ENVIRONMENTAL CONTAMINANTS ENCYCLOPEDIA
OIL AND GREASE ENTRY

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Like a library or many large databases (such as EPA's national STORET water quality database), this document contains information of variable quality from very diverse sources. In compiling this document, mistakes were found in peer reviewed journal articles, as well as in databases with relatively elaborate quality control mechanisms [366,649,940]. A few of these were caught and marked with a "[sic]" notation, but undoubtedly others slipped through. The [sic] notation was inserted by the editors to indicate information or spelling that seemed wrong or misleading, but which was nevertheless cited verbatim rather than arbitrarily changing what the author said.

Most likely additional transcription errors and typos have been added in some of our efforts. Furthermore, with such complex subject matter, it is not always easy to determine what is correct and what is incorrect, especially with the "experts" often disagreeing. It is not uncommon in scientific research for two different researchers to come up with different results which lead them to different conclusions. In compiling the Encyclopedia, the editors did not try to resolve such conflicts, but rather simply reported it all.

It should be kept in mind that data comparability is a major problem in environmental toxicology since laboratory and field methods are constantly changing and since there are so many different "standard methods" published by EPA, other federal agencies, state agencies, and various private groups. What some laboratory and field investigators actually do for standard operating practice is often a unique combination of various standard protocols and impromptu "improvements." In fact, the interagency task force on water methods concluded that [1014]:

> It is the exception rather than the rule that water-quality monitoring data from different programs or time periods can be compared on a scientifically sound basis, and that...
>
> No nationally accepted standard definitions exist for water quality parameters. The different organizations may collect data using identical or standard methods, but identify them by different names, or use the same names for data collected by different methods [1014].

Differences in field and laboratory methods are also major issues related to (the lack of) data comparability from media other than water: soil and sediments.

In spite of numerous problems and complexities, knowledge is often power in decisions related to chemical contamination. It is therefore often helpful to be aware of a broad universe of conflicting results or conflicting expert opinions rather than having a portion of this information arbitrarily censored by someone else. Frequently one wants to know of the existence of information, even if one later decides not to use it for a particular application. Many would like to see a high percentage of the information available and decide for themselves what to throw out, partly because they don't want to seem uniformed or be caught by surprise by potentially important information. They are in a better position if they can say: "I knew about that data, assessed it based on the following quality assurance criteria, and decided not to use it for this application." This is especially true for users near the end of long decision processes, such as hazardous site cleanups, lengthy ecological risk assessments, or complex natural resource damage assessments.

For some categories, the editors found no information and inserted the phrase "no information found." This does not necessarily mean that no information exists; it simply means that during our efforts, the editors found

none. For many topics, there is probably information "out there" that is not in the Encyclopedia. The more time that passes without encyclopedia updates (none are planned at the moment), the more true this statement will become. Still, the Encyclopedia is unique in that it contains broad ecotoxicology information from more sources than many other reference documents. No updates of this document are currently planned. However, it is hoped that most of the information in the encyclopedia will be useful for some time to come even without updates, just as one can still find information in the 1972 EPA Blue Book [12] that does not seem well summarized anywhere else.

Although the editors of this document have done their best in the limited time available to insure accuracy of quotes or summaries as being "what the original author said," the proposed interagency funding of a bigger project with more elaborate peer review and quality control steps never materialized.

> The bottom line: The editors hope users find this document useful, but don't expect or depend on perfection herein. Neither the U.S. Government nor the National Park Service make any claims that this document is free of mistakes.

The following is one chemical topic entry (one file among 118). Before utilizing this entry, the reader is strongly encouraged to read the README file (in this subdirectory) for an introduction, an explanation of how to use this document in general, an explanation of how to search for power key section headings, an explanation of the organization of each entry, an information quality discussion, a discussion of copyright issues, and a listing of other entries (other topics) covered.

See the separate file entitled REFERENC for the identity of numbered references in brackets.

HOW TO CITE THIS DOCUMENT: As mentioned above, for critical applications it is better to obtain and cite the original publication after first verifying various data quality assurance concerns. For more routine applications, this document may be cited as:

> **Irwin, R.J., M. VanMouwerik, L. Stevens, M.D. Seese**, and **W. Basham.** 1997. Environmental Contaminants Encyclopedia. National Park Service, Water Resources Division, Fort Collins, Colorado. Distributed within the Federal Government as an Electronic Document (Projected public availability on the internet or NTIS: 1998).

