Geochemical Evaluation of Lead Trace Element in Streambed Sediments

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Abstract: - Lead trace element was analyzed in streambed sediment samples collected from 30 sites in the Veysian River Watershed in Lorestan province, west of Iran. Sites sampled represented agricultural, mining, mixed, urban/rural, and recreation land uses and background conditions. Lead trace element was detected in streambed sediment samples collected at all sites. Because of it's concentrations in the study unit and its toxicity to aquatic biota, lead analyzed as detailed. Lead concentration in streambed sediment was highest at an urban effluent site in the Veysian River Watershed physiographic county. Sites affected by mining, generally exceeded the background concentrations by orders of magnitude for lead. Although natural background concentrations of lead may be high in the mineralized areas where mining occurs, mining land use practices cause increased concentrations of lead. The concentration of lead on streambed sediment generally increases as particle size decreases. Lead concentrations in streambed sediment samples collected from the Veysian River Watershed were compared to concentrations from other study units. More relations were observed between two study units, Veysian River Watershed and Southern Caspian Basin. The highest concentrations for lead in streambed sediment for two study units, Veysian River Watershed and Southern Caspian Basin, were at sites affected by urban activities. Particle size determination of the samples indicated that the mining sites in the Veysian River Watershed physiographic county contained a larger percentage of silt/clay particles than other sites. Higher percentages of silt/clay particles in combination with mining land use may be a factor for higher concentrations of lead at these sites.

Key-Words: - Geochemical evaluation; Streambed sediment; Veysian River Watershed; Background conditions; Aquatic biota; Physiographic county; Mineralized areas

1 Introduction

Studying the processes and patterns of an ecological system that integrates both social and environmental variables requires careful constraint of complex models, especially in the case of anthropogenic fluxes of toxic trace elements and materials. Lead trace element is a potent poison and already widely contaminates alluvial ecosystems [1]. It is harmful in very small amounts (as are most heavy metals). Lead is toxic to humans of all ages through ingestion and inhalation. Children are more susceptible because they still have developing nervous systems and are often exposed during normal play activities [2]. Once absorbed into the human subjected by contaminated system, lead combines with and inhibits the functioning of certain enzymes (often with severe physiological or neurological consequences). Short term exposure to high doses of lead can make human seriously ill. Long term overexposure can cause numerous health problems, including: 1) anemia and other blood disorders; 2) damage to your nervous system and brain; 3) kidney disease; and 4) reproductive impairments in men (impotence and sterility) and women (decreased fertility, abnormal menstrual cycles, and miscarriages). The National Water Quality Assessment (NIWQA) program is a new program of the I.R.Iran. The program is interdisciplinary and integrates chemical, physical, and biological data to assess the waters quality at local, regional, and national levels [3]. One components of this integrative assessment is to examine the occurrence and distribution of selected trace elements in streambed sediment samples on a watershedwide scale. The NIAWQA program emphasizes the use of consistent protocol methods for a nationwide approach. Trace elements in aquatic systems may be attributed to natural geologic sources or to past and present land uses [4]. Although lead may originate from natural sources, human activities such as mining, agriculture, and urbanization can affect its concentration and spatial distribution [5]. Characterizing the geographic distribution of lead constituents with regard to background conditions and sources is the main goal of the assessment. The use of streambed sediment analysis provides an understanding of the fate, distribution, and potential effects of lead constituents. The Veysian County in west of Iran is one of the suitable watersheds selected for the regional assessment. This report: (1) identifies the occurrence and spatial distribution of lead in streambed sediment at sampled sites; (2) determines the relation of lead in streambed sediments to natural and anthropogenic factors; and (3) compares the results with some similar studies in Iran and U.S. Streambed sediment samples for this study collected from distributed sites of Veysian County, in October 2005.

