Phytotoxicity

"... both isomerized paraffin and mineral oil developed extreme toxicity to lettuce (no germination) during bioremediation. These observations suggest that during the degradation of the paraffin constituents in the isomerized paraffin, mineral and diesel fluids, breakdown products are produced which are extremely toxic to plant growth."

B. Lee, (BP Amoco), S. Visser (U. Calgary), T. Fleece (BP Canada), and D. Krieger (Halliburton), "Bioremediation and Ecotoxicity of Drilling Fluids ...," Paper AADE-02-DFWM-HO-15. Presented at the conference of the American Assn. of Drilling Engineer, Houston, April 2-3, 2002.

NMCCA&W Exhibit 15 (b)

Earthworm toxicity

"...breakdown products of the paraffins in these fluids may explain the increase in toxicity. Although hydrocarbon loss from the diesel was extensive as a result of volatilization and microbial action, it was still extremely toxic to earthworms after a treatability endpoint of (4,176 mg/kg) soil had been achieved."

(Endpoint was cessation of CO_2 production at 93 days.)

B. Lee, (BP Amoco), S. Visser (U. Calgary), T. Fleece (BP Canada), and D. Krieger (Halliburton), "Bioremediation and Ecotoxicity of Drilling Fluids ...," Paper AADE-02-DFWM-HO-15. Presented at the conference of the American Assn. of Drilling Engineers, Houston, April 2-3, 2002.

Petroleum hydrocarbons in soil

Li, et al. studies of plant growth and water repellency (hydrophobicity).

Li et al. observe:

- Total Extractable Hydrocarbon < 1000 mg/kg is nearly impossible to reach when TEH concentrations are high or a significant fraction of the hydrocarbon contaminant is of high molecular weight.
- Residual TEH as large as 20,000 mg/kg may not affect earthworms, seed germination, or root elongation--but those toxicity tests do not assess plant growth.
- Ordinarily, ecotoxicity tests are conducted under optimal soil conditions of moisture and nutrients.
- Soil water repellency due to hydrocarbons may be slight when the soil is moist, but become severe as the soil dries.

