Journal of the American Mosquito Control Association, 13(3):275–277, 1997

DEGRADATION OF ALTOSID® XR BRIQUETS UNDER FIELD CONDITIONS IN MINNESOTA

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ABSTRACT. Incomplete degradation of control products and subsequent carryover of active ingredient to the next year are operational concerns for control agencies. Altosid® XR briquets were weighed before and after 6–18 months of exposure in temporary wetlands to determine the rate of physical degradation of the briquets. Degradation rate was influenced mainly by the number of days a briquet remained under water. The average briquet degraded to 19% of its weight within 150 days of immersion and was completely degraded after 1.5 yr under water. The active ingredient (methoprene) content of briquets declined faster among those exposed to air and more slowly among those that were immersed.

INTRODUCTION

A single application of slow-release Altosid® XR (extended residual) briquets provides long-term mosquito control (Knepper et al. 1992, Sulaiman et al. 1991, Weathersbee and Meisch 1991). Weathersbee and Meisch (1991) found no difference in activity between briquets in continuously flooded plots and those in plots periodically drained and reflooded.

The Metropolitan Mosquito Control District (MMCD) in Minnesota uses Altosid® XR briquets to control floodwater *Aedes* in intermittently flooded wetlands. When used in temporary wetlands, some briquets may not be continuously submerged and may not dissolve after a complete field season, especially during a dry year. The extent of active ingredient carryover in this remaining mass was therefore an environmental concern. Prior field studies by the MMCD identified the number of days the briquet was submerged and how many wet–dry cycles it experienced as factors affecting carryover of briquets. The degradation rate of the briquets under field conditions has not been evaluated, and questions have arisen regarding the possible extent of briquet carryover from one year to the next.

Although it would have been ideal to focus on the amount of active ingredient present in a treated site, this is a difficult and impractical way to measure the low concentrations of methoprene released by the briquets (Brooke 1988, Hershey et al. 1990). This study focused on the physical degradation rate of briquets under field conditions as an indirect measure of carryover activity to provide information to direct future treatments. The amount of methoprene remaining in the briquets was tested for a small sample of briquets.

MATERIALS AND METHODS

Briquet preparation and exposure: Small individual plastic-mesh "briquet bags" were constructed for each test briquet because the briquets must be retrieved from their field sites regardless of their physical condition. Therefore, the briquet "container" must be easily picked up with the briquet inside, yet not significantly influence the degradation rate.

These mesh bags, averaging 10.3 × 15.4 cm (4 in. × 6 in.) with a mesh size approximately 5 mm^3, were sewn with heavy nylon thread. A loop of heavy white vinyl was sewn into a seam of the bag to attach an identifying tag and to anchor the bag to a stake at the site.

To check the effect of the bags on briquet erosion, 5 pairs of briquets were exposed with 1 inside a bag and 1 anchored with an imbedded paper clip. Both were tied to a stake and then retrieved after various days of field exposure.

Each briquet was weighed on a calibrated electronic balance prior to treatment after being air-dried at 19–24°C (67–75°F) for at least 72 h. We weighed and dispersed 300 Altosid® XR briquets in the spring of 1991 and 297 briquets in 1992. After weighing, the briquets were placed into bags, and the bags were sewn shut and numbered. The briquets remained out of sunlight, and handling was kept to a minimum prior to placement in the field.

After retrieval from the field, the briquets were air-dried at 19–24°C (67–75°F) for 120 h and reweighed. The percent weight loss was calculated. To validate the drying time, several briquets were air-dried an additional 48 h, and no difference in weight was found due to extra drying time. A supplemental study was conducted to determine the length of time needed to fully dry prewetted briquets. It was found that 5 days of air-drying reduced the moisture content to a point where no more moisture could be removed without special equipment.

Site selection and briquet placement: Eighteen wetlands, United States Fish and Wildlife types 2, 3 and 4 (Shaw and Fredine 1971), less than 3 acres each and varying greatly with respect to size and vegetation type, were chosen from sites in the MMCD treatment area. Each site was surveyed to map the site's edge and elevations relative to the

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depth gauge. The elevational strata were designated as high, middle and low. All maps were overlaid with a 4.6 × 4.6-m (15 × 15-ft.) grid to locate stakes and place briquets.

Grid points on each map were numbered consecutively within each stratum, and intersections were randomly chosen for the test briquets. More placement locations were chosen in larger sites than in smaller sites. In 1991, 40% of the briquets were placed in the high stratum, 35% in the middle stratum, and 25% in the low stratum. In 1992, 20% were in high, 70% were in middle, and 10% were in low strata.

The bags containing the briquets were tied to wooden lath stakes using dacron line. The briquet identification number was written on each bag and also on its respective lath. The briquets were placed in each site's randomly chosen locations, with the briquet number and initial condition (wet or dry) recorded. Briquets were also applied to the rest of the site as per routine MMCD treatment (220 briquets per acre or 1 briquet every 200 ft.^{2}).

Briquet retrieval: The briquets were retrieved from each site and sorted into groups according to the number of days they had been submerged, and briquets in each group were sampled at random for methoprene analysis.

One hundred sixteen briquets were retrieved in the fall of 1991. Twenty-five were retrieved in the spring of 1992, and 67 were retrieved in October, after 2 full mosquito seasons. Of the briquets placed in the field in April and May 1992, 126 were retrieved in April 1993, and 98 were retrieved in October 1993.

At the time of retrieval, the water depth at each briquet and the depth gauge reading at each site were recorded. The bagged briquets were protected from sunlight and moisture and transported to the laboratory for drying and weighing.

