TITLE: Evaluation of the Potential Movement of Pesticides Following Application to Golf Courses

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EVALUATION OF THE POTENTIAL MOVEMENT OF PESTICIDES FOLLOWING APPLICATION TO GOLF COURSES

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EXECUTIVE SUMMARY

A critical issue facing the turfgrass industry is the environmental fate and safety of pesticides used in the management of recreational facilities. A major concern for the impact of pesticides on the environment is their potential entrance into drinking water sources which is facilitated by movement in surface water and groundwater from the treated site. Many golf course greens are constructed for maximum infiltration and percolation of water through the soil profile.

The objectives of our project are to: (1) determine the potential movement of pesticides from treated bermudagrass and bentgrass greens through effluent entry into surface runoff and groundwater and (2) determine the potential movement of pesticides from treated bermudagrass fairways by surface runoff and groundwater.

The initial funding of this project was received during the spring of 1991 and the proposed research time table for 1991 is for the development of the greenhouse and field lysimeter installations and to develop laboratory methods for accurately quantifying the pesticides according to Good Laboratory Practice Standards. Analytical methods were developed to accurately determine 2,4-D; mecoprop; and dicamba at levels of 1, 100, and 20 ppb, respectively, in aqueous solution using partition extraction and electron-capture gas-chromatography analysis.

The greenhouse lysimeter facility has been constructed to simulate golf course greens with Penncross bentgrass and Tifgreen bermudagrass turf. Thirty-six individual lysimeters were constructed by mounting a turfgrass growth-box on a PVC column containing a soil profile developed according to USGA specifications. An automatic track-irrigation system was developed for controlling the rates and times for irrigation. The watering nozzles traverse a horizontal track located above the growth boxes at a speed of 2.9 m/min. The flow rate of the water was adjusted to a rate of 1.8 ml/sec at 20 psi. The daily irrigation of 0.6 cm of water and a weekly rain event of 2.5 cm are controlled by an automatic timer. The coefficients of variation for water distribution were less than 0.08 across the boxes laterally and over the length of the track. The first pesticide treatments will be conducted during the last week in October, 1991.

The field lysimeter facility consists of small bermudagrass and bentgrass greens with lysimeters (55 cm diam.) installed below the sod. The 20 lysimeters are plumbed in the bottom for collection of aqueous effluent from the soil profile developed according to USGA specifications. Bentgrass will be seeded during the last week in October, 1991 and bermudagrass will be sodded in April, 1992.

INTRODUCTION

The public demand for high quality and uniform turf often requires the use of intensive management to maximize pest control. Additionally, the increasing interest by the general public for the environmental and human impact of certain management practices used at recreational facilities is a major concern for the research and regulatory institutions responsible for turfgrass management practices. A critical issue facing the turfgrass industry is the environmental fate and safety of pesticides used in management of recreational facilities and home lawns. The enhanced interest in pesticide use is, in general, a response to their increased use since the 1960's and the increased technological-proficiency in determining smaller quantities of pesticides in the environment.

A major concern for the impact of pesticides on the environment is their potential entrance into drinking water sources which is facilitated by movement in surface water and groundwater from the treated site. Although, most of the drinking water for rural areas comes from groundwater, much of the drinking water in urban areas is derived from surface water containments such as reservoirs. It is estimated that as much as 95% of the drinking water for some major metropolitan areas comes from reservoirs. Movement of pesticides in surface water and groundwater is considered the major source of potential pesticide movement into drinking water sources in the Piedmont and Coastal Plain regions, respectively.

Many golf course greens are constructed for maximum infiltration and percolation of water through the rooting media. Root zone mixture composition generally includes at least 85% sand allowing for rapid water percolation and having an extremely low cation exchange capacity. Additionally, soil sterilization is recommended during construction which influences the potential for soil-microbial decomposition of applied pesticides. These characteristics of the root zone mixture could allow for the rapid movement of pesticides through the rooting mixture resulting in a potential source of contamination of the effluent water from the greens. The effluent water ultimately resides in drainage ditches, ponds and streams.