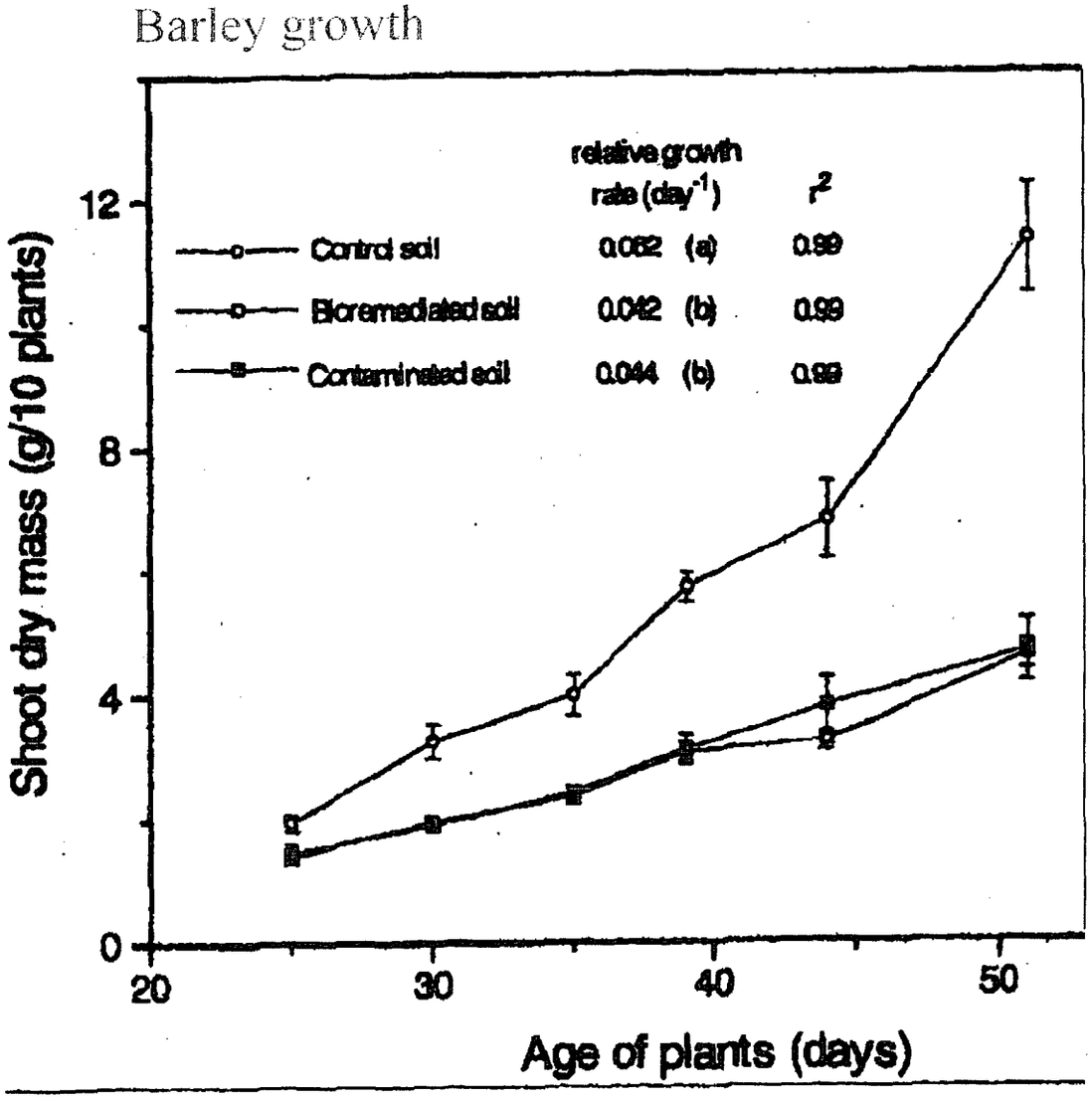
Li, et al. tested barley growth

- in a control soil,
- in a contaminated soil (TEH 40,000 mg/kg) TEH, and
- in a bioremediated soil with TEH 20,000 mg/kg after three years in a bioreactor.

Result: toxicity is not the sole issue.

NMCCA&W Exhibit 16 (a)

b)



