

A multi-methodological approach to determine CO₂ and CH₄ fluxes and concentrations in solid waste disposal

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The municipal solid waste (MSW) landfills are the significant sources of atmospheric contamination, due to biogas production by anaerobic decomposition of organic matter via bacterial activity. Biogas released from landfills is commonly composed of a mixture of methane (55%–60%) and carbon dioxide (40%–45%), with minor contents of N₂, H₂, CO and traces of toxic and bad smelling inorganic and organic compounds. Particular attention has to be paid to CH₄ and CO₂ because of their liability for the greenhouse effect. Presently, the U.S. methane emission from landfills is considered to be about 25% of the total methane released to the atmosphere. Accordingly, field measurements should be planned in order to verify and, eventually, optimize the amount of gases released from waste disposals to the atmosphere. Simultaneous measurements of methane and carbon dioxide fluxes are an effective tool to better evaluate: (1) the amount of biogas released, (2) the real efficiency of the impervious cover, and (3) the presence of anomalous degassing zones or of newly formed fractures. Static closed-chamber methods for CH₄ and CO₂ flux measurements have been developed and used in both natural and artificial systems. Furthermore, portable gas-chromatographers equipped with flame ionization detector (FID) and accumulation chamber connected to infrared detectors (IR) have been utilized for measuring CH₄ and CO₂ fluxes, respectively. This paper deals with a detailed investigation that combines (1) CH₄ and CO₂ flux measurements from solid waste disposal and surrounding areas (determined by an accumulation chamber equipped with two IR detectors, respectively), (2) chemical composition of soil and piezometer gases (collected in pre-evacuated glass tubes and analyzed by gas-chromatography), and (3) CO₂ linear concentration measurements on optical air paths with IR laser devices. This multi-methodological approach was successfully applied to an active MSW in Tuscany (Central Italy). The analytical results have shown that the CO₂/CH₄ ratios of the piezometer gases have large variations, likely related to the different stage of decomposition processes affecting the heterogeneous solid material of the waste landfill. Significant contents of light hydrocarbons and BTX were also detected. Nevertheless, CO₂ and CH₄ soil fluxes were very low, suggesting that the impervious cover is able to minimize biogas escaping toward the atmosphere.

Key words solid waste disposal; CO₂ flux; CH₄ flux; gas geochemistry; BTX

Comparison of antimony behavior with arsenic under various soil redox conditions

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Antimony (Sb) is a toxic element and belongs to group 15 of the periodic table, under arsenic (As). The geochemical behavior of Sb in the environment is still largely unknown. Since the behavior of Sb in the environment depends on its oxidation state, Sb analysis in environmental samples requires quantitative measurement of Sb (III) and Sb (V). The aim of this study is the speciation of Sb in both solid and water phases to understand the reaction and dynamics of Sb in soil-water system. Accordingly, we employed X-ray absorption fine structure (XAFS) analysis to determine the Sb and As species in soil in laboratory and natural systems, while we also determined the oxidation states in soil water by the conventional HPLC-ICP-MS method. Natural soil and soil water samples containing Sb and As were collected around the Ichinokawa mine pithead, Ehime, Japan. To observe the species under various redox conditions, the soil and soil water samples were collected at four depths. Soil containing Sb and As were incubated for 7 days at 25°C to observe their oxidation states under various redox condition by changing the total amount of water in the soil. Antimony K-edge XAFS spectra were measured at the beamline BL01B1 at SPring-8 (Hyogo, Japan) and K-edge XAFS spectra of As, Fe, and Mn at the beamline BL12C in Photon Factory, KEK (Thukuba, Japan). In the natural soil-water system, Sb was present exclusively as Sb (V) over a wide redox range (from Eh=-140 to 360 mV; pH 8), while As was present as a mixture of As (III) and As (V). This trend was confirmed in the laboratory experiments. These results suggest that Sb (V) is a very stable form in the environment and that Sb is oxidized under more oxic condition than As. Combining the results of Fe and Mn XAFS analyses and a positive correlation among Sb, As, and Fe abundances in the soil, the host phases of Sb and As in soil were Fe (III) hydroxide. EXAFS analyses of Sb and As are also consistent with this fact. Under reducing conditions, the concentrations of As in the soil water increased whereas those of Sb decreased in both the natural and laboratory systems. This suggests that this contrasting behavior is induced mainly by the different

redox properties of Sb and As.

