Quarterly Report of

EVALUATION OF THERMAL PROCESSES FOR CCA WOOD DISPOSAL IN EXISTING FACILITIES

To

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Quarterly Report (Mar – May 2005)

In this reporting period, experiments were carried out to evaluate various sorbent materials for their capability in reducing ash leachability as well as to characterize the crystalline speciation which provides critical information in understanding the metal-sorbent interaction. Experiments were carried out in an Isotemp Programmable Forced Draft furnace using metal spike containing the three metal compounds in the same mass ratio as CCA type C chemical. Metal concentration in the spike sample were; As – 13000 mg/l, Cr – 14600 mg/l and Cu – 8800 mg/l. The spike was mixed with various sorbents (20 gram sorbent for 50 ml of spike) in 75 ml porcelain crucibles. The samples were heated at 700^oC and 900^oC for 30 minutes. A portion of the residual was leached using the toxicity characteristic leaching procedure (TCLP) as per US EPA SW 846 Method 1311. This leaching test is used to determine whether a solid waste is a hazardous waste or not for its toxicity characteristic. The TCLP leachate was digested as per US EPA SW 846 Method 3010A. A portion of residue was digested for the total metal content analysis using US EPA SW 846 Method 3050B (Solid Digestion of sediments). All digested samples were analyzed using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). X-Ray Diffraction (XRD) analysis of the residue was conducted to determine the crystalline speciation of the products. Analysis for 700^oC and 900^oC batch experiments has been completed and is reported. Experiments and analysis for the 1050 ^oC batch is underway and will be reported in the next quarterly report.

Figures 1-6 show the results from heating the metal-sorbent samples at 700^oC and 900^oC.
<u>Retention</u> (Fig. 1 & 2): Alumina, Silica, Diatomaceous Earth and Kaolin result in over 90% retention for Cr in the ash but low retention for As. Kaolin shows negligible As retention at 900^oC. Alumina, Diatomaceous Earth and Kaolin show over 80% retention for Cu. Cement, Lime and Magnesium Hydroxide show over 98% retention for As & Cu at both temperatures but very low retention for Cr. Attapulgite Clay doesn't show appreciable metal retention at both temperatures; however, it's As and Cr retention is relatively higher at 900^oC.
<u>Leaching</u> (Fig. 3 & 4): Alumina and Silica result in leaching less than 5 mg/l of Cr (Toxicity Characteristic (TC) Regulatory limit for Cr) at both temperatures. Kaolin leaches less than TC limit for Cr at 900^oC. Cement, Lime and Magnesium Hydroxide leach Cr excessively (~100 mg/l). Alumina, Silica, Diatomaceous Earth, Attapulgite Clay and Kaolin leach more than the TC limit of 5 mg/l for As at both temperatures. Cement, Limestone and $Mg(OH)_2$ leach less than 5 mg/l of As in both cases and show very little Cu leaching. It is observed that only sorbents with very high retention (~ 98%) leach less than TC limit for As & Cr.
<u>Speciation:</u> XRD results indicate the formation of various metal-mineral compounds in the residue. For As & Cu, the major metal-mineral compounds formed in spike samples are $Cu_3(AsO4)_2$, $CaHAsO_4$, $CuHAsO_4$, etc., when sorbents like Cement and Lime (Fig.5) are used. These compounds may be thermodynamically stable and insoluble and hence might be a reason for low leachability of As & Cu with these sorbents. For Cr, $CaCrO_4$ is the major compound formed when Cement and Lime are used and $CuCr_2O_4$ is a major species when Alumina (Fig. 6) and Silica are used in spike samples. The formation of different Cr compounds could be a reason for the vast difference between the leachability

of Cr in these cases. It is also observed that Cu has high affinity for forming compounds with As and Cr besides the mineral sorbents.