The rolling topography of the Piedmont region allows for sloping fairways that drain into ponds and streams. Generally, grassed areas have been found to be effective in restricting the movement of water from slopes. However, closely mowed fairways that are compacted by traffic could allow for increased water runoff and the potential for pesticide movement into drainage areas. Fairways in the Coastal Plain region have less slope and are subtended with sandy soils having higher percolation rates compared to the finer textured soils in the Piedmont region.

A thorough search and review of the literature concerned with the environmental impacts of pest management strategies indicate that research on pesticide fate, following application to turf, should be placed high on a priority list and should receive immediate attention.

The objectives of the research proposal funded by USGA are to:
(1) determine the potential movement of pesticides from treated bermudagrass and bentgrass greens through effluent entry into surface runoff and groundwater and (2) determine the potential movement of pesticides from treated bermudagrass fairways by surface runoff and groundwater.

Proposed Research Time Table.

1991

Construct lysimeters in the greenhouse and begin sampling pesticide movement through rooting media. Construct and install field lysimeters and rain shelters and establish bentgrass greens for field-greens research.

1992

Continue sampling greenhouse and field lysimeters, install bermudagrass lysimeters, construct bermudagrass fairway plots with rain shelter and instrumentation and begin sampling surface runoff water and groundwater.

1993

Continue sampling of golf course greens and fairway simulations and initiate treatments to allow for the development of mathematical description for the movement of pesticides in surface and groundwater. Dependant on the results of research conducted during 1991 and 1992, the treatments for the lysimeter studies could include changing the organic matter and clay content in the rooting substratum and/or inoculation of the substratum with microorganisms. Treatments to the simulated fairway experiments could include increased water infiltration rate through aeration or slotting the ground surface and amelioration of the surface soil texture.

RESULTS

Personnel Assisting on the Project.

Nehru Mantripragada (Research Assistant) received the M.S. degree from the University of Georgia in Entomology. He has directed the laboratory research for Weed Science for 2 years and will be responsible for (1) conducting the greenhouse research, (2) performing pesticide extractions from vegetation and water samples, and (3) operating the analytical instruments.

Hong Song (Ph.D. candidate, Graduate Student) received the M.S. from Beijing Agricultural University, China in Pesticide Parmacy and worked in the Pesticide Analytical Laboratory with the Ministry of Agriculture in China. He will be conducting his dissertation research on the development of analytical methods for dithiopyr and will evaluate the movement of dithiopyr from the turfgrass surface by vaporization and the potential movement of dithiopyr through simulated golf course greens.

William Slaughter (Agricultural Specialist) is constructing the greens/lysimeter facility with the assistance of several additional technicians assigned to Project Leaders in Weed Science.

Arthur S. Lee (Research Associate) will receive the Ph.D. in Chemistry from Memphis State University in December. He will move to the Georgia Station and initiate a research program in our laboratories on the development of sensitive methods for analyzing pesticides and pesticide-metabolites in aqueous solutions. Dr. Lee will be the Facility Coordinator for the Good Laboratory Practice regulations. Funds for this position are included in the grant support from USGA.

Analytical Laboratory.

The analytical laboratory is being developed for the conduct of research according to Good Laboratory Practice Standards as established in the Federal Register 40 CFR part 160 and with special provisions established by USGA. An additional laboratory has been constructed for the research to be conducted by the Research Associate.

Gas chromatography methods are being improved for analysis of the pesticides to be included in the research programs. Historically, we have used methods of analysis for the herbicides at concentrations in aqueous solutions in the parts-per-million range. However, the design for this research will require a sensitivity range in the parts-per-billion which will require improved methodology for extraction and instrument analysis. Methods have been developed for accurately determining 2,4-D at a level of 1 ppb, mecoprop at 100 ppb, and dicamba at 20 ppb in aqueous solution using partition extraction and electron-capture gas chromatography analysis.

Greenhouse Lysimeters.