Oil and Grease

Brief Introduction:

Br.Class: General Introduction and Classification Information:

Oil and grease includes not only petroleum oils but also vegetable and natural oils. Sediments, biota, and decaying life forms are often high in natural oils lipids which make up part of the oil and grease measure.

Like Total Petroleum Hydrocarbon (TPH) and Total Recoverable Petroleum Hydrocarbon (TRPH) data, oil and grease data is very difficult (if not impossible) to interpret related to ecological effects. However, oil and grease does have some indirect value as one of the measures of oxygen demanding materials. Oil and grease should not be used as a measure for most oil pollution studies or other studies where petroleum hydrocarbons are the main concern (summary of information presented in more detail below).

A field test of bioremediation of soils contaminated with Bunker C at a refinery in Beaumont, showed that oil and grease was prone to producing misleading results concerning the degree of bioremediation taking place [727,728]. For additional details, see Br.Fate and Fate.Detail sections below.

Br.Haz: General Hazard/Toxicity Summary:

Some of the literature on sediment contamination by oil and grease from petroleum hydrocarbons was summarized in Olsen's 1984 annotated bibliography of the effects of contaminated sediments on fish and wildlife [449]. Factors to consider when interpreting residues of petroleum hydrocarbons in wildlife tissues were summarized by Hall and Coon in 1988 [128].

Oil and grease is difficult (if not impossible) to interpret related to petroleum hydrocarbon levels; scatter plots of oil and grease levels versus the levels of petroleum hydrocarbons often appear random (Brian Cain, U.S.Fish and Wildlife Service, personal communication).

In general, oil and grease is an inappropriate measure when considering hazard, toxicity, or risk (see details in sections below). Better methods include the expanded scan for PAHs [828] and other more rigorous methods.

The debates on exactly how to perform both ecological and

human risk assessments on the complex mixtures of PAHs and other hydrocarbons typically found at petroleum contaminated sites, are likely to continue. There are some clearly wrong ways to go about it, and using oil and grease as a primary measure is one of ways many risk experts would consider inappropriate. However, defining clearly right ways is more difficult. Petroleum contamination is usually typified by complex mixtures of PAHs, alkyl PAHs and BTEX compounds (see entries on those topics). Perhaps the most unambiguous thing that can be said about such complex mixtures is that they are often hazardous in many ways, including carcinogenicity and phototoxicity. (James Huckins, National Biological Survey/USGS, and Roy Irwin, National Park Service, personal communication, 1996).

One way to approach site specific risk assessments is to collect the complex mixture of PAHs and other lipophilic organic contaminants in a semipermeable membrane device (SPMD, also known as a fat bag) [894,895,896], retrieve the organic contaminant mixture from the SPMD, then test the mixture for carcinogenicity, toxicity, and phototoxicity (James Huckins, National Biological Survey/USGS, and Roy Irwin, National Park Service, personal communication, 1996).

Br.Car: Brief Summary of Carcinogenicity/Cancer Information:

Oil and grease is an inappropriate measure when considering carcinogenicity (see details in sections below and in "PAHs as a group" entry). Better methods include the expanded scan for PAHs [828] and other more rigorous methods.

Br.Dev: Brief Summary of Developmental, Reproductive, Endocrine, and Genotoxicity Information:

Oil and grease is an inappropriate measure when considering developmental, reproductive, endocrine, and genotoxicity hazards. Better methods include the expanded scan for PAHs [828] and other more rigorous methods.

Br.Fate: Brief Summary of Key Bioconcentration, Fate, Transport, Persistence, Pathway, and Chemical/Physical Information:

Oil and grease is a relatively weak measure when considering degradation of hazardous mixtures of petroleum compounds. Better methods include the expanded scan for PAHs [828] and other more rigorous methods.