Summary of Report on Current Arsenic Pollution Control Techniques

In the past, various studies have been carried out to evaluate pyrolysis (slow and flash), incineration, co–incineration and gasification as possible candidates for the best available technology to convert CCA treated wood into useful form (energy production mainly) with least emission of heavy metals. It was concluded (Helsen and Bulck, 2005) that co-incineration along with dilution could be an effective short term disposal strategy. Although this method leads to low metal concentration in air, but the total amount of metals released is still large. In the long term, low temperature pyrolysis in a moving bed has been considered suitable (Helsen and Bulck, 2005), as metal emissions, though non-zero, are lesser than regular incineration processes. Another strategy for the long term is high temperature gasification in a metallurgical furnace which can yield higher energy and lesser volume of gas cleanup required. However, appropriate gas cleaning equipments are needed and this strategy has not been verified in any pilot scale study.

The challenge for arsenic collection lies in the fact that it exists in particulate form as well as vapor form. As summarized in the 1^{st} quarterly report, the current air pollution control technologies in combustion systems like ESPs, baghouses, scrubbers and cyclones can only collect particulate matter efficiently. The efficiency of these devices is the lowest in the submicron range which is of concern as many volatile metals form fine particles in that size range. Simple cooling of metal fumes can't succeed in collecting all heavy metals (mostly Arsenic, as Cr & Cu are not very volatile at the usual combustion temperatures).

Surface active agents like activated carbon, silica gel and molecular sieves have been known to adsorb arsenic oxide vapor strongly. Amongst filters, high efficiencies have been reported for Nucleopore and Millipore filters. Impregnated filters (with alkalis, tetra-*n*-butyl ammonium hydroxide, silver nitrate etc) have also demonstrated good collection efficiency for both particulates and vapors. (Wouterlood et al, 1979; Walsh et al, 1977; Appel et al, 1984) However, they may not be a feasible solution on an industrial scale as temperature, flow rate and pressure drop across the system and management and maintenance of filters may be an issue there.

It is proposed (Helsen, 2005) that a combination of filters and scrubbers may be the best available technique to capture heavy metals in flue gas. However, the disposal of the metals captured still remains a problem, unless they can be regenerated and reused. Sorbent injection combined with filtration has been proven to be an efficient method to reduce As emissions during coal combustion and may be effective for CCA treated wood waste as well.

Table 1- Timeline for completion of major milestones

Milestone	2004				2005							
	S	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**
TAG Meeting		•										•
Task 1 – Inventory of Existing Wood-Fired Capable Facilities	•	•	•									
Task 2 – Survey of Available Pollution Control Technologies						•	•	•	•	•		
Task 3 – Evaluation of Potential Materials for Preventing Arsenic Leaching from Incineration Product			•	•	•	•	•	•	•	•	•	
Evaluation of Data	•	•	•	•	•	•	•	•	•	•	•	•
Preparation & Peer Review of Final Report										•	•	•
Submittal of Final Report												•

The shaded boxes represent the work done as against the total work

Work to be accomplished in the next quarter (June- August)

- Completion of analysis of 3rd batch of Phase 1 experiments
- Design of combustion system for Phase 2
- Submission of Final Report

References

1. Appel, B.R., Tokiwa, Y., Hoffer, E.M., 1984. Efficiency of filter sampling for arsenic in the atmosphere. Atmospheric Environment 18 (1), 219-222

2. Helsen, L., 2005. Sampling technologies and air pollution control devices for gaseous and particulate arsenic: A review. Environmental Pollution, *In Press, Corrected Proof, Available online 22 April 2005*,

3. Helsen, L., Van den Bulck, E., 2005. Review of disposal technologies for chromated copper arsenate (CCA) treated wood waste, with detailed analyses of thermochemical conversion processes. Environmental Pollution 134, 301-314.

4. Walsh, P.R., Duce, R.D., Fasching, J.L., 1977. Impregnated filter sampling system for collection of volatile arsenic in atmosphere. Environmental Science and Technology 11 (2), 163 -166.

5. Wouterlood, H.J., Bowling, K. McG., 1979. Removal and recovery of arsenious oxide from flue gases. Environmental Science and Technology 13 (1), 93-97.