Thirty six lysimeters were constructed by placing turfgrass growth boxes (40 X 40 X 15 cm deep) containing Penncross bentgrass and Tifgreen bermudagrass on top of a base. The bottom of the wooden growth boxes were perforated steel and at the inside-center of the growth boxes a 13 cm length of PVC tubing (15 cm long) was fastened to the bottom with acrylic caulk.

The base of the lysimeter consisted of a 52.5 cm length of PVC tubing (15 cm diam.) with a cap over one end (bottom) of the tube. The cap had a drain tube placed in bottom for the collection of aqueous effluent. The growth boxes were designed to be removed from the bases to allow for the pesticide application to the turfgrass sod using a spray chamber at a location separate from the greenhouse in order to minimize the contamination to the greenhouse.

The rooting media was a mixture of sand and sphagnum peat moss at ratios of 85:15 and 80:20 for bentgrass and bermudagrass, respectively. The water percolation rate for the mixtures were 39 and 33 cm/hr for the respective mixtures. The bases were filled with sized gravel (10 cm), coarse sand (7.5 cm), and rooting mix (35 cm) in order from bottom to top. The layers were packed, into the tubes, using a vibrating table. The lysimeter is located against the bottom of the growth box aligned with the PVC tube within the box.

The growth boxes were filled with the respective rooting mixes and sod of Tifgreen bermudagrass was placed into the bermudagrass lysimeters and Penncross bentgrass seed were seeded into the bentgrass lysimeters. The turf height is maintained to simulate a golf course green with Tifgreen bermudagrass or Penncross bentgrass.

An automatic track-irrigation system (Figures 1 and 2) was developed for controlling the rates and times for irrigation. The watering nozzles traverse a horizontal track located above the growth boxes at a speed of 2.9 m/min. The flow rate of the water was adjusted to a rate of 1.82 ml/sec at 20 psi. The daily irrigation of 0.625 cm of water and a weekly rain event of 2.5 cm were controlled with an automatic timer. During watering the coefficients of variation (CV) were less than 0.08 across the boxes laterally and on the length of the track.

Light intensity, daylength, and temperature are controlled in the greenhouse. The temperature of the rooting media is controlled using an air conditioner connected to the enclosed area around the base of the lysimeters. The soil is maintained at a temperature of 18-21 °C. The ambient temperature is maintained at 27-30 °C.

Field Lysimeter Facility.

Small field plots consisting of rooting mixtures of 85:15 and 80:20 sand:sphagnum peat moss subtending Penncross bentgrass and Tifgreen bermudagrass respectively, will be established with lysimeters installed under the turf. The design of the lysimeters allows for replacement of the rooting substratum at the end of each experiment in preparation for succeeding (Figure 3). Stainless steel inserts into a fiberglass jacket allows for easy removal of each lysimeter. The interior diameter of each lysimeter is 55 cm and the depth is 52.5 cm allowing for layers of gravel, sand and rooting media as used in the lysimeter bases in the greenhouse. The lysimeters are plumbed in the bottom for the collection of the aqueous effluent from the rooting profile. Controlled applications of irrigation water and fertilizer will be according to cultural practices for maximum maintenance. The lysimeters are being installed into the bentgrass field plots and the area will be seeded during the last week of October. The Tifgreen bermudagrass will be sodded during the spring of 1992.

An automatic moving rain shelter (Figure 4) was constructed for movement over the simulated greens area during rain events and for irrigation purposes. The lysimeters are instrumented for continuous monitoring of temperature and soil moisture content in the root zone. Irrigation will be used to simulate rainfall of 130 cm yr^{-1}. The event intensities are controlled to give two events of 0.63 cm and one event of 1.26 cm $week^{-1}$. Pesticides will be applied during the spring and summer of 1992 through a calibrated applicator and leachate will be continuously collected in stainless steel containers through stainless pipe plumbed into the base of the lysimeters. The stainless steel containers are located in a concrete-walled walkway cellar located between the bermudagrass and bentgrass plots (Figure 4). All excess eluant will be collected in a concrete well and pumped into a container for disposal.

Golf Course Fairways.

