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Streamwater Contamination After Aerial Application of a Pelletized Herbicide[1]

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SUMMARY

Concentrations of hexazinone and its metabolites were monitored in a Piedmont stream for 8 months after aerial application of a pelletized formulation (Velpar® Gridball™). Downstream water-users and fish are probably safe from toxic exposure if treatment areas have only small streams (less than 50 cm average channel width) and if labeled rates are not exceeded. Hexazinone concentrations were highest 30 minutes after application at 2.4 ppm, declining to less than half at I hour, 1.1 ppm, and half again at 2 hours, .49 ppm. No contamination was evident after the 5th-day sampling. Stream contamination from pellets was as much as 100 times the concentrations reported for foliar sprays, aerially applied over brush-covered streams at similar rates.

Additional keywords: hexazinone, Velpar® Gridball™, chemical silviculture.

[1] Use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use is not an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

If herbicides are handled, applied, or disposed of improperly they may be injurious to humans, domestic animals, desirable plants, and pollinating insects, fish, or other wildlife, and may contaminate water supplies. Use herbicides only when needed and handle them with care. Follow the directions and heed all precautions on the container label.

INTRODUCTION

Soil-active herbicides in pelleted forms are gaining increased interest and use in silvicultural treatments. Velpar® Gridball™, a large pellet of 10 percent active ingredient (a.i.) hexazinone, is now registered in all southern states for pine release and site preparation; but its widespread use is awaiting its widespread availability (Hamilton 1979, Parker 1979). Tordon 1 OK® (10 percent a.i. picloram) is commonly applied for kudzu (*Pueraria lobata*) control before reforestation, and further trials are examining the possible use for chemical site preparation (Mann and Haynes 1978). Other pelletized herbicides such as Graslan®(20 percent a.i. tebuthiuron) and Banvel XP® (10 percent a.i. dicamba) are now used in tangeland reclamation (Graslan) and right-of-way control (Banvel XP) and may become useful in forest management.

Pelleted chemicals are more likely than sprayed chemicals to land on the target areas because there is no spray drift. And soil active herbicide pellets do not need the stringent weather and foliage conditions required by foliar sprays. So, favorable application periods would be much longer than those for aerial sprays. Also, nonindustrial forest landowners could make ground applications without having to purchase expensive application equipment. Use of pellets could make herbicide applications in forestry more environmentally safe and operationally practical.

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To find how much an aerial application of pelletized herbicide contaminates streamwater, we applied Velpar Gridball aerially on a recently harvested Piedmont watershed. The basal area of unharvested hardwoods was 3.5 m^2/ha (15 ft^2/acre). For the next 8 months, we monitored concentration of hexazinone and its metabolites in a small stream in the treated area. Also, we studied joint application of pine seed and the pelletized herbicide. Such a combination of operations would help minimize costs of establishing a plantation.

METHODS

On February 23, 1978, a helicopter fitted with a Simplex Airblown Seeder applied 0.8 kg/ha (3/4 lb/acre) loblolly pine seed coated with arasan, a bird repellent, and endrin, an animal repellent. Then, from the same seeder at the largest gate openings, Velpar Gridball was applied to a 0.8 ha (2 acre) rectangular plot-66 by 122 m (216 x 400 ft)-extending from ridge to ridge across the valley (fig. 1); 4.6 percent of the 17.4 ha (43 acre) watershed was treated. Because of crosswinds, the treatment plot was flown in four 30.5 m (100 ft) swaths, 66 m (216 ft) long, parallel to the stream. One swath was applied directly over the flood plain, and we saw pellets falling into the stream.

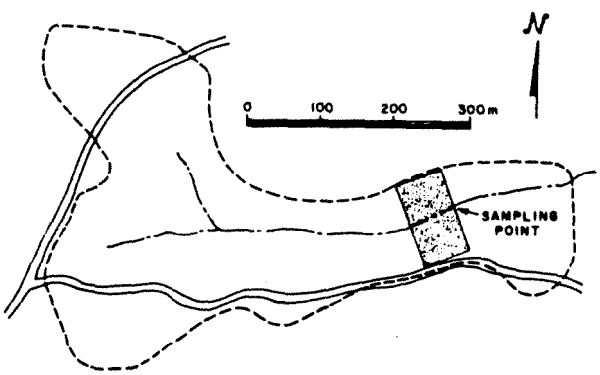

Figure 1 .-*Rectangular plot of 0.8 ha* **aerially** *treated with 1.8 kg/ha a.i. hexazinone after a selective harvesting of rhe entire 17.4 ha watershed.*

The rate of application was 18 kg/ha (16 lb/acre) Velpar Gridball or 1.8 kg/ha (1 .6 lb/acre) a.i. hexazinone. We made a pretreatment calibration of the seeder on an adjacent cleared area by using "blank" pellets. The stream channel was not over 1 m wide at pools and averaged 30 cm at rills. Herbs and shrubs grew along the edge, and leafless hardwoods along the banks provided partial channel cover.