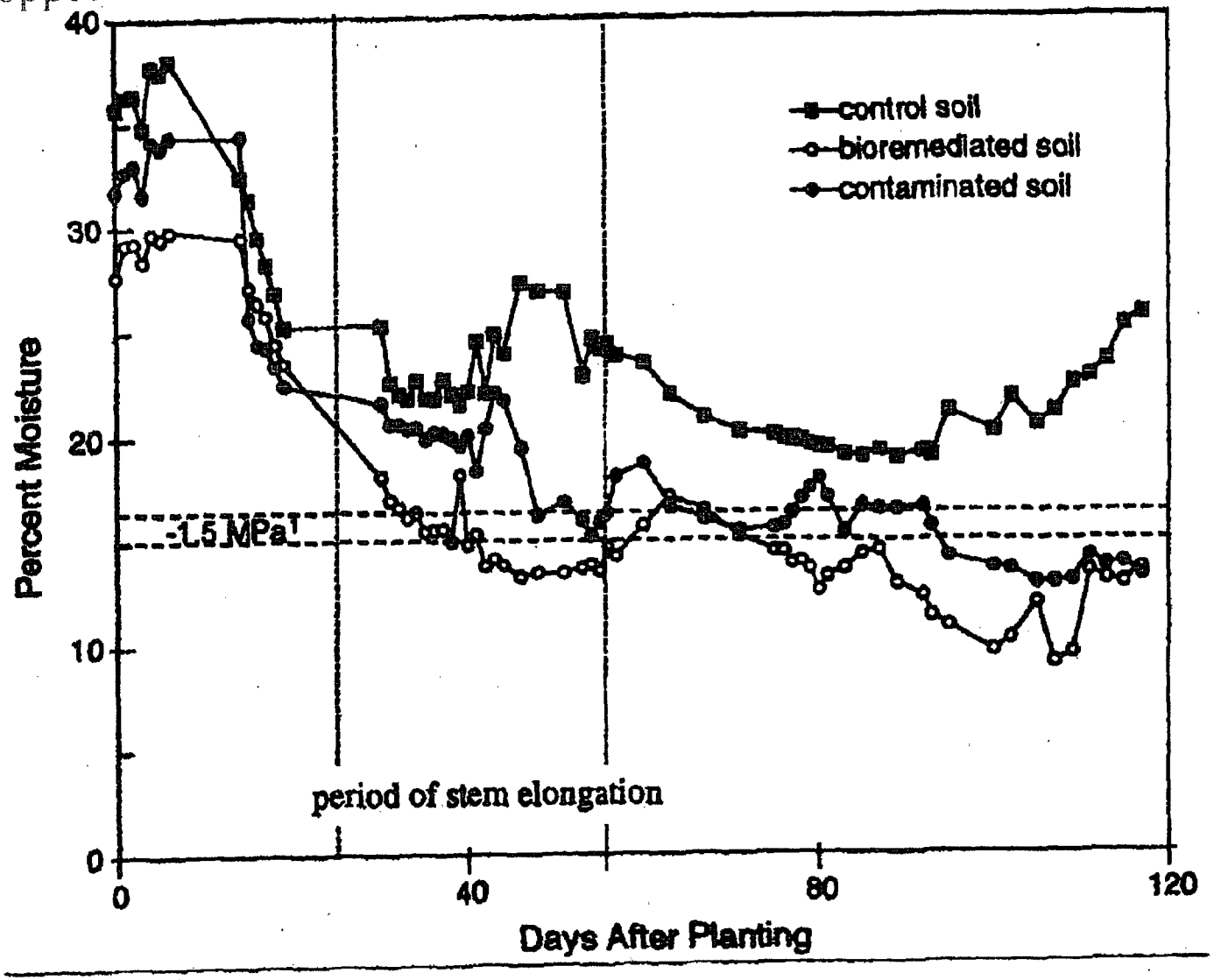
Root mass was similar in all three soils. Above-ground mass in the control soil was double that in either the contaminated soil or the remediated soil.

From: X. Li, Y. Feng and N. Sawatsky, (Alberta Research Council) Plant and Soil 192, 219-226 (1997).

6 (1997).