Surface water movement of pesticides from simulated fairways for the Piedmont region will be determined by developing an area of Tifway bermudagrass having a 2% slope. The soil type is a Cecil clay loam (clayey, kaolinitic thermic Hapludult) which is typical for the Piedmont region. The perennial vegetation on the area has been controlled by three timely applications of glyphosate over the summer. The area will be instrumented for determining pesticide movement through the soil profile, soil temperature, and soil moisture prior to deep-plowing and sodding with Tifway bermudagrass. The deep-plowing will simulate the preparation of fairways or lawns and will reduce the variability in water movement into the soil due to differences in soil structure.

Publications.

Smith, A. E. 1991. A greenhouse system for determining the potential movement of pesticides in effluent water from golf course greens. ABSTRACT. Proc. 31st Meeting of Weed Sci. Soc. Amer. P. 20.

Smith, A. E. 1992. An automatic watering system for use in the greenhouse research on pesticide movement. Environ. Sci. and Tech. In Preparation.

Smith, A. E. and N. Mantripragada. 1992. Comparison of BF_3-methanol and diazomethane for esterifying phenoxy and benzoic acids for gas chromatography. J. Agric. and Food Chem. In Preparation.

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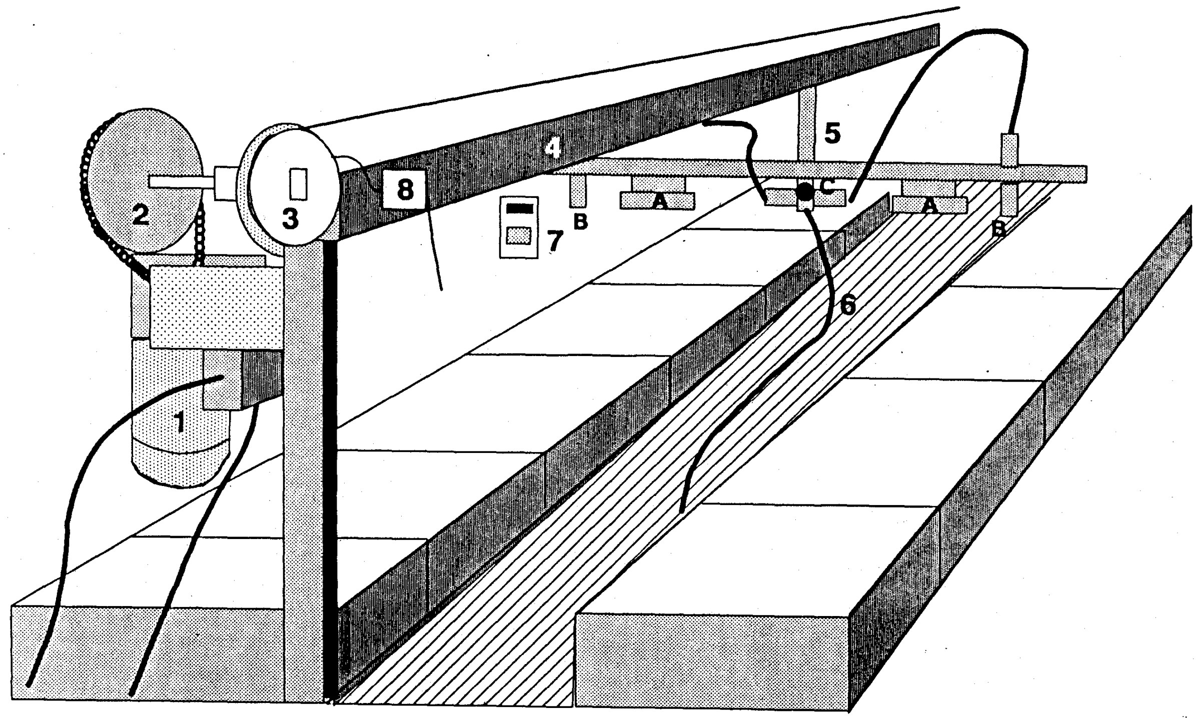

Figure 1. Schematic of track water system mounted above growth boxes of lysimeters.

