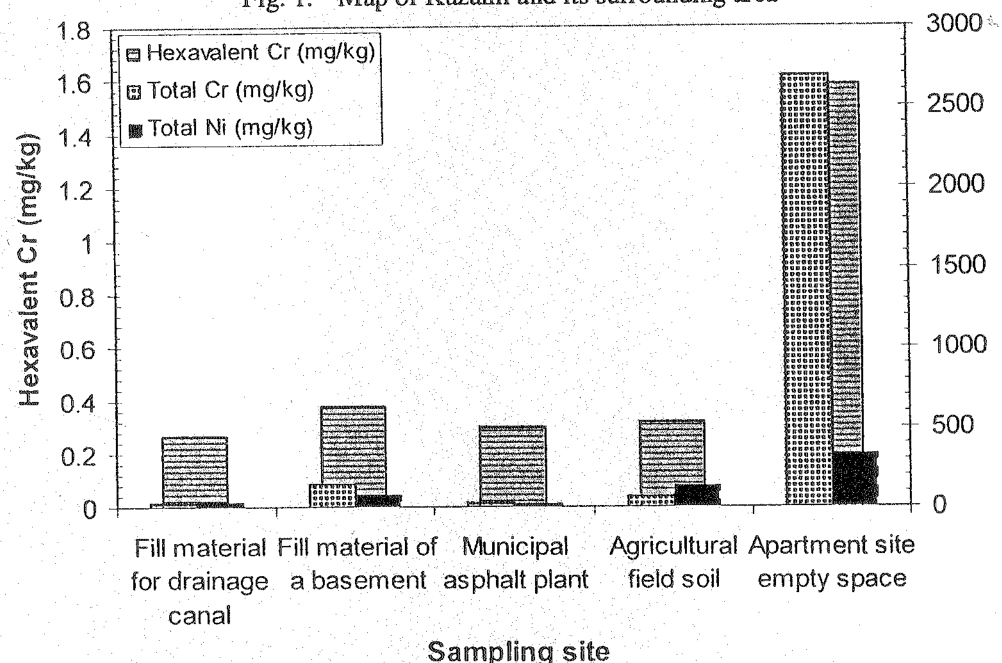

Fig. 2. Average element concentrations (regardless of deepness) (n = 3 for all samples) in soil (total nickel and total chromium levels are on the right (secondary) y-axis)

total chromium level fall between these concentrations. Soil chromium content ranging from 1.7–73 mg/kg, with a median of 8.4 mg/kg, was found to never exceed the regulatory limit (120 mg/kg) in Naples, Italy[6]. Total chromium and

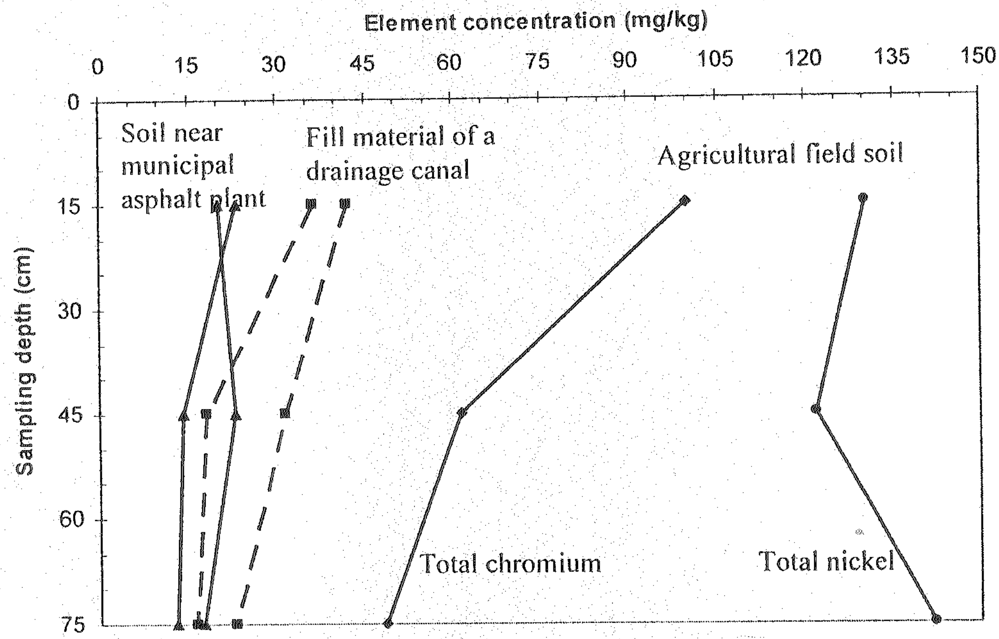

Fig. 3. Element concentrations in soil as a function of depth in different samples.

