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The Environmental characteristics of hydraulic fluid from regenerative raw materials

Hydraulic fluids from regenerative raw materials are more biodegradable and less problematical in eco-toxicity terms compared with mineral oils. Up until now, however, the ecological advantages result in no preferment in reduced liability insurance premiums or in appropriate releases in reparation claims. There is an urgent need for research into what appropriate actions have to be carried out in an oil accident in order to heighten the acceptance of hydraulic fluid from regenerative raw materials. This report records first results of the environmental characteristics of hydraulic fluids from regenerative raw materials related to their action in the soil (spread, degradability and plant toxicity).

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Keywords

Renewable raw materials, rapidly degradable oil, risk estimate of oil disaster

In a cooperative research project, the spread characteristics of biological hydraulic fluids within the soil and on the ground surface were investigated in more detail, along with their toxicity and degradability. The work concerned itself not only with the comparison of bio and mineral oils but also included defined aged hydraulic oil in the study. Furthermore, the type of measuring techniques suitable for assessing oil damage in the soil were looked at, as was the extent to which risk models can help in assessment of necessary cleaning-up actions after oil accidents.

Following the presentation of the measuring techniques for assessing oils in the ground (Landtechnik 5/99, pp 296-297) this report presents the first results with regard to the environmental characteristics of hydraulic fluids from regenerative raw materials in comparison to mineral oil. Trials were carried out in lysimeters containing different soil types (natural structures and artificially constructed piles) to assess spread performance with different amounts of oil, different soil moistures and different temperatures of oils. Commercial hydraulic fluids were used as well as fuels and lubricants on a triglyceride basis (HETG oils) and ester basis (HEES oils). Special criteria for the selection of the biologically rapidly-degradable hydraulic fluids to be used in the trials were in particular the viscosity, the oxidation stability and the operational temperatures in tractors and agricultural implements and the biological degradability according to the CEC L-33-A-94 test. New oils and also oils defined as aged in the hydraulic test station were used

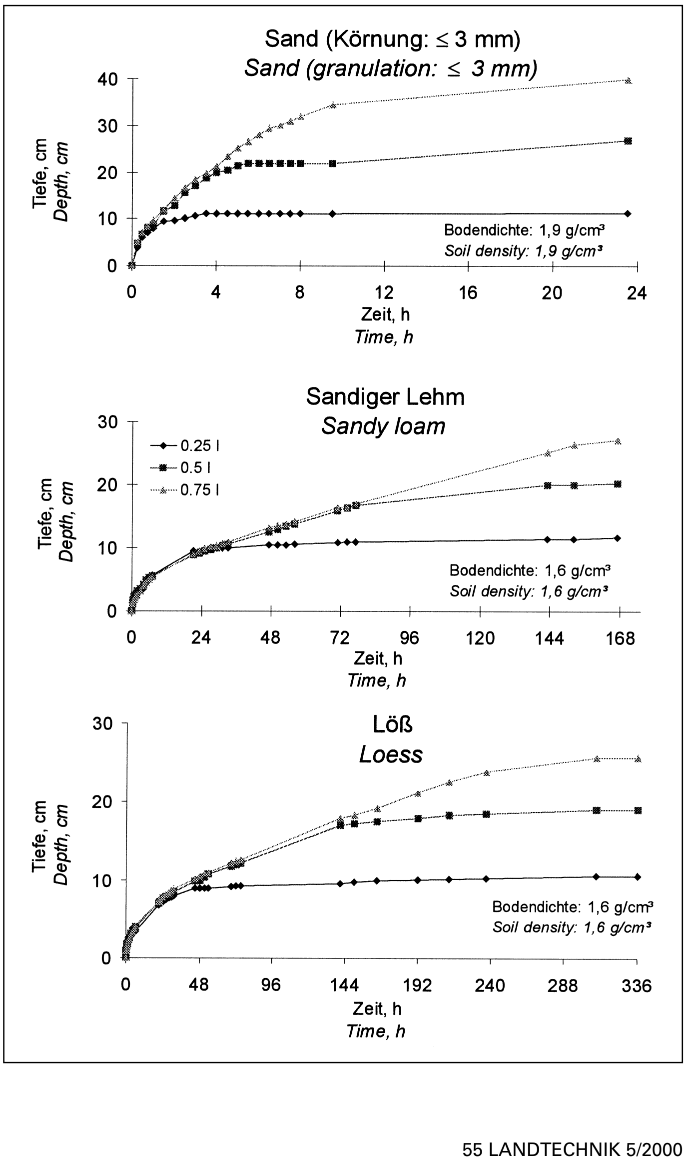

Fig. 1: Penetration of a rapidly degradable hydraulic fluid into a soil

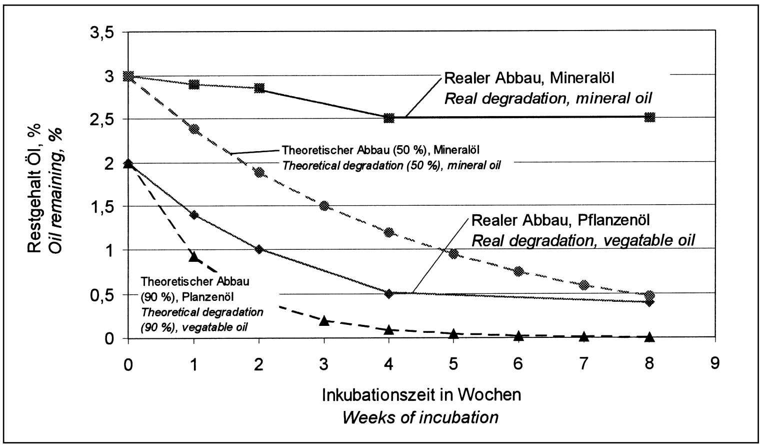

Fig. 2: Biological degradation of mineral oil and vegetable oil

in the project. The alteration of physical-chemical parameters and the element content of the hydraulic oils, as well as their temperature and pressure loads, gave information as to their working properties. It could be shown that these altered parameters could, in the case of spillage, have only a small influence on the penetration characteristics of the oils in the ground.