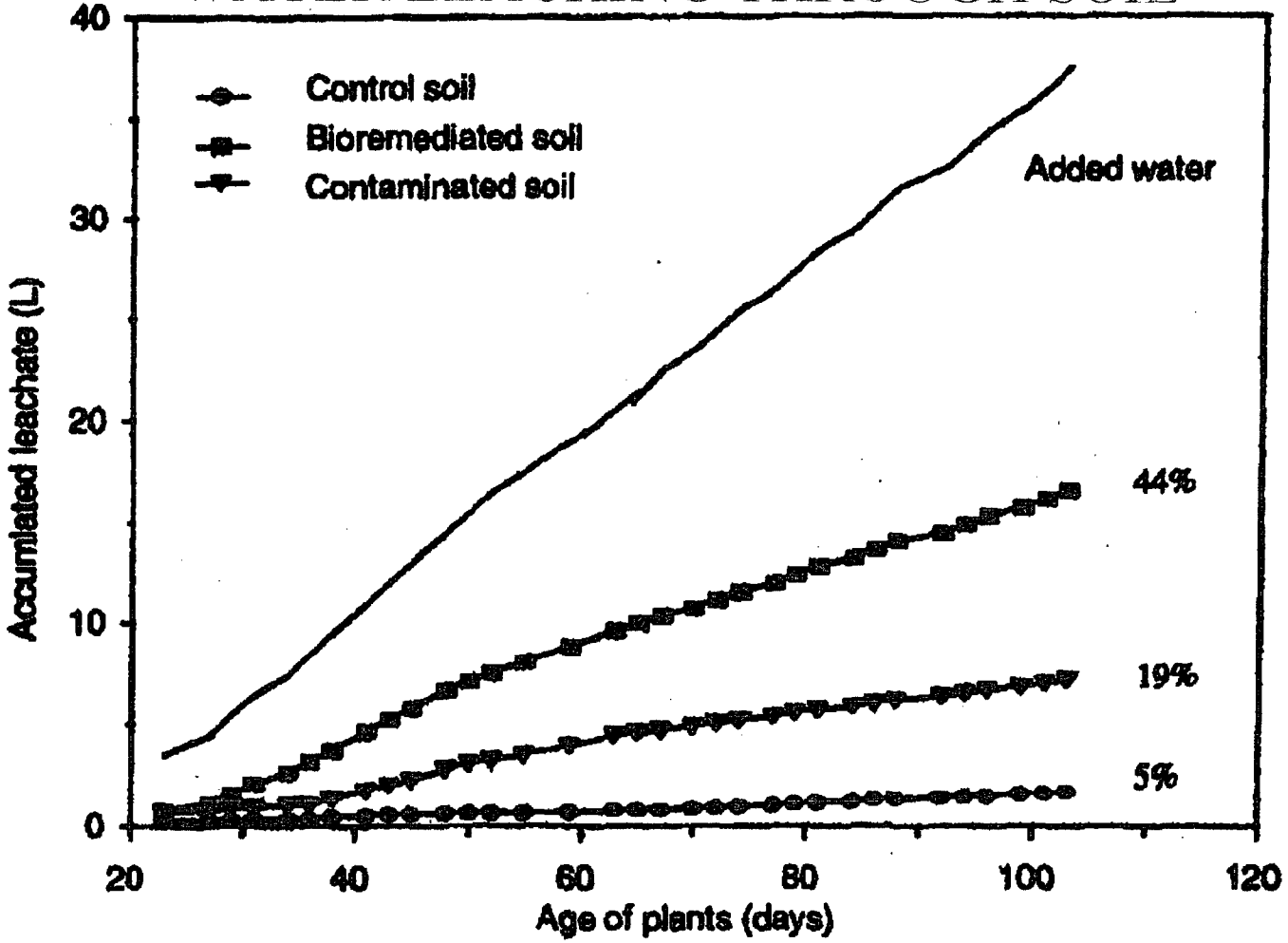
NMCCA&W Exhibit 16 (b)

Water was added to all soils when control dropped below 20% volumetric moisture.



From: X. Li, Y. Feng and N. Sawatsky, (Alberta Research Council) Plant and Soil 192, 219-226 (1997).

