DISPOSAL OF DRILLING WASTES IN THE MOUNTAINS

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ABSTRACT

The foothills and mountain regions are extremely varied in soils, vegetation, climate and geology. Oil and gas drilling wastes must be contained and then disposed of, despite of this extreme environment. An examination of three different drilling wastes indicates initially that salts are a main problem that have to be eliminated before any disposal can occur. Proper storage of waste materials in tanks or lined pits is essential to prevent leakage of salts or organics into the environment. Careful disposal planning before drilling begins can help mitigate any detrimental environmental hazards when waste disposal occurs. Land application of the waste at a pre-selected disposal site is a viable disposal alternative as the drilling wastes usually must be taken off lease in the mountain regions. Research is progressing and is needed to help demonstrate what disposal options are possible.

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DISPOSAL OF DRILLING WASTES IN THE MOUNTAINS

Oil and gas drilling waste disposal in the southern foothills and southeastern slopes of the Rockies raises some unique concerns. The geology, physiography, climate, soils and vegetation are all quite variable. Thus each drilling location will be different, and each drilling mud and waste component mixture will be unique. Such variability necessitates careful consideration of how drilling wastes disposal should occur in mountainous regions.

I ENVIRONMENT OF SOUTHERN FOOTHILLS*

a) Geology

The Geology of the area southwest of Pincher Creek consists of hard Pre-Cambrian rock in the southern portion and softer, more erodible Cretaceous rocks underlying the foothills and plants to the north and east. Various strata occur within these rock formations. Gray and black limestones, red and purplish-red sandstones, siltstones, argillites, dolomite, argillaceous dolomote and quartz sandstones are all found at various locations. The strata variation indicates the diversity that can thus be found in bore hole drill cuttings from drilling activities.

b) Physiography

Elevations range from 1 200 m to 2 755 m in the southern foothills. Very rough topography with bedrock ridges grade into hummocky foothills from a west-east direction.

c) Drainage and Climate

The Oldman River basin is predominant in the south region. The Castle River is the main stream with the Carbondale Belly and Oldman River being the major drainages. Maximum discharge occurs during June, just after snow melt.

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* Anderson, H. 1978.

Chinooks are common so snow cover does not always persist in winter. Strong winds are predominant in the southwest-northeast oriented valleys, or in a southwest or west direction (57% to 70% of the time). Precipitation ranges from 76 cm to 102 cm per year total.

d) Vegetation

Three main vegetation types occur in the southwestern foothills. The prairie exhibits a fescue-prairie oat mesic site. The forested areas comprise the other types, consisting of the Montane region and the Subalpine region. The Montane region supports douglas fir and lodgepole pine on the warm dry slopes while white spruce occurs on north exposures with seepage water. The Subalpine region consists generally of engelmann spruce, subalpine fir, whitebard pine and alpine larch (on sheltered slopes at treeline). Aspen becomes more abundant near the forest-grassland transition.

e) Soils

There are five recognized soil orders with shallow to little or no topsoil component. Dark Gray Luvisolic soils are the most common in the foothills. Developed under forest cover, the order has eluvial A and illuvial B horizons with clay as the main accumulations product. The Brunisols, Podzols, Gleysols and Regosols are also found throughout the region. Therefore, soils vary greatly in topsoil depth usually being thinner, in chemistry and in texture. Such variability will also be seen with drainage characteristics, with physical responses of the soils to moisture and salt loads, and with revegetation successes or failures. These soil differences require appropriate consideration when dealing with any waste disposal option.

The geological differences in the southern foothills will produce drilling wastes that have chemical and physical properties unique to each well drilled and that will thus require individual approaches to waste management. The varied soils, vegetation, topography and climate complicate the waste disposal problems because no two drilling sites are likely to have the same soil and vegetation environments.

II DRILLING WASTE COMPOSITION

Drilling wastes are made up of more than just the drilling mud components. Table 1 below indicates generally some major and minor conponents of water-based muds. Invert muds or oil-based mud will not be considered in this paper.

