Identifying and managing petroleum spills and leaks on turf

AT TIMES, petroleum products may spill or leak onto sports fields maintained with motorized power equipment. Fuel, oil, hydraulic and brake fluids, and grease can injure turfgrasses and have the potential to pollute soil, surface water bodies and groundwater. Turf injury symptoms often vary depending on the type of leak or spill. For example, hydraulic fluid leaks tend to damage turf in a straight line pattern, while a gasoline spill often causes an irregularly shaped, circular dead area of turf with a very distinct edge or margin. The amount of time turfgrasses require to recover after contacting petroleum often depends on a number of factors including the product type, volume, temperature and ingredients, and soil and climatic conditions.

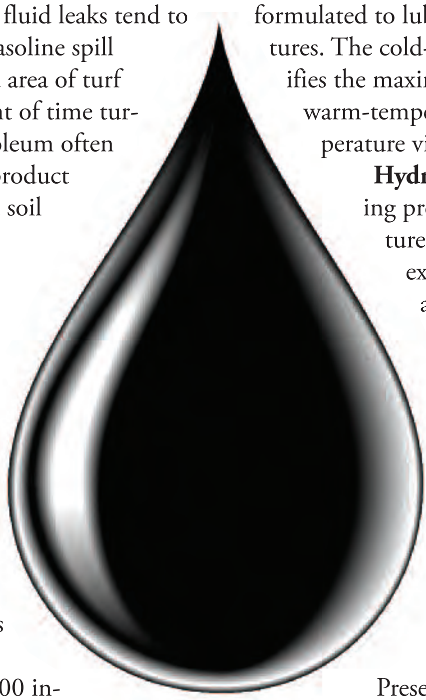
Petroleum products contain carbon - 83 to 87%; hydrogen - 10 to 14%; nitrogen - 0.1 to 2%; oxygen - 0.05 to 1.5%; sulfur - 0.05 to 6.0%; and metals - < 0.1%. Petroleum-contaminated soil and water may prevent turfgrass seeds from germinating, restrict photosynthesis or kill plants.

Products are categorized based on their composition and intended use.

Gasoline is a mix of hydrocarbons with a chemical formula of C_4 to C_{12}. Other substances including anti-rust and anti-icing agents and detergents may be added to improve performance. Gasoline often contains more than 500 individual compounds, is insoluble in water at a temperature of 68°F, has a boiling temperature of 80 to 437°F and has a flash point of -45°F. Depending on the refinement process, gasoline contains 85-88% carbon, 12-15% hydrogen and no oxygen.

Ethanol, with a chemical formula of CH_3CH_2OH, can be produced by fermenting sugars from corn, and distilling the fermented solution. This fuel can also be produced from the cellulose of several plants including switchgrass. Almost all of the ethanol used for industrial purposes contains 5% water. Ethanol has a boiling temperature of 172°F, a freezing temperature of -142.5°F and a flash point of 55°F. Ten percent ethanol is often mixed with 90% gasoline to create gasohol. Ethanol is also available as a high-level blend known as E85 for use in flexible fuel vehicles.

Diesel Fuel, like gasoline, contains hydrocarbons and additives. Additives may reduce wear and oxidation, deactivate metals or improve ignition and stability. Number 2 diesel fuels have a chemical formula of C_8 to C_{25}, a flash point of 165°F, and contain 84-87% carbon, 13-16 % hydrogen and no oxygen.



Petroleum Illustration ©istockphoto.com/julichka

Motor oil is classified according to viscosity standards developed by the Society of Automotive Engineers (SAE). In general, high-viscosity oils are "thick" compared to low-viscosity oils, which are considered to be "thin." Each standard grade of motor oil is defined by viscosity in accordance with SAE J300 specifications. Multi-grade or multi-viscous oils (for example SAE 5W-30 and 10W-30) are formulated to lubricate engine parts at both low and high temperatures. The cold-temperature standard (W or "winter" grade) specifies the maximum cold temperature viscosity, and the warm-temperature standard specifies the minimum high-temperature viscosity.

Hydraulic fluid, a very versatile hydrocarbon-containing product, is capable of performing at high temperatures (for example, 110 to 130°F) and pressures (for example, 3000 psi or greater). The base fluid may be a refined mineral oil, synthetically produced or bio-based, and may have fire-retardant properties. Typical additives include: corrosion (0.05-1.0%) and oxidation (0.2-1.5%) inhibitors, de-foaming (2-20ppm), anti-wear (0.5-2.0%) and anti-friction (0.1-0.75%) agents, and detergents (0.02-0.2%). Hydraulic fluid usually has a flashpoint at least 68°F higher than the maximum fluid "working" temperature. Atomized hydraulic fluid leaking from a hose may catch fire if exposed to an ignition source.

Brake Fluid is a type of hydraulic fluid.