Environmental characteristics of oils in soils

The greatest influence in the assessment of oil damage comes from the physical-chemical properties of the soil matrix. The spread characteristics of the oils in the ground are very strongly influenced by the type of soil (parameters such as soil moisture, porosity, compaction, hydraulic conductivity). Along with the type of soil, the amount of oil involved is also decisive in an oil spillage. The type of oil (viscosity, age) has less influence. *Figure 1* shows as an example the vertical spread after an oil spillage through the sudden leakage of a HETG oil on selected types of soil with different damage loads. The damage loads of 0.25 l, 0.5 l and 0.75 l represent 28.9 l/m^2, 57.7 l/m^2 and 86.6 l/m^2 in the case of a spillage. The results reported here deliver first steps towards the deduction of regular measuring factors such as seepage speed and depth of seepage. The results clearly show that seepage speed decreases as the distance of the seepage increases. Moreover, they indicate a linear dependence between the amount of oil involved and the seepage depth. Also demonstrated was the enormous difference of the seepage speed between absorption-weak and absorption-strong soils. As well as from absorption and boding characteristics, the influence of the soil on the holding characteristics also comes from the soil moisture and, from that, the amount of water throughout the soil. The spread takes place notably slower in moist ground.

For the measurement of the degradation characteristics in general the systems developed by the Organisation for Economic Cooperation and Development (OECD) – OECD Guidelines – were applied, as well as the defined CEC-degradation tests from the Commission for Cooperation in Environmental Questions (CEC). The problem with these test systems lie in the fact that none of the standardised test conditions were able to be exactly reproduced to match the conditions in the soil or the actual age condition of the hydraulic fluids which were to be tested. Because of this, the biological degradability of the hydraulic fluids from regenerative raw materials was compared with mineral oil under real conditions in the soil as part of a special research project. *Figure 2* indicates the measured progress of the biological degradation of a mineral oil in comparison to vegetable oil in the soil, and the theoretically calculated degradation curves of selected oil formulations. According to the CEC L-33-A-94 test, biological degradation degrees of around 90 % for new and used oils were measured after 21 days for the selected HETG and HEES oils. Degradation degrees of around 50 % were determined for the mineral oils. It was apparent that, especially with mineral oils, the actual degradation rate in the soil was to be placed notably below that given in the standardised procedure. In real conditions, biological oil should be assessed completely differently than mineral oil in terms of degradability.

For assessing the aquatic pollution potential, the hydraulic fluids were put through organic test systems with individual species, in particular luminous bacteria (*Vibrio fischeri*), flagellates (*Euglena gracilis*), and garden cress (*Lepidium sativum*). The growth of the garden cress in oil-polluted soil was used to assess plant toxicity. In *figure 3*, for example, the average fresh weight of the above-ground cress shoots is given in association with the pollutant load in the soil of the HETG oil in comparison with the performance with the mineral oil based hydraulic fluids. Through this biological test system evidence of phytotoxicity was given by the reduced growth of the cress. According to these results, plant toxicity from mineral oil as well as from HETG oil was shown for pollutant loads of 5 to 50 g oil/ kg soil. In the case of higher oil pollution loads, however, the toxicity of mineral oils is shown as substantially greater than that of biological oils.

Summary and outlook

Decisive for the environmental characteristics of the oils tested are their spread characteristics, degradability and toxicity. Concerning spread characteristics there were only small differences between hydraulic fluids from regenerative raw materials and mineral oils. Decisive in this case are the physical-chemical properties of the soil such as moisture, compaction and hydraulic conductivity. The practical effects of the parameters of aged hydraulic oils such as heightened neutralisation number and altered kinematic viscosity are of secondary importance for spread performance.

The investigations up until now show clear indications of a lesser environmental pollution from hydraulic fluids from regenerative raw materials with regard to degradability and toxicity. With this, reliable statements regarding the estimation of risk with oil spillages in soil and water are possible.

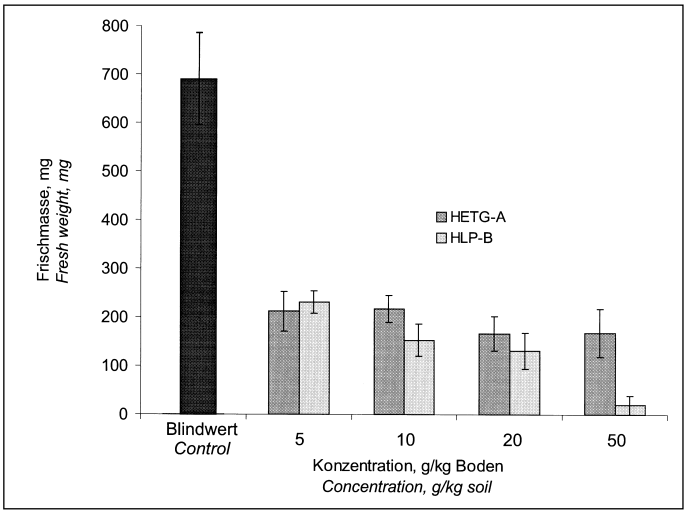

Fig. 3: Effects of different oil contaminations on plant growth (comparison rape seed and mineral oil based hydraulic fluid)