nickel regulatory levels in soil are 64 and 50, 150 and 120 and 120 and 35 mg/kg in Canada, Italy and Sweden, respectively[7]. According to Turkish soil quality standards, total nickel and total chromium should be below 75 and 100 mg/kg in soils that have pH > 6. Three samples examined in the present study were found to exceed this limit from both total chromium and nickel levels. Interestingly, these samples belong to apartment site empty space, agricultural field and residential dwelling basement fill material. This might pose a risk to the residents living in/near these locations if contaminated soil is used for certain purposes.

Fig. 4 illustrates element concentrations in groundwater. All samples were taken from 4 m below groundwater level. Averaging hardness as 100 mg/L

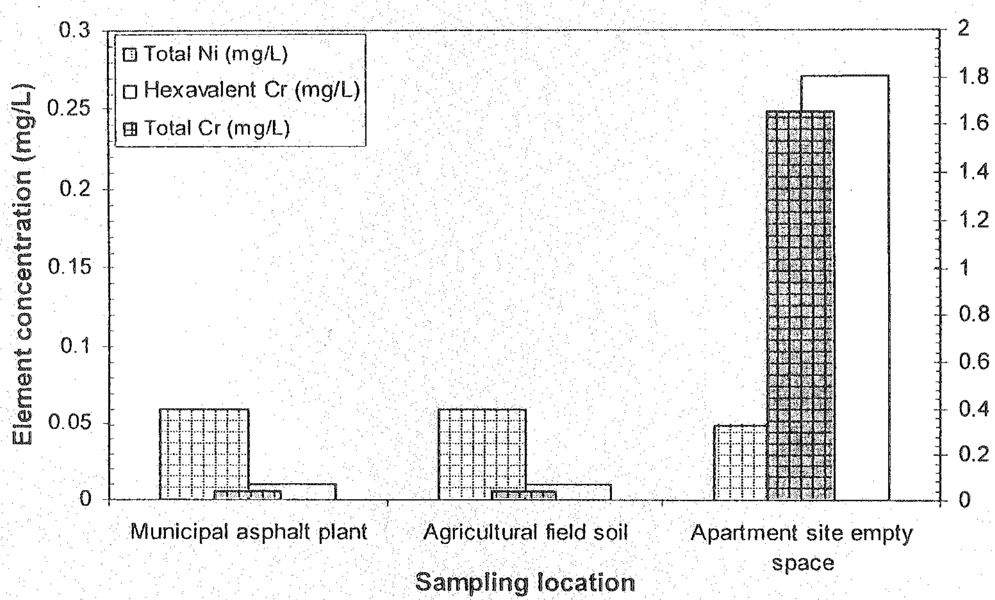

Fig. 4. Element concentration in groundwater in Kazanli (only total chromium is on the right (secondary) y-axis).

$CaCO_3$, acute Cr(III) toxicity was found to be over 1.74 mg/L and chronic Cr(III) toxicity was computed to be over 0.21 mg/L. Even the highest total chromium level of groundwater obtained 4 m below land surface was detected to be 1.66 mg/L. Based on this result, it can be estimated that acute chromium toxicity value was not exceeded in the apartment site empty space. Parallel to this finding, acute and chronic nickel concentrations in the aquatic environment were calculated to be 1.42 and 0.157 mg/L, respectively. From this point of view, nickel concentrations detected in groundwaters did not exceed the criteria.

It was found that a notable chromium and nickel pollution in soil and water exists in samples obtained from Kazanli. Industrial wastes that have been blamed to be responsible for some corrosion in buildings and increase in cancer cases cannot be fully classified as the most important responsible factor. In addition, other factors, *e.g.*, climatic conditions and living standards can have important roles in health conditions of residence in Kazanli. Both a serious environmental management plan for better control of industrial wastes and a well-planned education should be implemented to reduce prospective risks associated with the use of contaminated sediments as construction materials. As a conclusion, a responsive management plan for such contaminated land should be launched to minimize risks associated with high level metal containing soils in Kazanli.

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