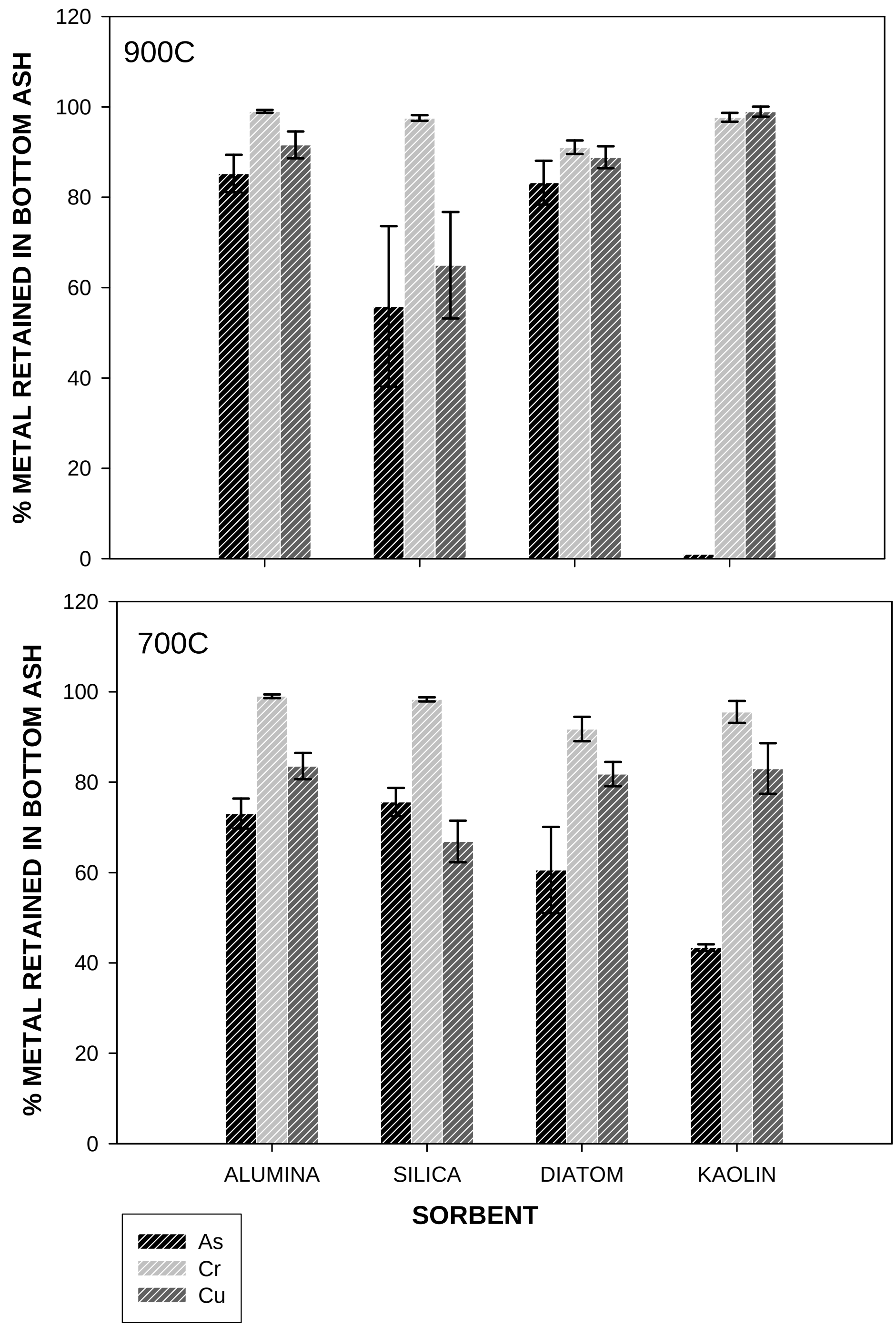

Figure 1: Percentage Metal Retained in Bottom Ash