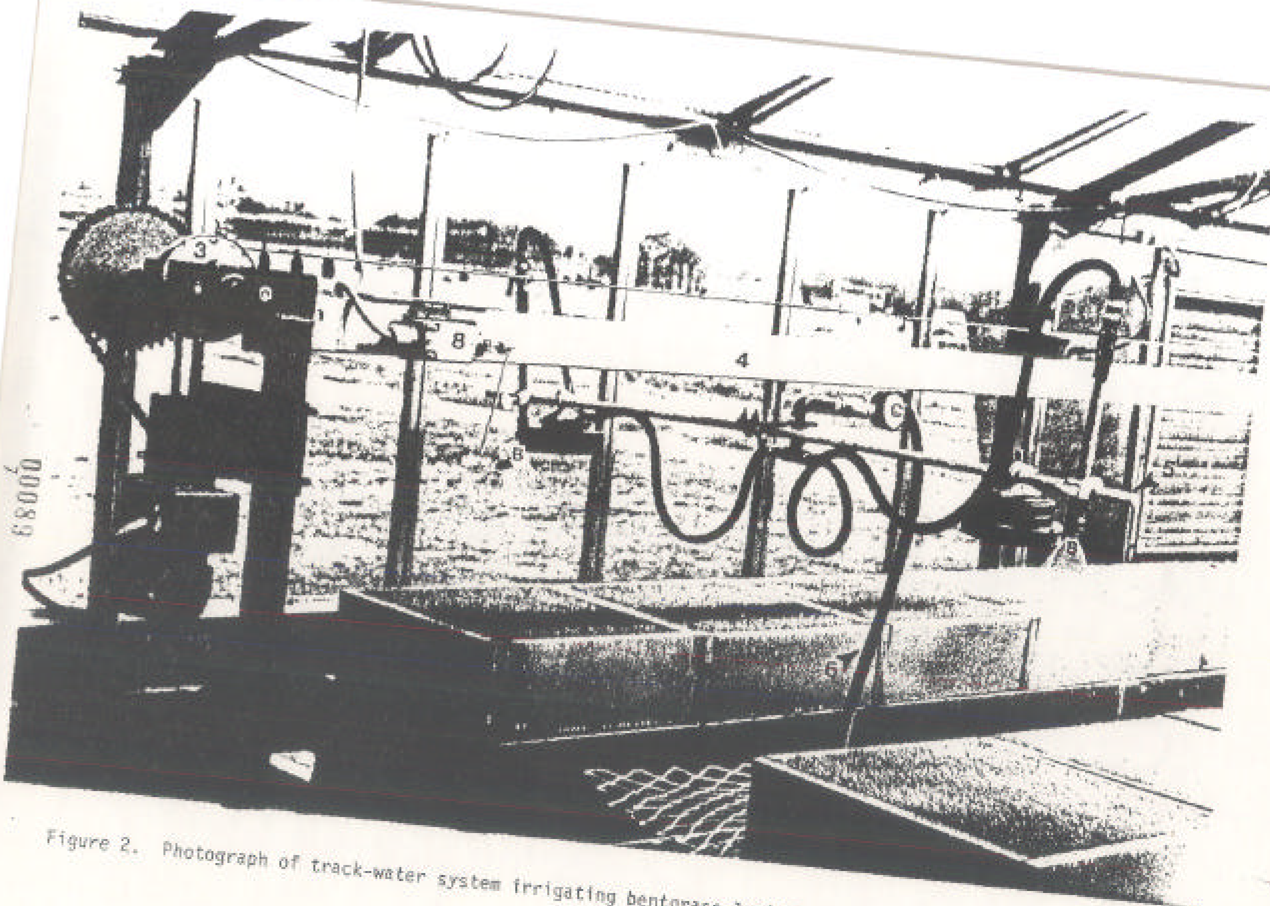

Figure 2. Photograph of track-water system irrigating bentgrass lysimeters.