Presently, three material groups: mineral oil, silicon or polyglycon ether (glycol), are used as brake fluids. Brake fluids with a glycol base are most widely used commercially. The boiling point varies among the brake fluid grades established by the Department of Transportation (DOT). For example, the dry boiling point of DOT Grades 3, 4, 5 and 5.1 is 401°F, 446°F, 500°F and 500°F, respectively. With the exception of DOT 5 (silicon base), the pH of these fluids must be no lower than 7.0 and no higher than 11.5.

Grease used for lubrication is recognized by the American Society of Testing and Materials (ASTM D 288, Standard Definitions of Terms Relating to Petroleum) as "A solid to semifluid product of dispersion of a thickening agent in liquid lubricant. Other ingredients imparting special properties may be included." The combination of base oil, thickener and additives affect the viscosity and intended function. Grease is usually classified according to thickness on a 0 (soft) to 6 (firm) scale.

Turfgrasses are capable of removing pollutants from soil and water. For example, researchers at Kansas State University determined that the breakdown of total petroleum hydrocarbons (TPH) in soil with an initial concentration of 0.05 lb. TPH per lb. of dry soil in which bermudagrass and tall fescue was maintained was reduced by 68% and 62%, respectively, after 1 year. Similarly, the concentration of TPH of refinery wastewater steadily decreased when perennial ryegrasses were introduced into an aquatic environment remediation system for 35 days. This research demonstrated that, in addition to appropriate plant species, the activity of microorganisms in soil and water is a critically important part of a bioremediation or purification project.

Soils can support huge populations of beneficial microorganisms most of which live in very thin water films surrounding the soil particles. It has been estimated that one spoonful of soil may contain as many as 8,000,000 species of bacteria. In sports turfs, many microorganisms gain energy as they break down carbon-rich compounds including grass clippings, roots, root exudates and certain fertilizers (for example, methylene urea, Milorganite, urea formaldehyde…). Under favorable conditions, microbial activity in the area surrounding turfgrass roots known as the rhizosphere is most often intense, and populations of microorganisms may be as much as 10 to 100 times greater than those in adjacent soils in which there are no roots.

Research regarding the direct effects of petroleum on turfgrasses and recommended treatments after a spill or leak is very limited.

Research conducted on TifEagle and Tifdwarf bermudagrass, and Sea Isle seashore paspalum greens at Edison College in Fort Myers, FL demonstrated that a spill of either a biodegradable vegetable/ester-based hydraulic fluid or a petroleum/mineral-based hydraulic fluid resulted in larger areas of damaged turf and a more intense foliar burn compared to a synthetic hydraulic fluid. Two-thirds ounce of hydraulic fluid was applied in a straight line through the center of each appropriate plot from a height of about ½ inch. The greens' soil was a 90:10 sand:peat mixture, and each of the three hydraulic fluids was at ambient air temperature when applied. At 15 days after treatment, bermudagrasses and seashore paspalum in plots treated with synthetic hydraulic fluid were completely healed.

A second study was conducted to investigate the effects of both spill volume (0.03 oz., 0.1 oz. and 0.17 oz.) and hydraulic fluid temperature (122°F, 140°F, 158°F and 176°F) on Tifdwarf bermudagrass maintained at greens height. By day 7, bermudagrass receiving the vegetable/ester-based hydraulic fluid or the petroleum/mineral-based hydraulic fluid was severely damaged. By day 28, bermudagrass receiving the synthetic hydraulic fluid treatments showed minimal damage compared to bermudagrass receiving the other two hydraulic fluids. The area of damaged turf and the intensity of foliar burn increased with rising fluid spill volume. While the temperature of the fluid at the time of treatment did not seem to affect the amount of damage caused by the vegetable/ester-based or the petroleum/mineral-based hydraulic fluids, the intensity of burn following the synthetic hydraulic oil treatment did increase with rising fluid temperature.

Researchers at Texas A&M University studied the effects of spray applications of gasoline (low octane, leaded), motor oil (30 SAE), and hydraulic (Ford Loader and Backhoe) and brake (Johnson's Supreme Heavy Duty) fluids, and a direct application of grease (Pennzoil 705) at ambient air temperature on Tifgreen bermudagrass growing in a sandy loam soil and mowed twice each week at a 1-inch cutting height with clippings returned before the petroleum products were applied. The researchers also evaluated the perform-

figure 1

A Comparison of Several Fuels[a]

Property

Fuel	Chemical Structure	Fuel Material	Flash Point	ignition Temperature	Comments
BIODIESEL	$C_{12} – C_{22}$	Fats and oils- animal fats, waste cooking oil, rapeseed, soybean	212 °F to 338 °F	-300 °F	Higher percentage blends may affect seals and hoses; improved lubrication compared to that of conventional diesel fuel
DIESEL #2	$C_8 – C_{25}$	Crude oil	165 °F	-600 °F	
ETHANOL	CH_3CH_2OH	Corn, small grains, cellulose	55 °F	793 °F	Lubricants may have to be added
GASOLINE	$C_4 – C_{12}$	Crude oil	-45 °F	495 °F	