2 Description of Study County

Study unit of Veysian River Watershed (VRW) in west of Iran is situated in the center of Lorestan province (Fig.1). The primary river in the study unit, the Sarab Robat River, originates from the mountainous terrain above Robat County (Chakriz mountain ranges) and flows about 6.2mi northwest into Khorram Abad city. After conjunction point of Sarab Robat River to Karganeh River, it is nominated Veysian River (sometimes it is nominated the Khorram Abad River). The Veysian River drains southwest into the Kashkan River in southern Lorestan. Its headwater and most of the tributaries originate from the mountains that form the northern boundaries of study unit. Veysian County is situated in simple folded zone of the Zagros (west of Iran). Elevations range from more than 6,300 ft. at the headwaters to less than 3,300 ft. at the confluence with the Kashkan River near Cham Anjir County, Southern Lorestan. The major population center in the area is the city of Khorram Abad. Geology structure of study watershed is simple, orderly folded and composed of anticlines ranges that compressed together with usually vertical axial plain and NW-SE trending. The geology exposed at the surface and underlying the basin is varied. Stratigraphic situation of study unit is very complicated and there are different exposures of folded Zagros depositional units. Mesozoic rocks crop out in the western part of the drainage basin southwest of Robat forming the high rugged mountainous area of the VRW. Cenozoic sedimentary rocks crop out in the northern, eastern and southwestern parts of the drainage basin. The headwaters of the VRW are underlain by the Tertiary carbonate rocks that formed as a result of a lower Miocene age episode (Aquitanian) of sea level rise followed by a later episode of sea level retrogression and deposition of shallow carbonates of Asmari formation (Burdigalian-Vindobonian). This area of the VRW above Robat has been extensively collapsed, hydrochemically altered, and mineralized by Holocene weathering activity. The extent of mining and urbanization activities within various portions of the VRW can be estimated from the distribution of mining and urbanization claims and minerals availability system records [6] within the basin. Mineral deposits in the Red Mountain district in the southwestern part of the Robat county, the Doureh district in the Sephid Kouh anticline, western part of the drainage basin,and the Khorram Abad district along the southern and southwestern margins of the Dareh Garm county, north of the city of Khorram Abad

[1] comprised the majority of the mineral production. Some of the porphyry lead deposits are surrounded by small iron bogs at the surface. Iron bogs are found elsewhere within the watershed associated with springs flowing from decomposed and weathered areas within the basin [7].

3 Sample Collection and Analysis

Collection and field processing of streambed sediment for analysis of lead trace element followed established NAWQA (National Water-Quality Assessment of U.S) protocols [8,9]. Streambed sediment samples were collected at 30 sites throughout the VRW study unit (Fig.1). Streambed sediments were collected from undisturbed, continuously wetted, depositional zones in the stream channel. Depositional zones were selected to represent upstream effects and various flow regimes. Sampling was confined to the upper 10-15cm of streambed sediment to insure that the most recent deposition was being sampled. Each depositional zone at a sampling site was subsampled at several locations, and the subsamples were composited. Field processing of streambed sediment included wet sieving samples through a 43µm sieve for the trace element analysis [9]. Streambed sediment samples were analyzed for lead trace element at the Chemistry Laboratory of Azad University, Zahedan Branch, by this report's authors. Replicate samples were collected for streambed sediment for quality assurance/quality control. The difference between field replicate samples for streambed sediment ranged from 10 to 15 percent.

4 Lead Trace Element in Streambed Sediments

Lead is unevenly distributed in the aquatic environment and, by the process of absorption, tends to be associated with fine grained sediment. Lead is toxic to aquatic biota [10]. The concentration of lead in streambed sediment is strongly affected by the particle size distribution of the sample [11]. The lower level of determination (LLD)[1] for lead in streambed sediment is 4ppm [12]. Because of its concentrations in the study unit and its toxicity to aquatic biota, lead analyzed as detailed. One approach to evaluate elevated concentrations is by comparison to reliable studies in Iran and other countries (Table 1). To determine the extent of contamination in an aquatic system by means of the trace element in streambed sediment, the natural level (or the background concentration) needs to be established. A watershed specific background concentration for lead was determined by plotting cumulative frequency curves [13] for the VRW study unit for data from 30 streambed sediment samples. The concentration at the first break point was designated as the background concentration (Fig.2). Lead had determined background concentrations of 64ppm (Fig.2; Table1). Lead concentrations greater than the background concentration were considered elevated and may have been affected by natural or human activities. Site 15, an urban effluent site, had four times the background concentration. Sites 17 and 18 (sites chosen to represent background conditions) had lower concentrations of lead than the background concentrations for the watershed. Because of the extent of mineralized areas in study unit, the concentrations of lead could represent natural conditions at some sites. Twenty seven sites exceeded background concentration for the VRW (Fig.2). Sites affected by mining (9, 26, 27, and 28) generally exceeded the background concentrations by orders of magnitude for lead. Although natural background concentrations of lead may be high in the mineralized areas where mining occurs, mining land use practices cause increased concentrations of lead [14]. Lead concentrations in streambed sediment samples collected from the VRW were compared to concentrations from three other study units (Table 1). Comparison of streambed sediment sample background concentrations for the four study units indicated significant differences for lead between Veysian River Watershed and two basins, Upper Colorado River Basin

[1]The lower level of determination is three times the standard deviation of the blank added to the average of the blank [12].