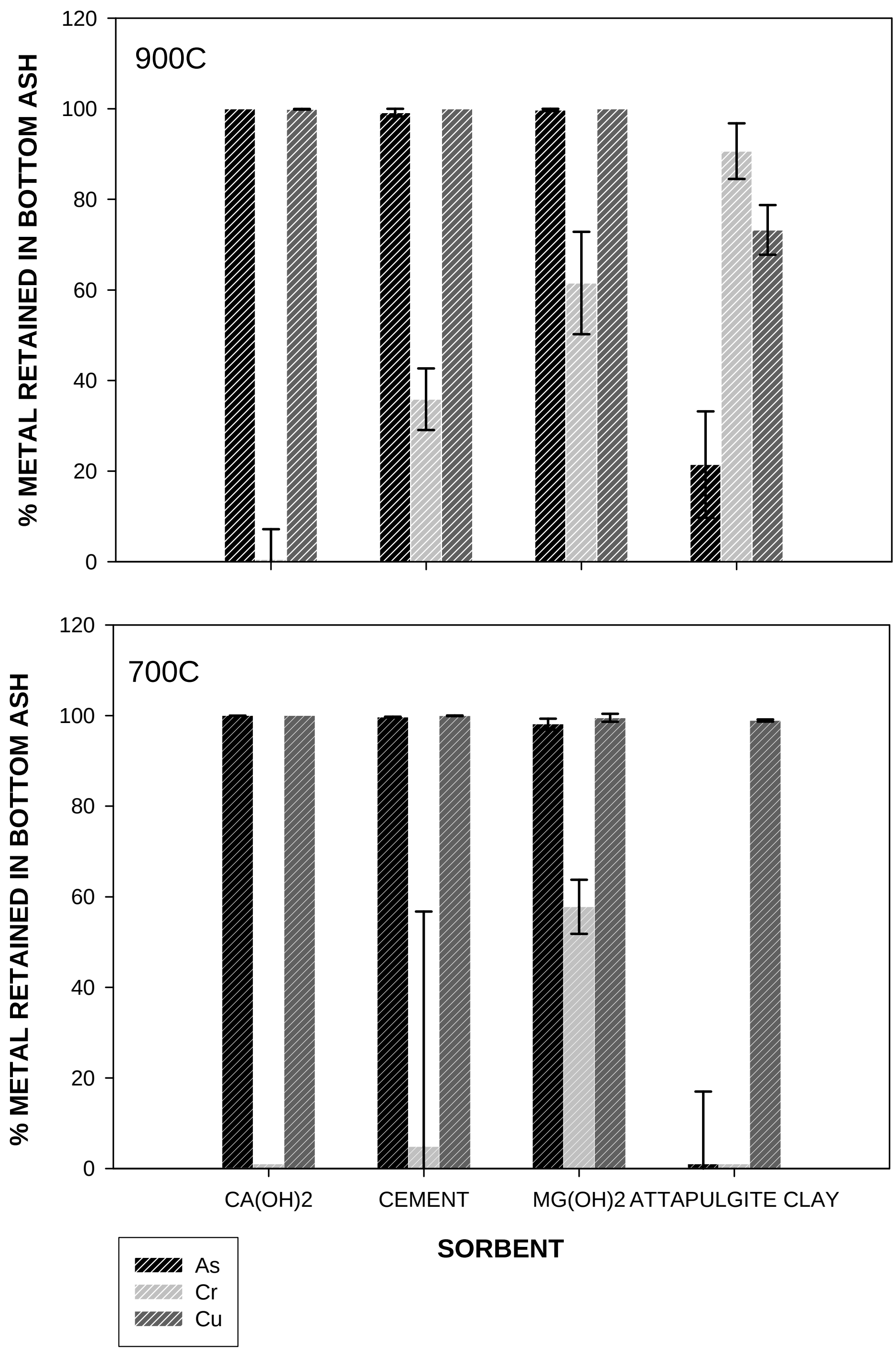

Figure 2: Percentage Metal Retained in Bottom Ash