Calculation of immersion times and days: Water depths were recorded in each site 3 times per week during each year to track the exact number of wet and dry days as well as the number of times each briquet became wet. Linear interpolation was used to estimate depths on days between observations. These data were used for final analysis. For each briquet at known elevation, the series of depths was used to estimate the dates when the site's water rose above and dropped below the briquet.

Methoprene content: We randomly selected 30 briquets from the pool of 1991 briquets, 15 of which had been in the field for 1 mosquito season and 15 for 2 mosquito seasons. These were assayed for methoprene content (procedure for the analysis of *S*-methoprene in briquet and premix, Zoecon procedure CAP 311) as measured by percent methoprene by weight.

Data analysis: Regression analysis using SYSTAT (Wilkinson, 1992) was used to examine the relationship between briquet degradation and the variables. The "days wet" variable was normalized using a $\ln(x + 1)$ transformation. Analysis of variance (ANOVA) was used to test the influence that site type had on degradation of briquets. The days-wet coefficient was used along with the final model equation and was then back-transformed to predict the amount of briquet degradation at a range of days-wet values.

RESULTS AND DISCUSSION

Influence of the bags: We found no difference ($P > 0.05$; paired *t*-test) in briquet degradation between the bagged and unbagged briquets. Grass grew through and mud entered the bags, but none, including the actual carryover test bags, limited movement of water, air, or sunlight through the bags. Therefore, we assumed the bags had no significant influence on briquet degradation.

Prediction of briquet degradation: The briquet weights declined linearly with a logarithmic increase in days spent submerged ($P < 0.001$, $r^2 = 0.669$). Briquets in site types 2 and 3 degraded at a slower rate than those in site type 4 ($P < 0.05$, Tukey's HSD). This was probably primarily due to the permanent water condition of the type 4 sites. However, the pattern of greater briquet degradation with greater days wet did not change with different site types (i.e., no days wet × site type interaction). The number of times the water level rose above and fell below the briquet elevations, the number of days the briquet was above water level, and the date of briquet retrieval had no effect on briquet degradation ($P > 0.05$).

The final model was used to predict briquet degradation in relation to how many days the briquets spent under water (Fig. 1). The model predicted that the 150-day briquets would have 19% mass remaining at 150 days wet. The briquets lost most of their mass in the initial month of immersion. As the mass decreased, the speed of degradation decreased. The number of days the briquets spent above the water level did not affect the breakdown of the briquets. The degradation was more directly linked to days immersed. The model predicted that 0% of the mass of a briquet would remain after submersion for a total of 510 days.

The number and amounts of rainfalls affecting the exposed briquets were not taken into account in this study. They may contribute to the seemingly large amount of degradation in the briquets that were submerged only a short period (0–50 days wet, Fig. 1). Snow, runoff, and rain may play a role in breaking down these exposed briquets but not influence the briquets that were under water.

Methoprene content: The briquets were formulated with 1.8–2.0% methoprene content (by weight). Among a sampling of the briquets retrieved after at least 150 days, the fewer days the briquets were under water, the less methoprene they contained (Fig. 2). Conversely, the fewer days bri-

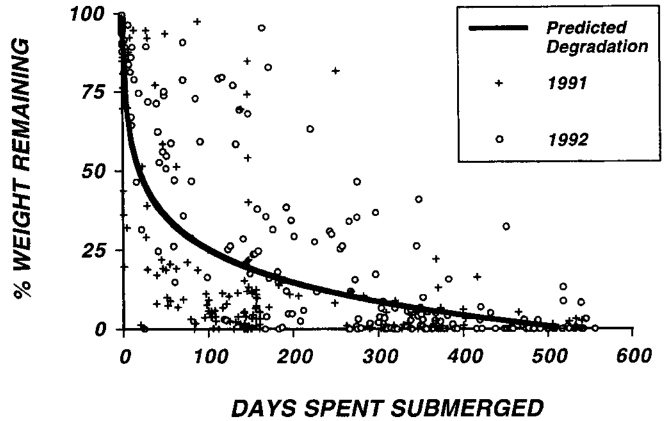

Fig. 1. Actual and predicted Altosid® XR briquet degradation at various numbers of days during which briquets had been submerged while in the field. Briquets were placed in the field in 1991 (+) and in 1992 (o).

quets spent above the water level, the closer was their methoprene content to the initial content.

This indicated that the number of days that the briquets were not in the water was a controlling factor of the methoprene content. The ultraviolet rays of sunlight are known to break down methoprene (Quistad et al. 1975). The days-dry parameter is directly related to the amount of sunlight the briquets receive. The briquets that had the most mass remaining in the field were those that spent the fewest days under water. These same briquets with the larger mass remaining are those that will have reduced methoprene content. We conclude that, while there most likely will be some carryover in temporary water sites, the briquets that do remain will have low concentrations of methoprene.

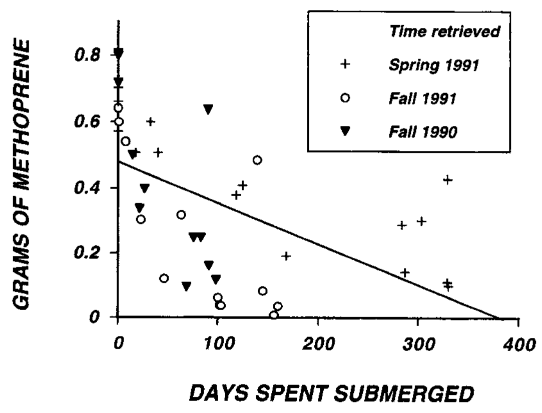

Fig. 2. Relationship between amount of methoprene remaining in briquets (g) and the number of days the briquets had been submerged. Initial formulation is 1.8–2.0% methoprene by weight, or approximately 0.7–0.85 g of methoprene per briquet. $Y = -0.001x + 0.480$, $r^2 = 0.292$.

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