Atmospheric N in the Alberta Oil Sands, Canada

Sagar Krupa and Kevin Percy

The Alberta Oil Sands contain the third largest oil reserve in the world and contribute daily production to North American energy needs. Of the three oil sands deposits, the Athabasca Oil Sands Region (AOSR) is the largest. Production there is currently 1.8 M bpd and is expected to reach 3.5 M bpd by 2020. Bitumen (oil that is too solid to flow) is extracted by open pit mining (20% of the reserve) or by drilling (80% of the reserve). Upgrading of the bitumen occurs on site or downstream. In addition to the stationary point source air emissions, of concern are the fugitive dust from mining, overburden deposits, tailing pond dykes, 400 ton mine heavy haulers, and forest fires. Total anthropogenic N emissions (total 310 T/d) in the AOSR were: (a) industrial stacks 211T, (b) mine fleets 75T; and (c) non-industrial sources 24T. Spatial patterns of N were characterized as feasible in this remote region by integrating: (a) continuous air monitoring; (b) passive air sampling; (c) through the accumulation of total N and stable Pb isotope tracers (206, 207 and 208 ratios) in an epiphytic lichen bio-indicator; and (d) regional dispersion modeling.

Atmospheric concentrations of N (NO_x, NH_3) and N in particulate matter (PM) are being measured at 18 sites. The highest hourly NO_2 values ranged from 52.1 ppb at a community station, and 141 ppb at an industry site. The 99th percentile values ranged from 11.4 ppb to 42 ppb. Annual average NH_3 concentrations were 0.07 ppb and 0.01 ppb. Maximum one-hour NH_3 concentrations in 2012 were 64 ppb and 34 ppb. Both these values were above the 99th percentile. In the limited, partial summer time precipitation samples, NO_3 concentrations ranged from 0.5 to 9 ppm, and NH_4 from 0.1 to 2 ppm. Due to logistics (access to distant sites only by an helicopter), the continuous monitoring sites were located close to the source cluster, and likely did not allow measurements of effective atmospheric plume scavenging. Total N in the bio-indicator lichen showed 1.2% by tissue dry weight within the first 10-15 km from the sources and declined rapidly to 0.7%, reaching plateau-linearity all the way to >100 km. Several crustal elements and the stable Pb isotopes showed the same pattern (coarse particle deposition). At distant sites where trace elements, such as Zn appeared to be more important, possible fine particle deposition was detected.

Spatial patterns of total N deposition modeled with CALPUFF indicated the primary influence of NOx sources were within a nominal 20 km radius where the deposition was greater than 4 kg N/ha/yr (20kg N/ha/yr maximum). The influence of the sources decreased from 4 kg/ha/yr at 20 km, to about 2 kg N/ha/yr at 50 km. At 100 km, the deposition converged to the background value of about 1.8 kg N/ha/yr. In order to understand these overall results, application of receptor models ***PMF and Unmix*** showed that (a) combustion contributed 19 to 23%, (b) fugitive tailing sand 19 to 25%, (c) oil sand processing 11 to 15%, (d) mobile sources and lime stone 15 to 17% and (e) others (general anthropogenic, e.g., urban) 28% to the total elemental concentrations in the lichen.

Sagar Krupa, University of Minnesota, St. Paul, MN, USA (krupa001@umn.edu) and
Kevin Percy, Wood Buffalo Environmental Association (WBEA), Fort McMurray, Alberta, Canada (kpercy@wbea.org).