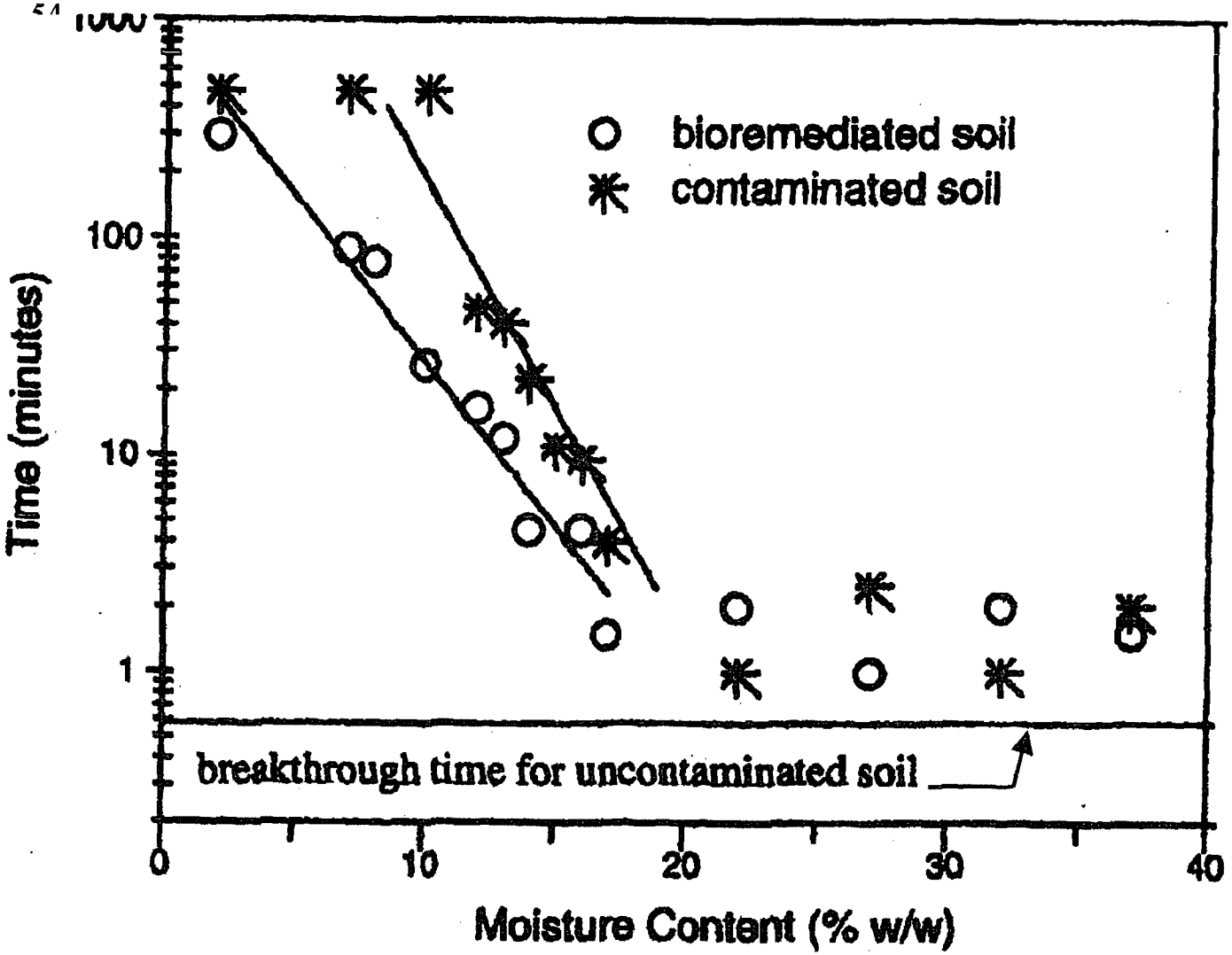
WATER LEACHING THROUGH SOIL



The remediated soil leached twice as much water as the contaminated soil, and about nine times as much as the control soil.

From X. Li, Y. Feng, and N. Sawatsky (Alberta Research Council), Plant and Soil 192, 219-226 (1997).

NMCCA&W Exhibit 18



Time for water to break through a 1.5 cm column of soil.

Initial contamination 40,000 mg/kg crude oil, saturated paste EC=17 dS/m.
Bioremediated three years; residual hydrocarbon content 20,000 mg/kg.
Hydrocarbon content measured by toluene extraction and gravimetric method.

From N. Sawatsky and X. Li (Alberta Research Council), Plant and Soil 192, 227-236 (1997).

Li et al. conclude that water infiltration in the hydrocarbon contaminated soils was dominantly along preferential flow paths, and that tests for land disposal of such soils should assess water adsorption as well as hydrocarbon content.

Petroleum hydrocarbons in soil

Roy, et al. studied the hydrophobicity of soils at sites affected by petroleum hydrocarbons.