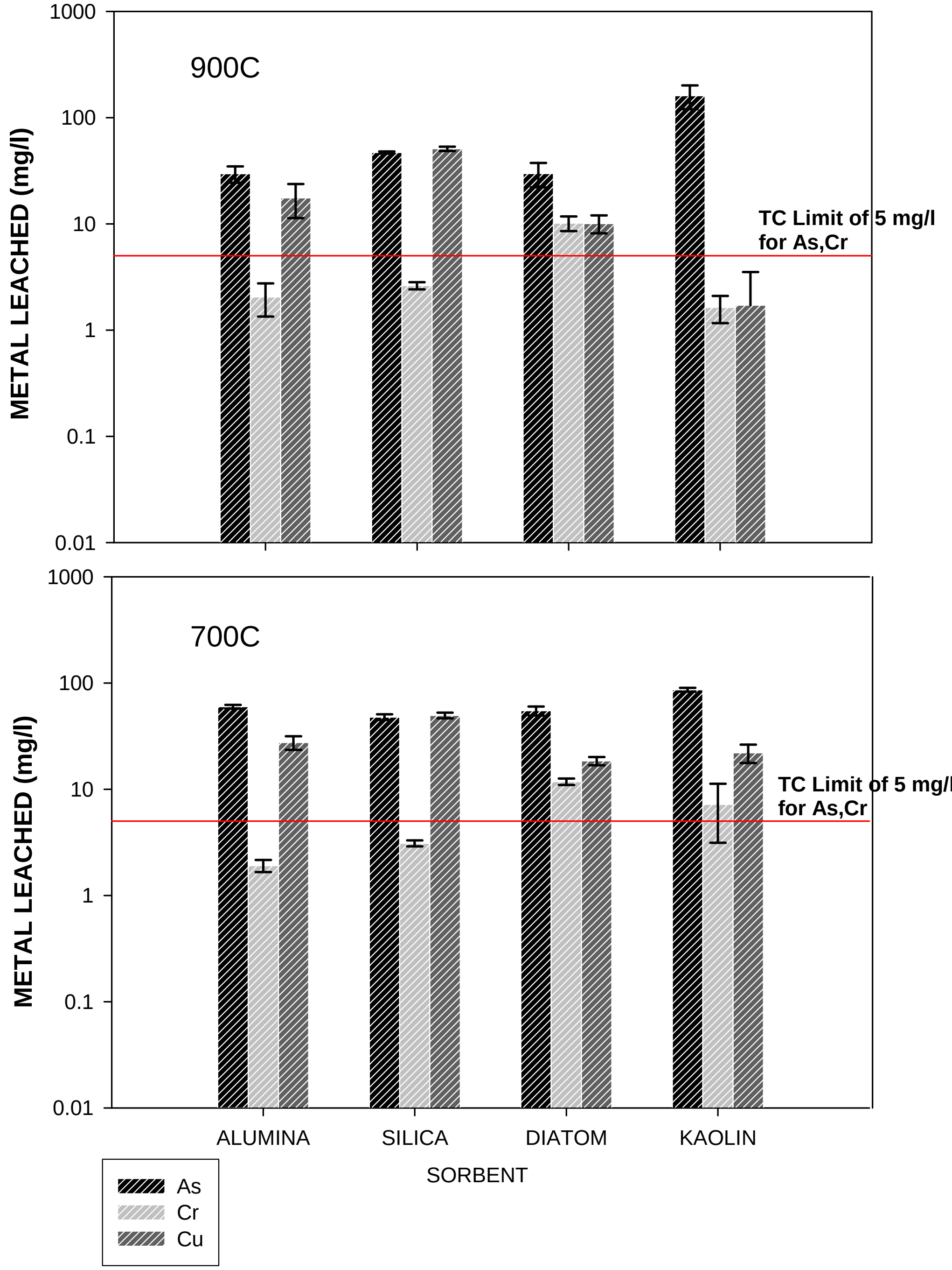

Figure 3: Amount of Metal Leached

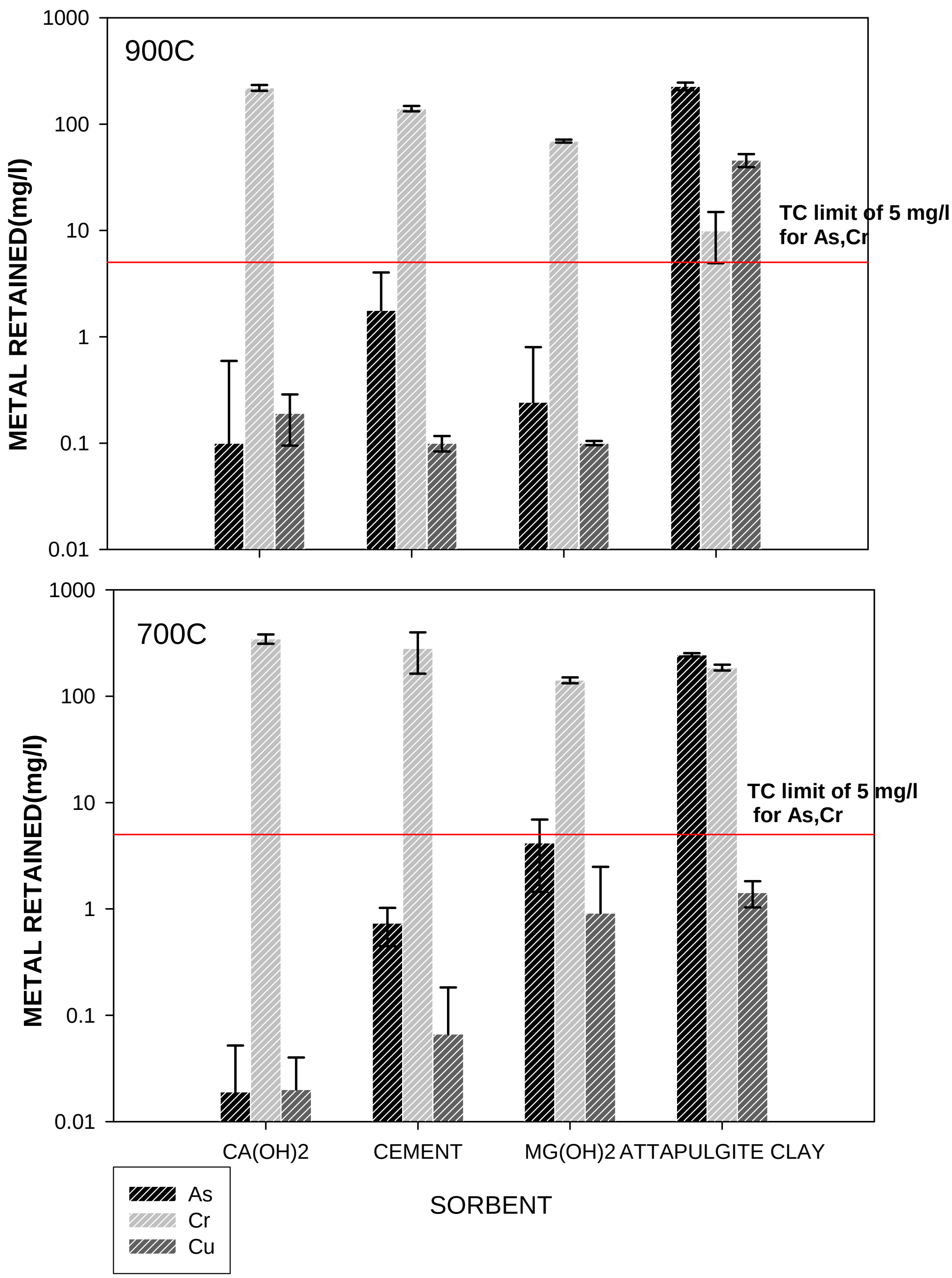