In a simultaneous 11-week study of biodegradation at a

Bunker C contaminated refinery in Beaumont, TX, one group of researchers used GC/MS SIM [727], while the other group used the standard TPH method for Oil and Grease [728] on the same weekly composite soil samples. Using the more simple TPH analysis, the researchers concluded that oil contents in the soil were reduced over time in general (the raw TPH data was very variable) [728]. Using GC/MS SIM, the other researchers concluded that the highly weathered oil did not markedly change over the eleven weeks of the experiment, indicating little or no biodegradation. These researchers used GC/MS SIM to quantify a series of molecular biomarkers, such as hopane, in order to test ratios as indicators of in situ biodegradation. They also suggested that low bioavailability may have accounted for the lack of bioremediation at this site [727].

Since different combinations of petroleum hydrocarbons and natural lipids typically contribute to "oil and grease" at different sites, the fate characteristics are also typically different at different sites, even if the oil and grease concentration is the same.

Synonyms/Substance Identification:

No information found.

Associated Chemicals or Topics (Includes Transformation Products):

Site Assessment-Related Information Provided by Shineldecker (Potential Site-Specific Contaminants that May be Associated with a Property Based on Current or Historical Use of the Property) [490]:

General Types of Materials Associated with Oil and Grease Processing:

- Metals
- Petroleum hydrocarbons
- Solvents

Water Data Interpretation, Concentrations and Toxicity (All Water Data Subsections Start with "W."):

W.Low (Water Concentrations Considered Low):

No information found; this method not particularly appropriate for this application.

W.High (Water Concentrations Considered High):

No information found; this method not particularly appropriate for this application.

W.Typical (Water Concentrations Considered Typical):

No information found; this method not particularly appropriate for this application.

W.Concern Levels, Water Quality Criteria, LC50 Values, Water Quality Standards, Screening Levels, Dose/Response Data, and Other Water Benchmarks:

W.General (General Water Quality Standards, Criteria, and Benchmarks Related to Protection of Aquatic Biota in General; Includes Water Concentrations Versus Mixed or General Aquatic Biota):

Evidence from the following research suggests that discharges of 10 mg/L oil and grease allowed by several western states are too high [786]:

> Cutthroat trout (Salmo clarki) were exposed for 90 days to four concentrations (ranging from 100 to 520 ug/L) of a Wyoming crude oil in water. Survival was reduced to 52% at 520 ug/L, but was not affected by the 3 lower concentrations. Growth was significantly slower than control fish at all four concentrations. Exposure concentrations of 520 and 450 ug/L induced gill lesions and development of lesions on the retina and lens of the eye. Accumulation of total hydrocarbons in fish tissue was directly related to water concentration, except for fish in the 520 ug/L concentration. Alkylated mono- and dicyclic aromatic hydrocarbons were accumulated most readily, and naphthalenes were the dominant aromatic component in oil, water, and fish.

Narrative statement -- See Gold Book [302]

W.Plants (Water Concentrations vs. Plants):

No information found; this method not particularly appropriate for this application.

W.Invertebrates (Water Concentrations vs. Invertebrates):

No information found; this method not particularly appropriate for this application.

W.Fish (Water Concentrations vs. Fish):

No information found; this method not particularly appropriate for this application.

W.Wildlife (Water Concentrations vs. Wildlife or Domestic Animals):

No information found; this method not particularly appropriate for this application.

W.Human (Drinking Water and Other Human Concern Levels):

No information found; this method not particularly appropriate for this application.

W.Misc. (Other Non-concentration Water Information):

No information found.

Sediment Data Interpretation, Concentrations and Toxicity (All Sediment Data Subsections Start with "Sed."):

Sed.Low (sediment concentrations considered low):

no information found; this method not particularly appropriate for this application.

Sed.High (Sediment Concentrations Considered High):

Texas: The statewide 90th percentile value for oil and grease was 3,700 mg/kg dry weight [7].

Sed.Typical (Sediment Concentrations Considered Typical):

No information found; this method not particularly appropriate for this application.

Sed.Concern Levels, Sediment Quality Criteria, LC50 Values, Sediment Quality Standards, Screening Levels, Dose/Response Data and Other Sediment Benchmarks:

Sed.General (General Sediment Quality Standards, Criteria, and Benchmarks Related to Protection of Aquatic Biota in General; Includes Sediment Concentrations Versus Mixed or General Aquatic Biota):

Ontario Ministry of the Environment guidelines for open lake disposal of sediments (1986): The guideline for oil and grease is 1,500 ppm [347].