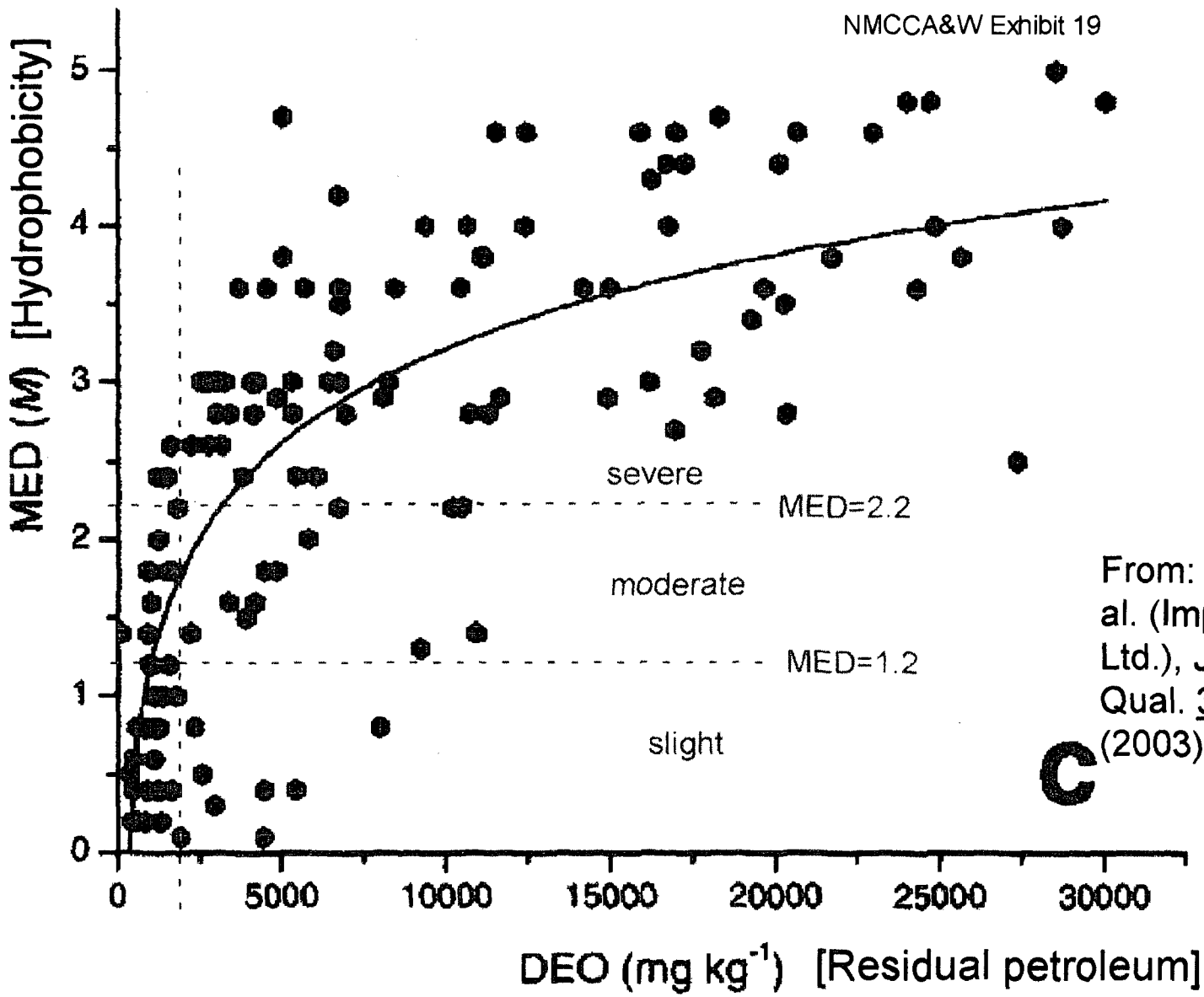
Vegetation and soil structure varied without simple relationship to the hydrophobicity.

Roy ...

MED (ethanol + water drop test) measured hydrophobicity.

DEO (gravimetric content after methylene chloride extraction) measured the hydrocarbon content.