Water is a main component of mud systems. Other items are also present in varying amounts. Sodium montmorillonite (bentonite) is used as a

Table 1

DRILLING WASTE COMPONENTS

A) COMPONENTS OF WATER BACED MUDS
- Water
- Bentonite (Gel) Viscosified
  - sodium montmorillonite 35-70 kg/m^3
  - caustic soda (NaOH) at pH of 9-10
  - carboxymethylcellulose 1-3 kg/m^3
  - polyacrylamides (viscosity extender)
- KCl - 20000 - 40000 $mg\ L^{-1}$
- K_2SO_4 - 10000 - 30000 $mg\ L^{-1}$
- NaCl - up to 200000 $mg\ L^{-1}$
- cuttings from the hole being drilled

B) TREATMENT ADDITIVES - 16 CATEGORIES

Some are:
1) Alkalinity pH control - $NaHCO_3$
2) Corrosion Inhibitors - Ammonium bisulfate (oxygen scavenger)
3) Thinners - Calcium lignosulfonate
4) Weighting Materials - Barite
5) Lubricants - graphite, oil
6) Lost Circulation - NaCl, sawdust, walnut hulls

C) OTHER COMPONENTS
- spent crank case oil
- plastic sheeting
- used cans, plastic bottles, glass bottles
- rig wash
- garbage debris
- gasoline, diesel fuel

viscosifier to which other components such as caustic soda (a yielding agent) and carboxymethyl-cellulose (for fluid loss control) are added in varying amounts. Salts such as KCl and NaCl may be added to stabilize mud systems or promote cleaner, faster drilling practices. In all, there are 16 major categories of mud additives used, with over a thousand individual items available as possible mud components ranging from simple additives, such as glass and sawdust, to complex chemicals.

Drilling wastes also contain bore hole cuttings, as a major component, that come up from the geological formation being drilled. The waste pits can also be receptacles for various unwanted garbage components, such as spent engine, oil, diesel fuel, scrap iron, drums, cans, plastic sheeting or rig detergent.

Because the waste sumps contain such a complex mixture of liquids, solids, organic and inorganic compounds, the components may remain inert, or more likely interact synergistically or antagonistically (Shaw 1986, personal communicae). Such degree of unknown reaction and component complexity makes treatment difficult and potential detrimental environmental impact very probable. As an example, the 1985 ERCB (Energy Resources Conservation Board) Interim Report No. 1 titled "Determination of Toxicity of Sump Fluids" illustrates the concern relating to toxicity. In 1983-84, 10,929 wells were spudded. Sump fluids were tested for 574 of these wells and 344, or 60%, of the wells were found to be toxic. The toxicity parameter used was the 96 Hour Trout Test or the Microtox Test which uses luminescent bacteria.

III SAMPLE ANALYSIS OF WASTES

To help determine interactive soil parameters, typical soil analysis can be done on the drilling fluids and solids.

An example soil analysis of three different drilling waste systems shows the chemical composition and components that can occur (Table 2). These wastes were sampled from pits in the Cold Lake and Peace River areas of the province, and thus do not reflect the soils or geology of the foothills. However, the analysis does indicate the range of chemical concentrations found in a waste.

It is immediately apparent from the table that salt problems and specific ion toxicity must be mitigated if soils, vegetation and groundwater are to escape adverse effects. The sodium salts evident in Table 2 would have to be washed out of the mud system before any disposal option could be considered. Once the salts have been reduced, then the waste would be quite suitable for spreading on the land surface. A calcium amendment would probably then have to be added to the waste and soil component to lower the SAR value to acceptable levels. Organics from lubricating oils, and other waste organic products are difficult to analyze for specific components. However, their presence is definitely noted both visually and by smell. These products also have to be removed or detoxified.

Table 2

Analytical Results of a KCl Sump, a Fresh Water Gel Sump and a NaCl Sump.

Location	Cl Sump Type*	Cl mg/l	SO4 mg/l	HCO3 mg/l	CO3 mg/l	Na mg/l	K mg/l	Ca mg/l	Mg mg/l	SAR mg/l	EC mS/cm	Sat%	pH	ESP	Gypsum T/ha
NW Plains	KCl-Polymer - Solids	925	2,152	87.8	30	851	41.4	838	5.8	8	5.9	64	10.4	14.6	2.2
	- Liquids	690	616	219	72	690	24	180					9.0		
NE Plains	Fresh Water Gel - Solids	103	999	176	96	858	10.6	54.3	0.5	32	4.2	110	11.5	43.7	15.7
	- Liquids	135	111	128	144	270	3	162					10.0		
NE Plains	NaCl - Solids	67,361	5,523	146	30	43,681	133	1,494	4.1	311	117	63	10.3	88.1	233
	- Liquids	80,092	2,057		467	55,000	179	221					11.9		

Location	Sump Type*	Oil %	Carbon %	Available N kg/ha	Available P kg/ha	Available K kg/ha	Sand %	Silt %	Clay %	Texture	CEC
NW Plains	KCl-Polyer - Solids	0.12	1.0	2	1	488	32	44	24	L	24.4
NE Plains	Fresh Water Gel - Solids	0.22	1.3	6	1	456	36	32	32	CL	20.6
NE Plains	NaCl - Solids	0.36	2.5	8	1	585	42	34	24	L	32.4

* Solids analyzed by a commercial laboratory.
Liquids analyzed by the ERCB Laboratory.