(UCOL) and Front Range Urban Corridor, Colorado (FRUC), and indicated that lead was significantly different among these study units. Regional similarities in streambed sediment concentrations occurred more often than regional differences among the study units. More relations were observed between two study units, Veysian River Watershed and Southern Caspian Basin (SCB), rather than among all four study units. All four study units have agricultural, mining, urban/rural, and recreation land use. The highest concentrations for lead in streambed sediment for two study units, VRW and SCB, were at sites affected by urban activities whereas the highest concentrations for two other basins, UCOL and FRUC, were at sites affected by mining.

5 Discussion and Results

Streambed sediment is the best indicator for assessing the occurrence and spatial distribution of lead on a watershedwide scale in the VRW study unit and for developing relations between study units and land use. Streambed sediment is a consistent sampling medium among sites, which lessens the variability.

The concentration of lead on streambed materials is strongly affected by the particle size distribution of the sample [15]. The concentration of lead on streambed materials generally increases as particle size decreases. Elevated concentrations from some sites may be a result of natural and human factors. Natural factors include weathering of carbonate, and detrital rocks; and human factors include urbanization, and mining. Although sites 11, and 12 represent urban/recreation land use, they also had past mining activities in the upper part of the watershed. Site 13 represents a mixed land use site and receives water from a mining affected river just upstream from the sampling site. Elevated concentrations of lead at site 11 and site 13 also may be a combination of natural and human factors. The underlying geology, consisting mainly of Amiran Shale of Paleocene age, and the irrigation return flows upstream are likely contributing factors to the elevated lead concentration. Lead is present naturally in the shale bedrock of the middle and lower reaches of the basin and is present in the surface and ground water.

Particle size determination of the samples indicated that the mining sites (9, 26, 27, and 28) in the VRW physiographic county contained a larger percentage of silt/clay particles than other sites. Besides human disturbances at the urban land use sites have contributed to the larger percentages of silt/clay particles. The weathering of the rocks in the Southern altitudes of VRW produces large amounts of small particulates (silt/clay). Higher percentages of silt/clay particles in combination with mining land use at sites 9, 26, 27, and 28 may be a factor for higher concentrations of lead at these sites. Site 15, an urban effluent site, with the highest concentration of lead, had one of the highest percentages of silt/clay particles of the sites in the VRW. Overall, sites in the VRW physiographic county contained larger percentages of silt/clay particles than sites in the Southern Caspian Basin (Fig.3). Weathering of the sedimentary rocks in the VRW is one contributing factor to larger percentages of silt/clay particles at these sites.

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Table1. Background concentration for lead in streambed sediment
[All values in ppm. All of the streambed sediment samples were analyzed and used to compute background concentration for this study].

Element	Shaham (1999) [1]	Deacon & Verlin (1995-96) [2]	Severson & Tourtelot (1994) [3]	Veysian County	Range of concentration from this study
Lead	60	130	140	64	30-268

[1]Background concentrations established for Southern Caspian Basin streambed sediment samples (SCB) [16].
[2]Geochemical data for streambed sediment samples in the Upper Colorado River Basin, Colorado (UCOL) [17].
[3]Geochemical data for soils in the Front Range Urban Corridor, Colorado (FRUC) [18].