NMCCA&W Exhibit 19



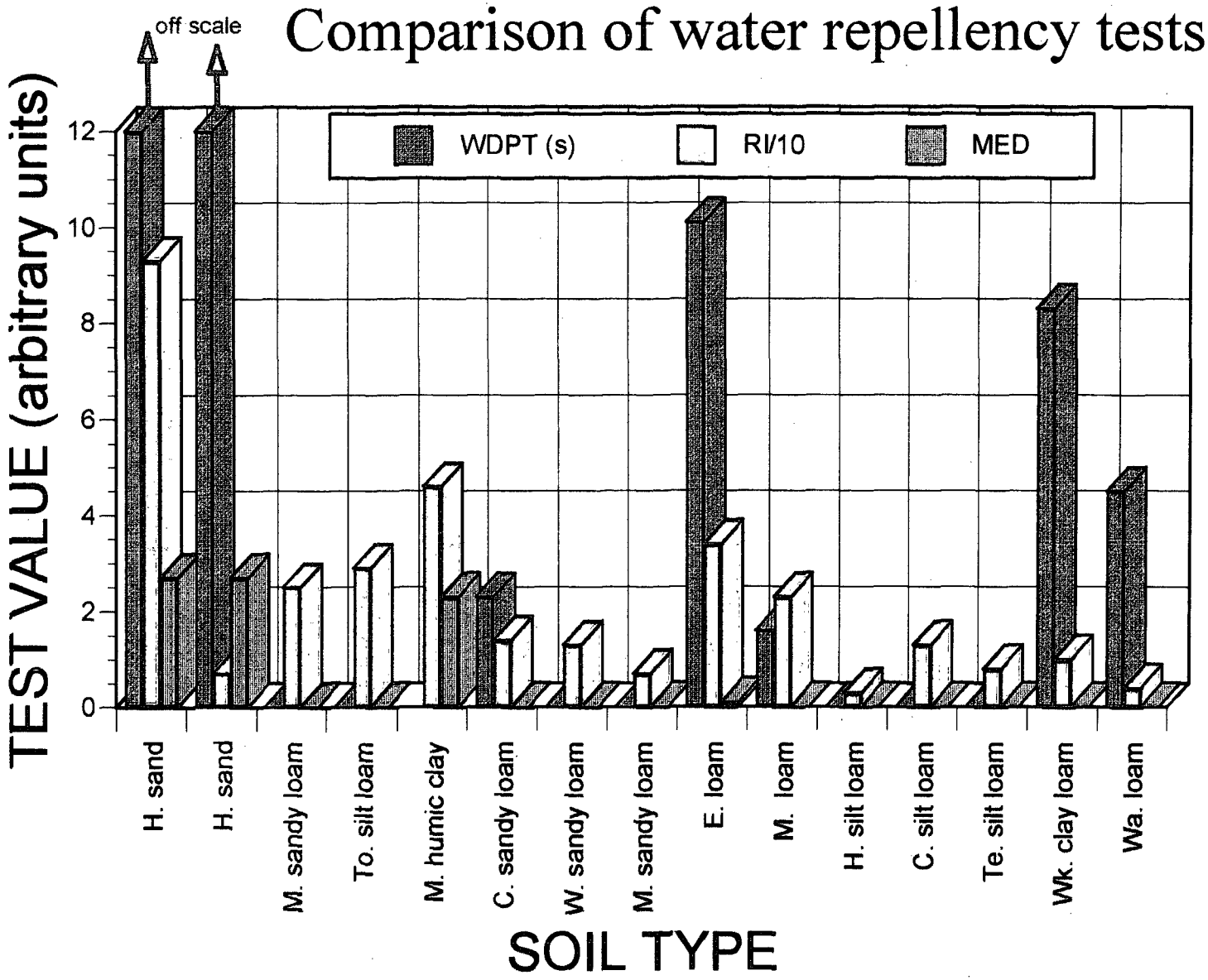
From: J. L. Roy et al. (Imperial Oil Ltd.), J. Environ. Qual. 32, 583-590 (2003).

Approximately half of all samples with petroleum < 2000 ppm exhibit hydrophobicity with MED > 1.2 (moderate or severe).

Petroleum hydrocarbons in soil

Wallis, et. al. evaluated hydrophobicity of non-petroleum soils according to three test methods:

- RI comparative rates of sorption of ethanol and water
- MED methanol drop test (like Roy)
- WDPT water drop penetration



Adapted from M. G. Wallis, et al., Aust. J. Soil Res. 29, 353-362 (1991)

Conclusion

regarding hydrophobicity tests

The MED test, used by Roy, would be appropriate for petroleum wastes, if New Mexico wants to test hydrophobicity.