Emissions from Burning Herbicide Treated Forest Fuels - A Laboratory Approach

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INTRODUCTION

Questions have been raised concerning the possibility of toxic smoke being released as a result of "brown and burn" land management activities. The brown and burn method involves applying a herbicide to unwanted forest and range vegetation followed weeks to months later by a prescribed fire. This paper describes a laboratory method which can be used to help assess the environmental impact and occupational risk from such open burning activities.

METHODS

The burning experiments were carried out in a large (700 m^3) controlled environment combustion laboratory at the Southern Forest Fire Laboratory. The fuel bed consisted of newly fallen slash pine (Pinus elliottii Engelm.) needles uniformly distributed over a shallow (20 cm) wire basket (0.9 m wide x 1.2 m long). Slash pine litter is a good physical model for fine forest fuels and has been used in prior laboratory experiments [1,2]. The fuel beds were spray-treated with one of the common herbicide mixtures used in the Southeast. A mixture of 2,4-D (2,4-dichlorophenoxyacetic acid) and Picloram (4-amino-3,5,6-trichloropicolinic acid) both as the triisopropanolamine salts was applied to yield levels between 300 and 700 Micrograms per gram for Picloram and 3000 and 6500 Micrograms per gram for 2,4-D. These high application rates were used to represent a worst case treatment and to insure positive analytical results. Various fire behavior conditions can be simulated by altering fuel loading and moisture, the slope of the fuel basket, and site of ignition. For these experiments, fuel loading (1600 g), moisture (~20 percent) and slope (50 percent, 45°) were held constant while we tested two burning methods, upslope or heading fires and downslope or backing fires. From prior work [1,2], we expected the upslope fires to result in low combustion efficiency as evidenced by high smoke production while the downslope fires were expected to yield high combustion efficiency and low smoke production. We feel these two burning methods bracket the variable burning regimes encountered in many prescribed fire operations. Combustion products were channeled into a wide (4.6 m diameter) inverted funnel and then into a stack (0.6 m diameter) located directly over the burning fuel bed. Conditions were controlled to yield a stack flow rate of approximately 4000 cfm. Dilution air cooled the combustion products to below 52°C at the sample pick-up point located 6 meters above the fire. Two sampling systems were employed; a modified "hi-vol" with glass fiber filter, and a separate sample train consisting of a 47-mm in-line filter (glass fiber) followed by two polyurethane foam plugs (2.5 cm diameter by 3.5 cm). The hi-vol flow rate was maintained at 30 cfm while the 47-mm train was maintained at 0.8 cfm. These sampling procedures had proven effective for collection of pesticides in an earlier study which burned

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pesticide treated wood samples in a tube furnace[3]. Sampling periods averaged 20 min. for the upslope fires and 15 min. for the downslope fires. Herbicide residues in the filter and foam samples were extracted and quantitated by gas chromatographic methods at a University of Georgia pesticide residue laboratory which had previously demonstrated quantitative herbicide recovery from fortified filters and foam samples.

RESULTS

A total of 15 fires were conducted, 6 treated with herbicides (3 upslope, 3 downslope) and 9 untreated. In addition to background fires, each herbicide fire was followed by an untreated fire to see if herbicide cross-contamination was a problem (none was found). As an indicator of combustion efficiency, particulate matter emission factors were determined and found to average 9 g kg^{-1} for the downslope fire and 53 g kg^{-1} for the upslope fires. These results are consistent with previous laboratory studies [1,2]. Herbicide recoveries for the downslope fires were less than 0.02 percent for Picloram and averaged 0.08 percent for 2,4-D. Recoveries for the upslope fires (where herbicide distillation is more probable), were less than 0.04 percent for Picloram and averaged 5 percent for 2,4-D. The low recovery of Picloram in all the fires was somewhat expected. The acid form decomposes at 190°C. Based on results from an earlier study[3], 4-amino-2,3,5-trichloropyridine (4-ATP) was quantitated as a major thermal decomposition product of Picloram. 4-ATP accounted for 2.3 percent of the Picloram loss in the upslope fires while none was detected in the downslope fires. No attempt was made to optimize procedures for all major decomposition products in this study; however, that could be accomplished with some minor additions to the sampling methods and a more comprehensive analysis plan. In addition, this laboratory methodology can be adapted to other fuels, fire types, and herbicide mixtures. The recovery data from our lab studies when combined with known herbicide residues from operational applications can yield airborne concentration data from which occupational and general population risk can be assessed.

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