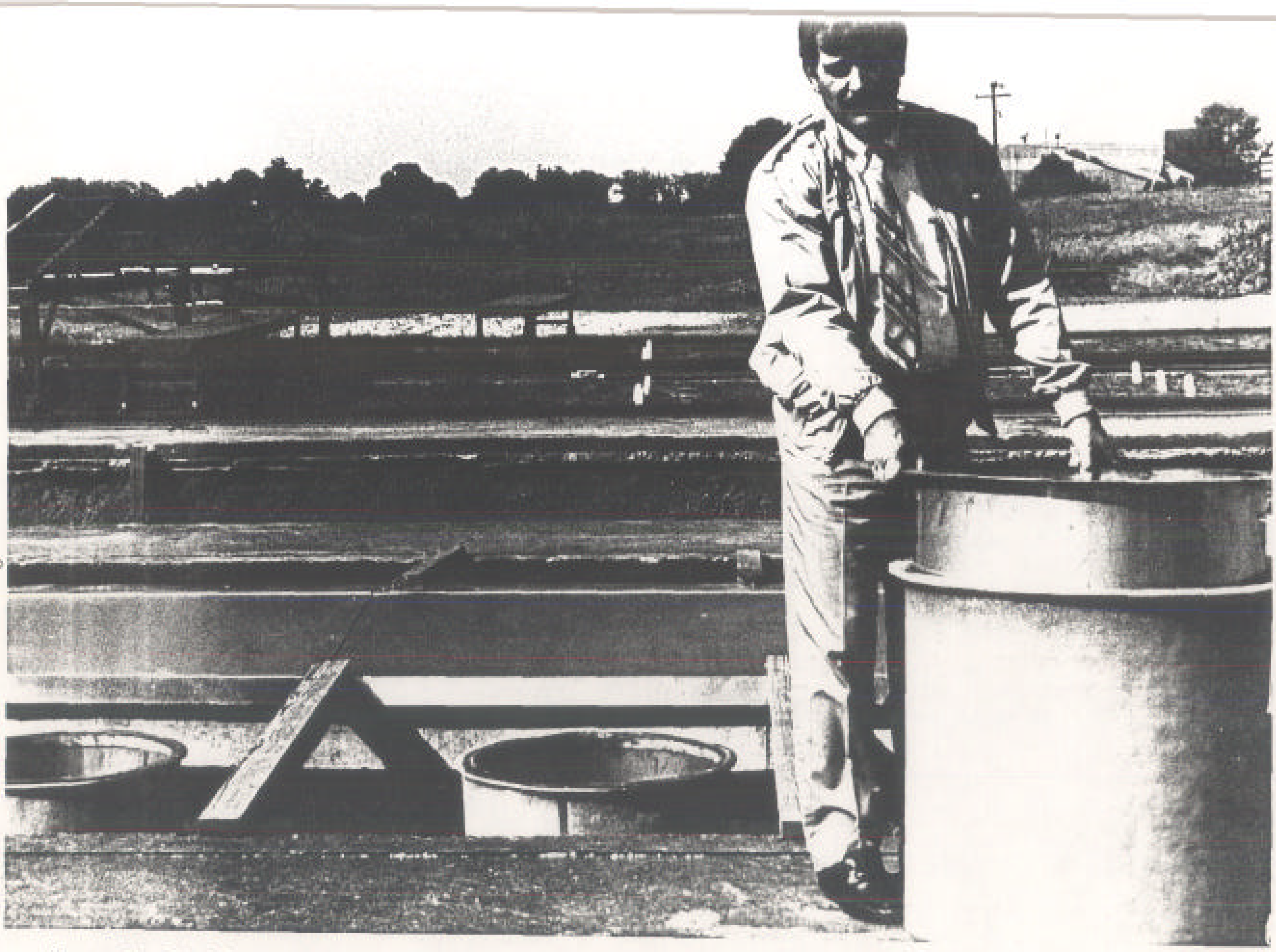

Figure 3. Stainless-steel insert and fiberglass jacket of lysimeter.