Streamwater samples were collected and discharge measured at a point immediately downstream from the treatment plot (fig. 1). One sample and a measurement were taken after treatment at 1, 5, 15, and 30 minutes; 1, 2, and 3 hours; 1, 5, 10 and 46 days; and at 8 months. Polythene bottles were given a final rinse with a sample before collection. Samples were then kept frozen until analyses. Using a gas chromatographic technique and a nitrogen-phosphorus detector, the Biochemical Department at E. I. duPont deNemours & C o analyzed residues. This procedure quantifies hexazinone (3-cyclohexyl-6-(dimethylamino)- 1 -methyl- 1,3,5-triazine,2,4 (1 H, 3H)-dione) and two of its most prevalent metabolites — Metabolite A is 3-(4-hydroxycyclohexyl)-6-(dimethylamino)-1-methyl-1,3,5-triazine,2,4 (1 H,3H)dione, and Metabolite B is 3-cyclohexyl-6-(methylamino)-1 -methyl-l ,3,5-triazine-2,4(1H,3H)dione.

RESULTS AND DISCUSSION

Hexazinone concentrations in streamwater were highest 30 minutes after application, 2.4 ppm, and declined to less than half at 1 hour, 1.1 ppm, and half again at 2 hours, .49 ppm (fig. 2a). This concentration pattern is the same as. that reported by Norris (1967) for a complete aerial spray application of 2.2 kg/ha (2 lb/ acre) acid equivalent (a.e.) 2,4,5-T to a 5-acre watershed in Oregon's Coast Range (fig. 26). But stream contamination from hexazinone pellets was about 100 times the conceitrations from spray (Norris 1967).

In both cases, contamination resulted mainly because chemicals were applied directly to the stream surface. In our study, chances were slight

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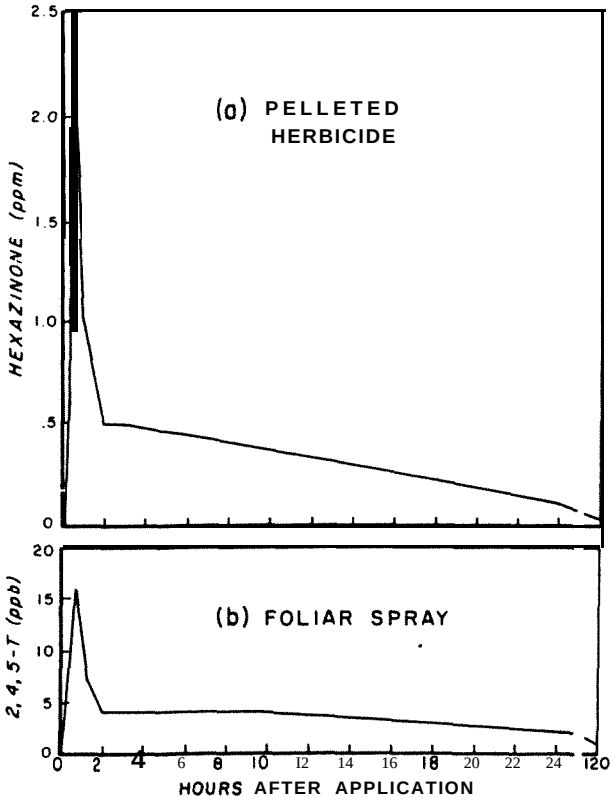

Figure *2.-(a) Hexazinone concentrations (ppm) after aerial application of a pellet formulation in Alabama, (b) 24.5-T concentrations (parts per billion) after aerial spraying in Oregon (from Norris 1967).*

that hexazinone might have reached the stream by subsurface leaching through the soil, except where pellets landed close to the stream. In a 9-month study with ^{14}C labeled material, after heavy precipitation (191 cm or 75 in) on a silt-loam soil, hexazinone was leached only to the 30 cm (12 in) depth (Riggleman 1978). Because our study area had a clay-loam soil and 75 cm (30 in) of precipitation during the 8-month sampling period, downward or lateral leaching was probably much less than 30 cm.