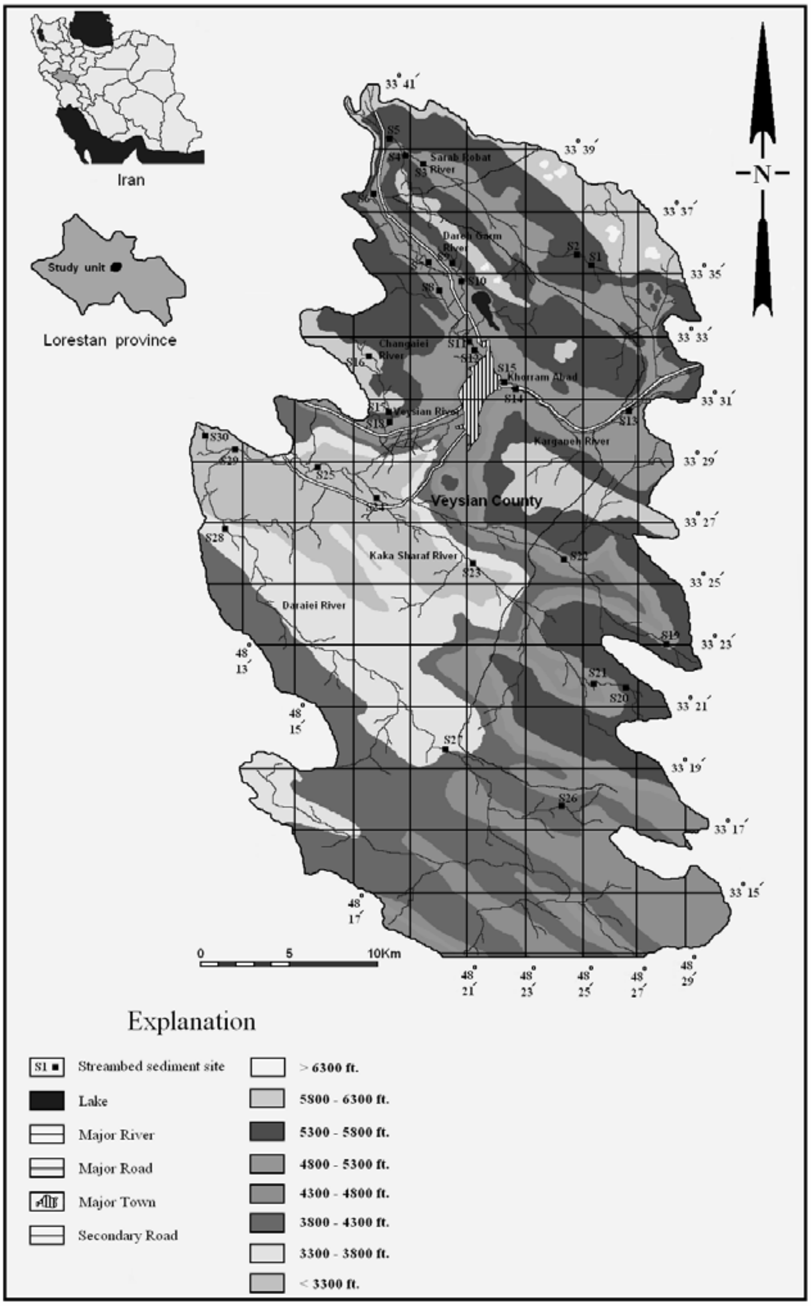

Figure1. Elevation and streambed sediment sites localities, Veysian River watershed.