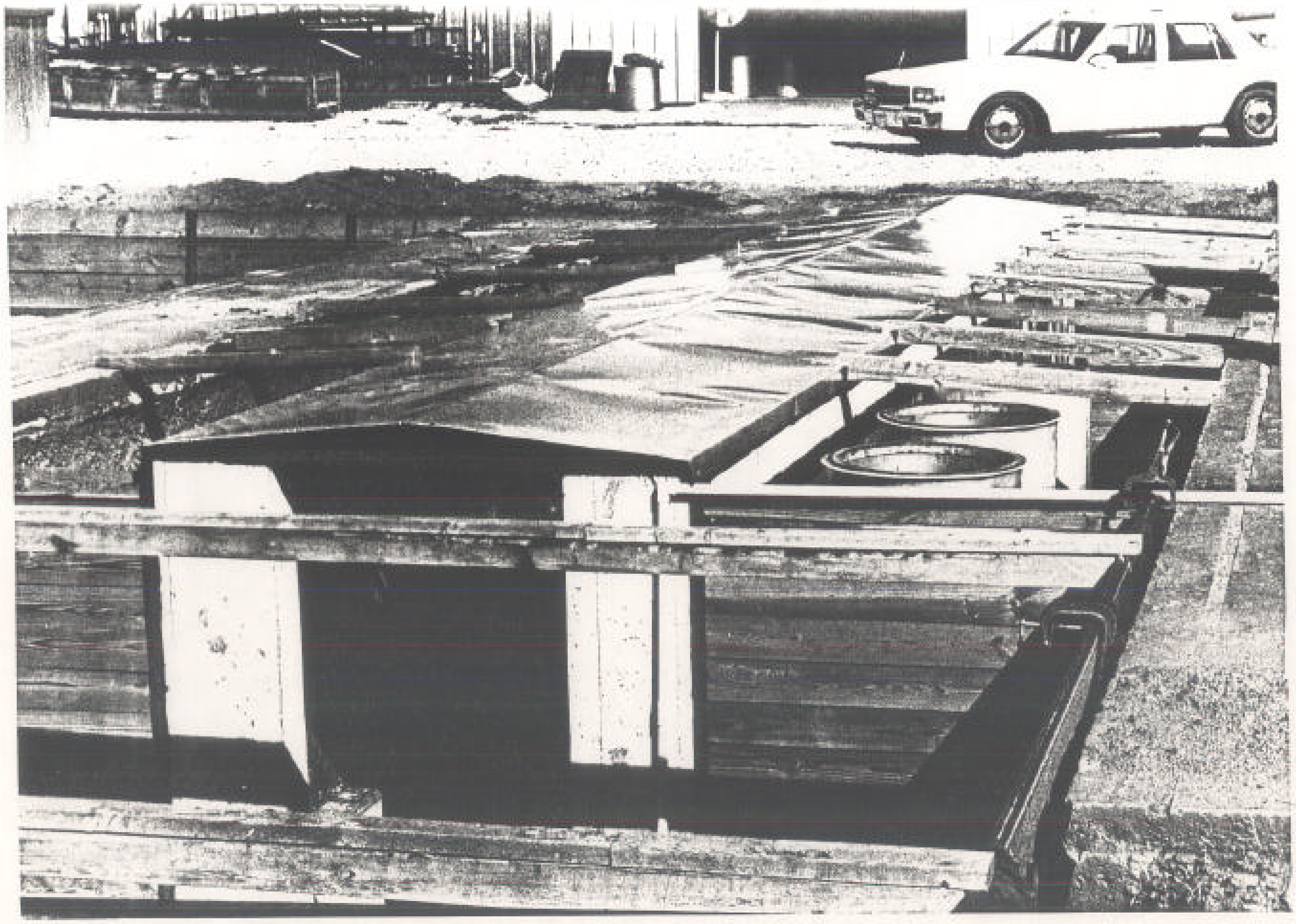

Figure 4. Field lysimeter facility prior to establishing the bentgrass and bermudagrass on left and right sides of walkway cellar.