IV STORAGE OF WASTE MATERIALS

In the interim between waste accumulation and actual disposal, proper storage of the waste must occur. Salt muds should be collected in sealed steel tanks until disposal. If the waste must be stored in the ground, then the pit must be lined with at least a 20 mil fibreglas reinforced plastic to prevent salt leakage. Any seams in the plastic must be heat-sealed before the plastic is laid into the pit. All rocks and protruding roots, etc., must be removed or smoothed over. Oil-based muds should be handled in the same manner as salt-based muds.

Freshwater muds should be stored temporarily, prior to treatment and disposal, in clay lined pits that have been artificially packed down after pit excavation to ensure a sealed system.

V A SUITABLE DISPOSAL OPTION FOR THE FOOTHILLS

In the mountains and foothills, waste disposal presents unique concerns because of water runoff concentration that occurs in valleys and from nearby slopes. The shallow soils overlying bedrock often located in the slopes is unsuitable for burial or landspreading of waste. Therefore, to avoid any contamination of fish-inhabited streams, all drilling waste should be properly stored prior to disposal. The wastes should then be carefully examined for toxicity and detoxified if sample analysis shows toxic to fish or microtox. In the mountain-foothills area, because wellsites are usually located in narrow valley bottoms, on steep valley slopes or on hill crests, the sump waste materials are often located off-site at a more suitable location. With a little careful planning that can occur at the wellsite leasing application stage, the waste material can thus be transported to a suitable pre-selected location where surface waste disposal can occur. A more suitable location would mean at least a lighter, porous soil, such as a loam, sandy loam or silty loam, minimal slope (approximately 0-9%), low salt and sodium levels in the receiving soil, and a distance of at least 100 m from any surface water.

Land spreading of drilling wastes is probably the most suitable option when dealing with the waste. The texture of the waste component, as presented in Table 3, indicates that particle size distribution favours surface spread of the waste, especially for lighter textured receiving soils. Surface spread will also tend to spread over a larger area the available ions in a waste and thus dilute and greatly reduce any detrimental soil and plant impact. The dilution factor from spreading should allow the indigenous soil chemistry to buffer any monovalent ion problems.

Surface spreading allows for degradative processes to act on organic components that are often found in wastes. Bacteria and fungi present at the soil surface will more effectively deal with organic wastes as, " ... in general, aerobic attack is a much more efficient, faster and "cleaner"

Table 3

PHYSICAL PARAMETERS (TEXTURE)
OIL AND GAS DRILLING WASTES

	% Sand	% Silt	% Clay
KCl	43.8	37.8	18.4
NaCl	35.8	41.8	22.4
Freshwater	36.0	32.0	32.0

process than anaerobic attack. Aerobic conditions generally are preferred for degradation of xenobiotics (synthetic compounds) and complex compounds since some compounds are not known to degrade anaerobically (eg. some hydrocarbons, lignin; Hungate, 1982) ... ." Further, ultraviolet radiation can cause photolysis of certain larger compounds, rendering the broken down compounds more susceptible to microbial attack (Foght, 1985). As there are often diesel fuels, oil lubricants and crankcase oils found in the waste pits, the degradative processes at the soil surface remain the safest, quickest and cheapest detoxifying process available. If the waste material is adequately desalinized, it could be that several surface applications of the waste may be possible at one disposal site. Proper soil and groundwater monitoring would have to occur to ensure that any disposal site does not become sterilized or pose a hazard to fauna and vegetation.

VI ONGOING WORK WITH DRILLING WASTES YET TO BE DONE

Further work has commenced in Alberta with assessing drilling mud solids characteristics and the waste effect on plants. The Alberta Research Council is pursuing component analysis of the various general waste systems used by industry and will be assessing the effects of various waste concentrations on specific plant species. The Council will also be examining the literature for the effects of different salts and salt concentration on clay liners.

Further work is needed to determine how the waste material should be properly sampled, as present sampling methods are totally inadequate. Retention characteristics of waste pits for salts and organics are much in question and need to be better understood. Finally, the logistics of land spreading and the environmental effects of muds on different receiving soils and their effects on plants need to be carefully examined.

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