Ontario Ministry of the Environment Freshwater Sediment Guidelines, 1993 [761]. Lowest effect level: 1500 ug/kg dry weight.

Wisconsin interim criteria for sediments from Great Lakes harbors for disposal in water (1985): oil and grease should not exceed 1,000 ppm (dry weight)

[347].

No other information found; this method not particularly appropriate for this application.

Sed.Plants (Sediment Concentrations vs. Plants):

No information found; this method not particularly appropriate for this application.

Sed.Invertebrates (Sediment Concentrations vs. Invertebrates):

No information found; this method not particularly appropriate for this application.

Sed.Fish (Sediment Concentrations vs. Fish):

No information found; this method not particularly appropriate for this application.

Sed.Wildlife (Sediment Concentrations vs. Wildlife or Domestic Animals):

No information found; this method not particularly appropriate for this application.

Sed.Human (Sediment Concentrations vs. Human):

No information found; this method not particularly appropriate for this application.

Sed.Misc. (Other Non-concentration Sediment Information):

No information found.

Soil Data Interpretation, Concentrations and Toxicity (All Soil Data Subsections Start with "Soil."):

Soil.Low (Concentrations Considered Low):

No information found; this method not particularly appropriate for this application.

Soil.High (Concentrations Considered High):

No information found; this method not particularly appropriate for this application.

Soil.Typical (Soil Concentrations Considered Typical):

No information found; this method not particularly appropriate for this application.

Soil.Concern Levels, Soil Quality Criteria, LC50 Values, Soil Quality Standards, Screening Levels, Dose/Response Data and Other Soil Benchmarks:

Soil.General (General Soil Quality Standards, Criteria, and Benchmarks Related to Protection of Soil-dwelling Biota in General; Includes Soil Concentrations Versus Mixed or General Soil-dwelling Biota):

Between 25 and 30 states, and 4 out of 10 Canadian provinces, have numerical cleanup criteria for petroleum contaminated soils [738]. Until recently, most numerical criteria were expressed as maximum concentrations of certain gross contaminants such as oil and grease, total petroleum hydrocarbons, gasoline, or diesel fuel [738]. Numerical criteria for these parameters range from 1,000 mg/kg to 20,000 mg/kg for oil and grease [738]. Aesthetic or phytotoxicity considerations were typically the basis for the development of such standards; little or no consideration was given to the human health risks associated with the contaminant levels [738].

Soil cleanup criteria for decommissioning industrial sites in Ontario (1987): For residential/parklands and commercial/industrial lands oil and grease should not exceed 1 % [347].

No other information found; this method not particularly appropriate for this application.

Soil.Plants (Soil Concentrations vs. Plants):

No information found; this method not particularly appropriate for this application.

Soil.Invertebrates (Soil Concentrations vs. Invertebrates):

No information found; this method not particularly appropriate for this application.

Soil.Wildlife (Soil Concentrations vs. Wildlife or Domestic Animals):

No information found; this method not particularly appropriate for this application.

Soil.Human (Soil Concentrations vs. Human):

No information found; this method not particularly appropriate for this application.

Soil.Misc. (Other Non-concentration Soil Information):

No information found.

Tissue and Food Concentrations (All Tissue Data Interpretation Subsections Start with "Tis."):

Tis.Plants:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Plants:

No information found; this method not particularly appropriate for this application.

B) Body Burden Residues in Plants: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

No information found; this method not particularly appropriate for this application.

Tis.Invertebrates:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Invertebrates:

No information found; this method not particularly appropriate for this application.

B) Concentrations or Doses of Concern in Food Items Eaten by Invertebrates:

No information found; this method not particularly appropriate for this application.

C) Body Burden Residues in Invertebrates: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

No information found; this method not particularly appropriate for this application.

Tis.Fish:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Fish (Includes FDA Action Levels for Fish and Similar Benchmark Levels From Other Countries):

No information found; this method not particularly appropriate for this application.

B) Concentrations or Doses of Concern in Food Items

Eaten by Fish:

No information found; this method not particularly appropriate for this application.