[a] From: Fuel Properties. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Alternative Fuels Data Center; *http://www.afdc.energy.gov/afdc/fuels/properties.html*.

figure 2

Summary of Recommended Corrective Treatments and Recovery Times for Bermudagrass after Five Intentional Petroleum Spills (Texas A&M University).[a]

Petroleum Product	Recommended Treatment	----- Recovery Time in Weeks ----- Treated	Untreated
GASOLINE	None	4	4
MOTOR OIL	Detergent	4	8 to 10
HYDRAU1IC FLUID	Detergent	4	8 to 10
BRAKE FLUID	Detergent	2 to 3	8
GREASE	None	8 to 10	8 to 10

[a] From: Johns, D. and J.B. Beard. 1979. Effects and treatments of petroleum spills on bermudagrass turf. Agron. Journ. Vol. 71. Pp. 945-947. Nov.-Dec.

ance of calcined clay fines (0.2 mm.), activated charcoal and detergent (anionic and non-ionic granules) as corrective treatments. Gasoline, motor oil, hydraulic fluid and brake fluid were applied to the bermudagrass at a rate of 4 oz./sq.ft. Grease was uniformly and directly spread on the turf. Activated charcoal, calcined clay or detergent was applied within 20 minutes later at the rate of 0.2 oz./sq.ft., 2.1 oz./sq.ft. and 0.7 oz./sq.ft., respectively. An untreated check receiving a water drench immediately after petroleum treatment was also included for comparison purposes. During the study, bermudagrass was irrigated daily with 0.25 inch of water and received 1 pound of nitrogen per 1,000 sq.ft. throughout the growing season. Mowing was resumed 2 weeks after all treatments were applied.

Turf injury symptoms varied among the petroleum products:

Gasoline. Turf was shiny, slightly oily and had a pungent smell immediately after treatment. Within 30 minutes, bermudagrass plants were drying rapidly, had rolled leaves and were darker than plants in the untreated check. Leaf rolling was considered severe after 1 hour and the turf was completely brown after 16 hours.

Motor oil. For the first 16 hours after treatment, turf was oily and appeared shiny. A few leaves were rolled. Leaf browning occurred after 20 hours and after 48 hours, 50% of the aerial shoots were killed and the turf still appeared to be oily.

Hydraulic fluid. Although leaves did not die as rapidly, the initial injury symptoms following the hydraulic oil application were very similar to those of gasoline. Turf developed a dark brown color after 16 hours; however several leaves and stems remained green.

Brake fluid. Initially, turf treated with brake fluid had a characteristic odor, and leaves appeared shiny for about 30 minutes before beginning to roll, darken and dry. Leaf roll was considered extensive after 16 hours and turf was pale grayish-green. All aerial shoots were dead after 48 hours.

Grease. Although no distinct injury symptoms appeared during the first 16 hours after treatment, grease remained visible on the surface of leaves. After 48 hours, about 30% of the aerial shoots had died and grease was still visible on many leaves.

The rate of recovery of bermudagrass following corrective treatments also varied.

Gasoline. None of the corrective treatments following the intentional gasoline "spill" improved the rate of recovery of bermudagrass which was totally recovered within 4 weeks.

Motor oil. Detergent proved to be the most effective corrective treatment following the motor oil application. Bermudagrass treated with detergent reached 85% recovery by 4 weeks and 95% by 8 weeks after spill. Bermudagrass treated with either activated charcoal or calcined clay had achieved only 30% recovery by 8 weeks after spill.

Hydraulic fluid. Detergent was an effective treatment following the hydraulic fluid spill, with bermudagrass recovery reaching 90% within 4 weeks. Activated charcoal and calcined clay were much less effective post-spill treatments. Bermudagrass recovery after 4 weeks was 25% following the activated charcoal treatment and 15% following the application of calcined clay. After 8 weeks, bermudagrass recovery following the application of either activated charcoal or calcined clay was only 50%, just slightly better than the 45% recovery rate of untreated, water-drenched bermudagrass.

Brake fluid. Since the brake fluid was relatively water soluble, bermudagrass in the untreated, water-drenched plots totally recovered within 4 weeks. Bermudagrass in plots treated with detergent totally recovered within 3 weeks.

Grease. Bermudagrass required 10 weeks to fully recover following the grease application regardless of the corrective treatment.

By knowing what injury symptoms look and perhaps, smell like, and what corrective action to take immediately following a petroleum leak or spill will help protect the environment and may speed turfgrass recovery. ■

Tom Samples, John Sorochan and Adam Thoms, Plant Sciences Department, and William Hart, Biosystems Engineering and Soil Science Department.