Key words antimony; arsenic; XAFS; HPLC-ICP-MS; redox condition

Remediation of electric arc furnace dust leachate by the use of cementitious materials: A column-leaching test

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Disposal of industrial solid wastes in a hydrologic environment can cause environmental risks due to the mobility of toxic trace elements. It is increasingly important to find simple and inexpensive treatments to remove undesirable elements from industrial solid wastes. One of the most important problems in the secondary steel mill industry is the disposition of dusts produced from electric arc furnace. A large quantity (10–20 kg) of electric arc furnace dust (EAFD) is generated per ton of steel produced. The Toxicity Characteristic Leaching Procedure (TCLP) shows that the total Cr and Cr (VI) concentrations (9.7 and 6.1 mg/L respectively) from the EAFD studied exceeded the Toxicity Characteristic Regulatory Level. Some heavy metals of EAFD like chromium are toxic and have high solubility. Chromium (VI) is particularly problematic because it must initially be reduced before fixed in an insoluble phase. To counter this problem, the use of ordinary Portland cement (OPC) and ground granulated blast furnace slag (GGBFS) was investigated. Column leaching test was performed to evaluate the leaching of EAFD amended with GGBFS and OPC under dynamic conditions simulating heap leaching. The goal of this study is to find a simple and economic way to decrease contaminants in the leachate. Test columns have been set up to evaluate the effect of alkaline additives (OPC and GGBFS) on the geochemistry of drainage water. The control column consists of EAFD only. A set of columns presents the effect of the addition of 5% by mass of OPC or GGBFS mixed homogeneously with the EAFD. Another set of columns was set up with the same quantities of OPC and GGBFS but concentrated at the base of the EAFD simulating a liner. Columns were fed three times weekly during 1 month. The parameters monitored after each flush of water include leachate volume, pH, electrical conductance and water quality (Cr-Ni-Pb-Zn concentrations). The leaching of the control (EAFD only) presents high Cr concentration. The addition of GGBFS and OPC increases the pH conditions and decreases metal concentrations. The concentration of OPC and GGBFS at the base of the EAFD as a liner was the more efficient disposition. The use of a mixture of EAFD with 5% of OPC or GGBFS applied at the base of EAFD heap is a simple and economic way to remove contaminant. In spite of a significant decrease in Cr concentration, values remain slightly above regulatory level.

Key words remediation; industrial solid waste; electric arc furnace dust; ordinary portland cement; ground granulated blast furnace slag

A geochemical study of redox behavior of As in a contaminated aquifer from Sonargaon, Central Bangladesh

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The Bengal Basin has been exposed to the most serious As problem in the world. Although it has been agreed well among many researchers that the contamination has been induced by natural geochemical process, detailed mechanisms are still under debate. Arsenic is easily soluble into groundwater as pentavalent arsenate and trivalent arsenite. Their adsorption behavior for various solid phases, particularly for Fe oxyhydroxide (FeOOH), is different. Thus speciation of As in solid phase is essential to examine the process of contamination. However, few studies have been done about As speciation in sediment due to its analytical difficulty. In this study, we applied XANES (X-ray adsorption near the edge structure) spectroscopy to determine oxidation states of As and Fe, and investigate As behavior along change in redox condition. We studied the Sonargaon area located 25 km southeast of Dhaka. Sediment core samples were collected from one site in the area up to the depth of 100 m using penetration-drilling method. The samples were packed into oxygen impermeable film with deoxidizer on site, then brought back to laboratory in Japan within 2 weeks