C) Body Burden Residues in Fish: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

No information found; this method not particularly appropriate for this application.

Tis.Wildlife: Terrestrial and Aquatic Wildlife, Domestic Animals and all Birds Whether Aquatic or not:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Wildlife, Domestic Animals, or Birds:

No information found; this method not particularly appropriate for this application.

B) Concentrations or Doses of Concern in Food Items Eaten by Wildlife, Birds, or Domestic Animals (Includes LD50 Values Which do not Fit Well into Other Categories, Includes Oral Doses Administered in Laboratory Experiments):

No information found; this method not particularly appropriate for this application.

C) Body Burden Residues in Wildlife, Birds, or Domestic Animals: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

No information found; this method not particularly appropriate for this application.

Tis.Human:

A) Typical Concentrations in Human Food Survey Items:

No information found; this method not particularly appropriate for this application.

B) Concentrations or Doses of Concern in Food Items Eaten by Humans (Includes Allowable Tolerances in Human Food, FDA, State and Standards of Other Countries):

No information found; this method not particularly appropriate for this application.

C) Body Burden Residues in Humans: Typical, Elevated, or of Concern Related to the Well-being of Humans:

No information found; this method not particularly appropriate for this application.

Tis.Misc. (Other Tissue Information):

No information found.

Bio.Detail: Detailed Information on Bioconcentration, Biomagnification, or Bioavailability:

No information found; this method not particularly appropriate for this application.

Interactions:

No information found; this method not particularly appropriate for this application.

Uses/Sources:

No information found.

Forms/Preparations/Formulations:

No information found.

Chem.Detail: Detailed Information on Chemical/Physical Properties:

Oil and grease includes not only petroleum oils but also vegetable and natural oils. Sediments, biota, and decaying life forms are often high in natural oils lipids which make up part of the oil and grease measure.

Oil and grease results tell one little about the detailed chemical composition of a substance. PAHs are important hazardous components of many of the petroleum products sometimes (inappropriately) measured by oil and grease. Oil and grease is not a good measure of petroleum products. Risk assessments involving petroleum products should include analyses of PAHs and alkyl PAHs utilizing the NOAA protocol expanded scan [828] or other rigorous GC/MS/SIM methods.

Fate.Detail: Detailed Information on Fate, Transport, Persistence, and/or Pathways:

Oil and grease method not particularly appropriate for this application. A field test of bioremediation of soils contaminated with Bunker C at a refinery in Beaumont, Texas, utilized oil and grease data, which (although the data was quite variable) seemed to indicate bioremediation was taking place [728]. A comparison of the oil and grease data at this site with TPH data indicated that TPH was suggesting the same thing, that the data was quite variable but if anything, the oil was being slowly being cleaned up by bioremediation

(Bruce Herbert, Texas A. and M., Department of Geology, personal communication, 1995). However, a later study of the same site utilizing the expanded scan for PAHs (a modified EPA 8270 including alkyl homologues and lower detection limits), indicated that very little bioremediation of hazardous alkyl PAHs and multi-ring PAHs was actually taking place [727]. Thus, utilizing either oil and grease or TPH analyses would tend to lead one to the faulty conclusion that the harmful compounds were being naturally cleaned up at an acceptable rate. This is partly because the TPH and oil and grease methods tend to favor the lighter and less alkylated PAHs, whereas many of the carcinogenic and longer lasting PAHs are the heavier multi-ringed and alkylated compounds.

See also: Br.Fate section above. No other information found.

Laboratory and/or Field Analyses:

For investigating biological effects of petroleum products, do not use oil and grease analyses. Low values tend to give the mistaken impression that a site is clean when it really isn't (a false negative). For example, a field test of bioremediation of soils contaminated with Bunker C (a heavy fuel) at a refinery in Beaumont, Texas, utilized oil and grease data, which (although the data was quite variable) seemed to indicate bioremediation was taking place [728]. A comparison of the oil and grease data at this site with TPH data at this site suggested the same thing, that the data was quite variable but if anything, the oil was slowly being cleaned up by bioremediation (Bruce Herbert, Texas A. and M., Department of Geology, personal communication, 1995). However, a later study of the same site utilizing the expanded scan for PAHs [828] (a modified EPA 8270 including alkyl homologues and lower detection limits) [828], indicated that very little bioremediation of hazardous alkyl PAHs and multi-ring PAHs was actually taking place [727]. Thus, utilizing either oil and grease or TPH analyses would tend to lead one to the faulty conclusion that the harmful compounds were being naturally cleaned up at an acceptable rate. This is partly because the TPH and oil and grease methods tend to favor the lighter and less alkylated PAHs, whereas many of the carcinogenic and longer lasting PAHs are the heavier multi-ringed and alkylated compounds.