Figure 4: Amount of Metal Leached

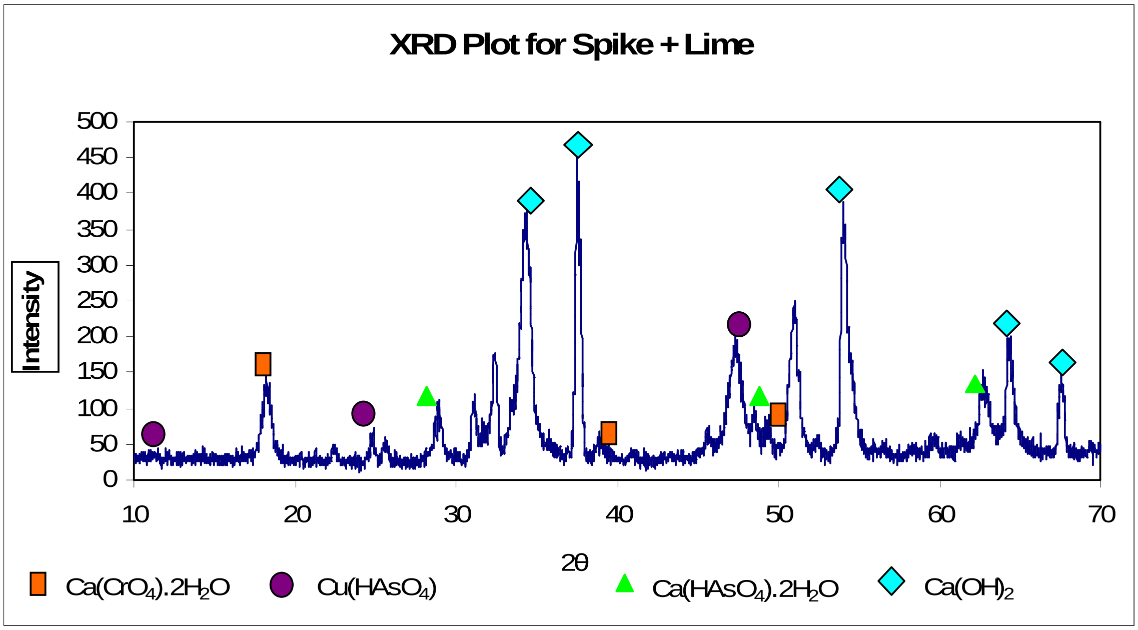

Figure 5: XRD plot for Spike + Lime Sample

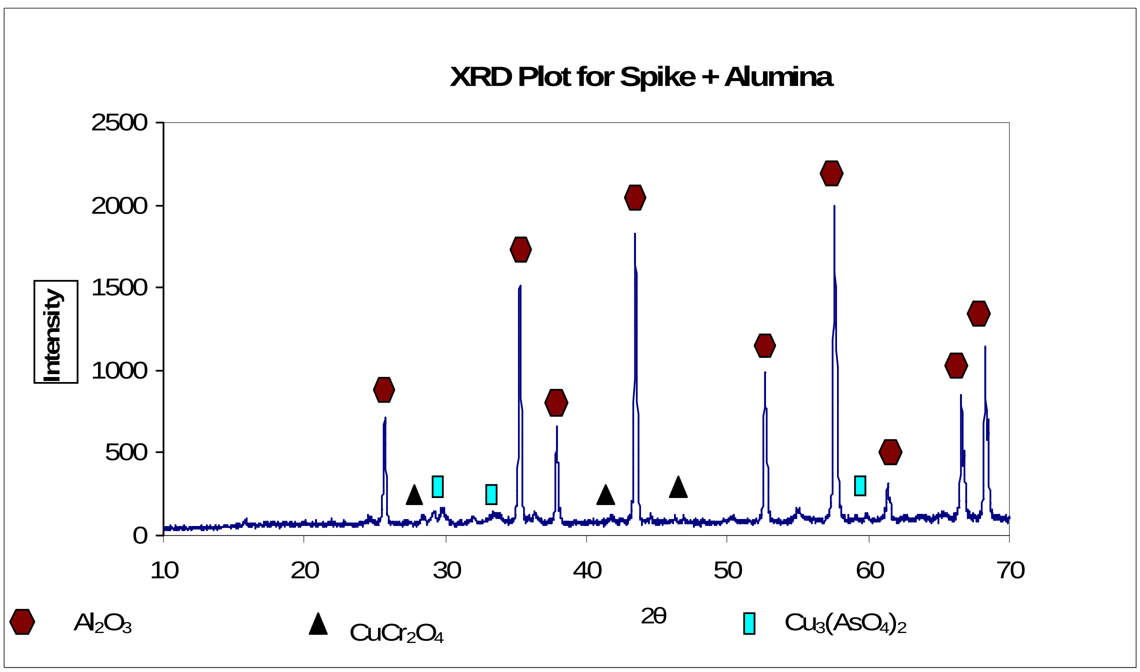

Figure 6: XRD plot for Spike + Alumina Sample