Contamination might also enter the stream in surface runoff, which is usually negligible in forest soils (Hewlett and Nutter 1971). Observations in selected spots showed that pellets remained in place on sloping skid-trails and were 80 percent dissolved within the first 10 days. But, using analytical techniques with a .02 ppm detection limit, we found no stream contamination from hexazinone after the 5th-day sample. A 3.6 cm (1.4 in) storm occurred before the 5-day sampling, but no increase in concentration was caused by surface runoff or subsurface migration (fig. 2a). Precipitation was 1.3 cm (.9 in) before the 10-day sampling and 6 cm (2.5 in) before the 46-day sampling. Neither sampling had detectable hexazinone or its metabolites.

Total placement of hexazinone into the stream was 4.4 g, equivalent to 12.5 pellets landing in the water with .35 g a.i. each. We calculated this amount of loss by integrating concentration and discharge data. Stream discharge at the time of treatment was at low flow, .05 l/sec (.0018 ft^3/sec). The loss to streamwater is 1.2 percent of the herbicide we applied in the swath over the flood plain. This percentage approximates the percentage of the swath we estimated was occupied by the stream. So, most contamination resulted from pellets landing in the stream. One can estimate total amount of pelleted herbicide that will be placed in a stream system during a treatment by multiplying the application rate (kg/ha a.e. or a.i.) by the estimated surface area (ha) of the stream channel to be overflown.

Stream-cover interception apparently accounts for the difference in contamination concentrations between aerial sprays and pellets. The degree of contamination from pellets is apparently not influenced by brush and logging residues overhanging the stream channel. The foliar sprays reported by Norris (1967) were applied after full leaf development in a region with abundant shrub and herbaceous cover along and over the upland streams. Generally, low-volume sprays are applied so that foliar interception will be maximized. But rounded pellets aerially applied will not be stopped by foliage and will most likely land on the ground or in the stream. Therefore, aerial applications of pellets over a stream represent a greater potential for contamination than does aerial application of sprays.

ESTIMATE OF ENVIRONMENTAL HAZARD

The actual hazard of hexazinone contamination to downstream water-users and aquatic populations depends on peak and sustained concentrations. Peak concentrations are difficult to estimate since they depend on the rate that the pellets dissolve, streamflow, and the rate that the active ingredient is detoxified *or* adsorbed -by bottom sediments. Prolonged exposure to a toxic substance is more hazardous in aquatic en-

vironments than are peak concentrations. Estimates of potential sustained concentrations can be made from this study's findings if we assume sustained concentrations to be additive. Because this study monitored low-flow conditions, we are using the most extreme situation with maximum concentrations for estimating potential environmental hazards.

For every 66 m (218 ft) of flood plain treated in a watershed, hexazinone contamination would have a 0.1 ppm increment and would remain at that level for about 96 hours at the streams' confluence. As figure 2a shows, the 0.1 ppm level was reached at 24 hours, and then concentration declined to .04 ppm at 120 hours. The sustained concentrate for the first 96 hours was about 0.1 ppm.

No-effect levels of hexazinone for commonly occurring fish species and 96 hour exposures have been determined[2]: 370 ppm for bluegill sunfish (*Lepomis macrochirus*), 240 ppm for rainbow trout (*Salma gairdneri*), and ,160 ppm for fathead minnow *(Pimephales promelas).* Here, "no-effect levels" means the highest concentration having no visible effects and causing no mortality. The TL_{50} (concentrations in the water for 96 hours causing 50 percent mortality of test fish) for bluegill is > 370 ppm and < 420 ppm. A reliable estimate for the Piedmont's drainage density is 2.4 km perennial stream per 100 ha of land area (4 mi stream per mi^2 land).[3] For the most susceptible fish, fathead minnow, an assured no-effect size of treatment area within one watershed would be ≤ 4440 ha (10,971 acres). This figure assumes that all streams are the size treated in this study (C 0.5 m width) and that larger streams would be avoided during application. Environmental hazards of such careful applications appear minimal for indigenous fish, because operational applications would be unlikely to treat 4440 ha.

The potential for levels toxic to humans can only be estimated from toxicity data on laboratory animals. No-effect levels for rats and dogs have been determined as 1000 ppm hexazinone[2] in food, ingested daily for 90 days. This no-effect level was substantiated by numerous clinical tests and tissue examinations. Because treatment of 4440 ha with hexazinone would result in estimated concentrations of only 160 ppm for 96 hours, levels representing threats to human safety would not be approached in normal forestry practices.

[2] Data from *Toxicological Information,* Hexazinone by Haskell Laboratory for Toxicology and Industry Medicine. E. I. duPont deNemours & Co., Elkton, Md.

[3] John Hewlett. Personal conversation. School of Forest Resources, University of Georgia, Athens. Ga.

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