For the most useful chemical analyses of spilled petroleum hydrocarbon products, it is often appropriate to ask the laboratories for an "expanded" PAH scan which includes the most important alkylated PAHs [828]. In cases where a less expensive screening scan is desired, consider using a GC/FID or an HPLC/Fluorescence scan method for sediment or bile metabolite samples. Such scans are available from laboratories such as Texas A. and M., Arthur D. Little, and the NOAA lab in Seattle,

It is important to realize that contaminants data from different labs, different states, and different agencies, collected by different people, are often not very comparable (see also, discussion in the disclaimer section at the top of this entry).

This factor is particularly important for oil and grease.

As of 1997, the problem of lack of data comparability (not only for water methods but also for soil, sediment, and tissue methods) between different "standard methods" recommended by different agencies seemed to be getting worse, if anything, rather than better. The trend in quality assurance seemed to be for various agencies, including the EPA and others, to insist on quality assurance plans for each project. In addition to quality control steps (blanks, duplicates, spikes, etc.), these quality assurance plans call for a step of insuring data comparability [1015,1017]. However, the data comparability step is often not given sufficient consideration. The tendency of agency guidance (such as EPA SW-846 methods and some other new EPA methods for bio-concentratable substances) to allow more and more flexibility to select options at various points along the way, makes it harder in insure data comparability or method validity. Even volunteer monitoring programs are now strongly encouraged to develop and use quality assurance project plans [1015,1017].

At minimum, before using contaminants data from diverse sources, one should determine that field collection methods, detection limits, and lab quality control techniques were acceptable and comparable. The goal is that the analysis in the concentration range of the comparison benchmark concentration should be very precise and accurate.

It should be kept in mind that quality control field and lab blanks and duplicates will not help in the data quality assurance goal as well as intended if one is using a method prone to false negatives. Since oil and grease is prone to both false positives and false negatives, other more rigorous analyses, such as the NOAA expanded scan for PAHs [828] are often preferable. Methods may be prone to false negatives due to the use of detection limits that are too high, the loss of contaminants through inappropriate handling, or the use of inappropriate methods (such as oil and grease in many applications).

The following information on oil and grease method 413.1 was provided by Peter Wong, California Health Services Lab Certification Program (personal communication to Roy Irwin):

> One has to be careful with oil and grease values because different labs use different methods for preparation of the samples and different oils (cooking oil, mineral oil or motor oil) to calibrate instruments.

One of the EPA methods for oil and grease is a gravimetric method called EAD 1652 "Oil and Grease." It is summarized as follows [861]:

> EAD 1652 Oil and Grease 1 EAD_METHODS GRAV mg/L DL "Oil and Grease by Solid Phase Extraction" This method is used to determine total oil and grease and oil and grease amenable to solid phase extraction [861]. This method measures the materials that may be extracted on a bonded silica solid phase sorbent material from surface water, saline water, industrial, and domestic wastewater [861]. It is applicable

to the determination of relatively non-volatile hydrocarbons, vegetable oils, animal fats, waxes, soaps, greases, and related matter [861]. The method is not applicable to measurement of light hydrocarbons that volatilize at temperatures below 70 degrees C [861]. Petroleum fuels in the range from gasoline through No 2 fuel oils are completely or partially lost in the solvent removal operation [861]. The sample is acidified to a pH <2 and drawn through a bonded silica sorbent material [861]. The oil and grease remain on the solid phase sorbent while the aqueous phase passes through [861]. The oil and grease are then eluted with an organic solvent into an evaporating vessel [861]. The solvent is evaporated from the extract, and the remaining residue is weighed [861].