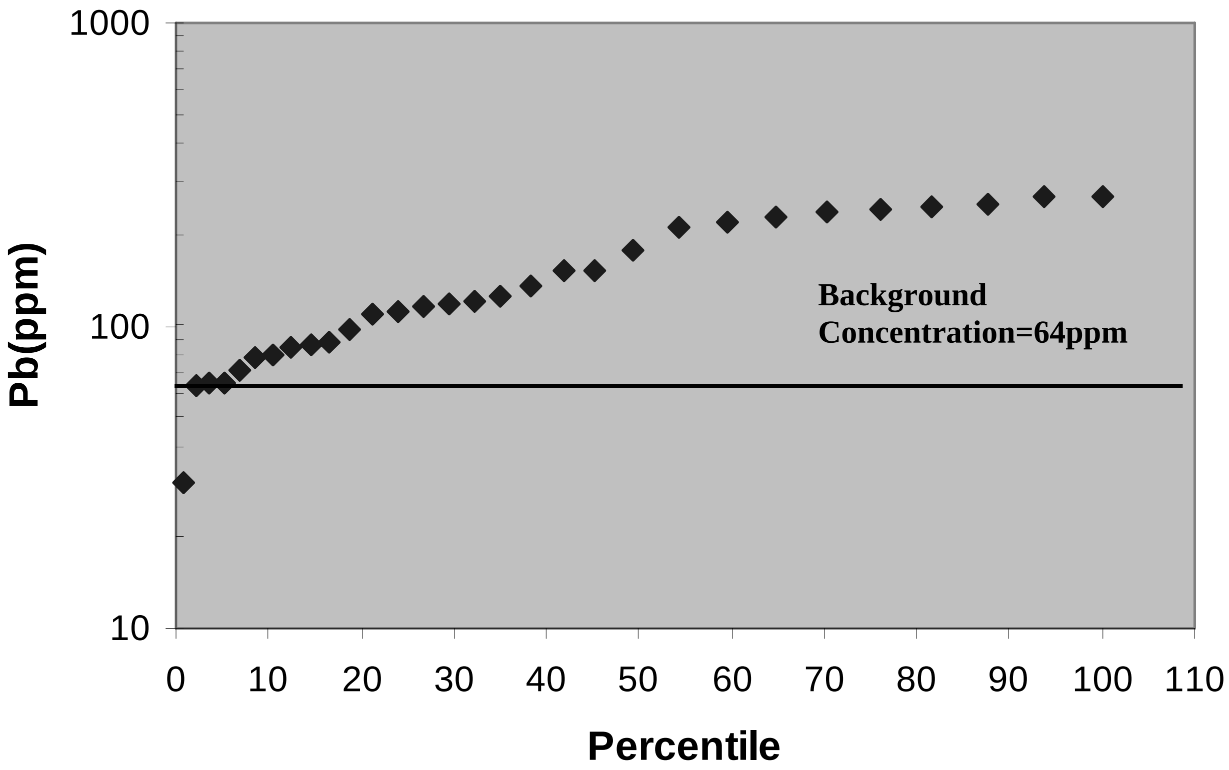

Figure2. Cumulative frequency curve used to determine the background concentration of lead.

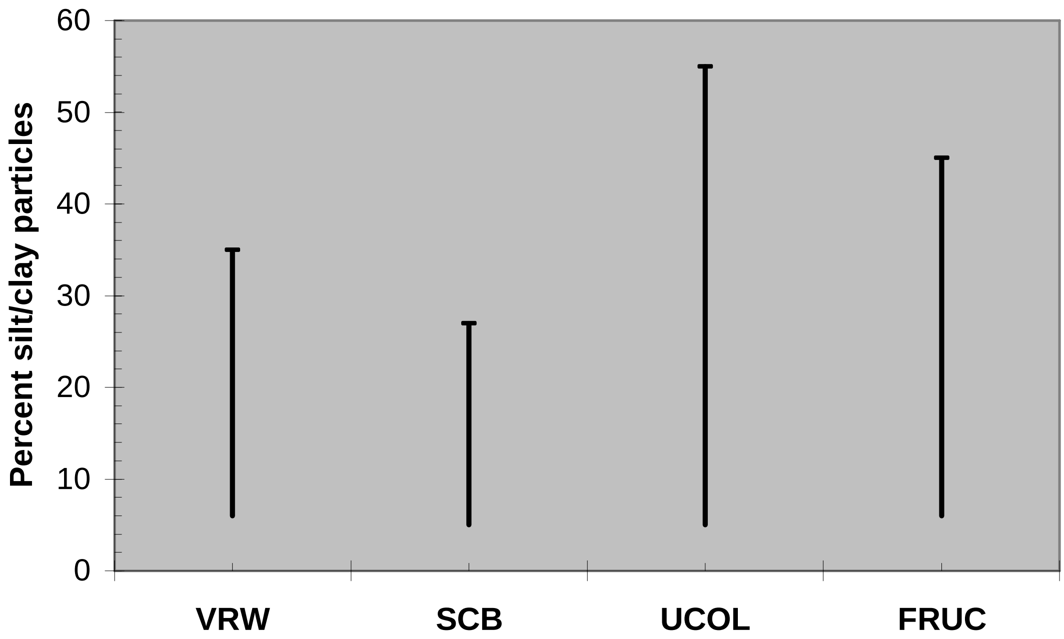

Figure3. Comparison of particle size percentages between sites in the Veysian River Watershed (VRW), Southern Caspian Basin (SCB), Upper Colorado River Basin (UCOL), and Front Range Urban Corridor, Colorado (FRUC) physiographic units.