Biodiesel and Renewable Diesel Workgroup

California Biodiesel Multimedia Evaluation Tier I Report

March 12, 2009
Sacramento, CA

Tom McKone, University of California, Berkeley

Tim Ginn, University of California, Davis

Tiered Approach Refresher

Tier 1 Preliminary Review

- Define framework and approach
- Identify information needs and gaps
- Peer review

Tier 2 Multimedia Risk Assessment Design Review

- Experimental design developed and submitted
- Design peer reviewed, feedback provided for Tier 3

Tier 3 Final Multimedia Risk Review

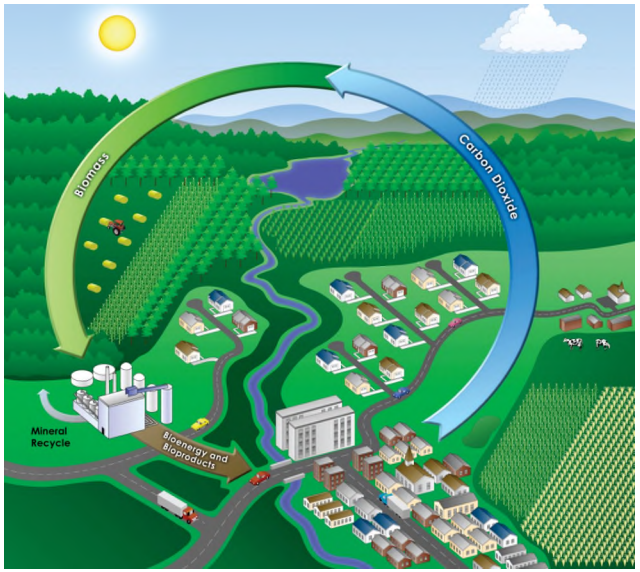
- Final report is used as the basis for recommendations submitted to the Environmental Policy Council
- Final report is peer reviewed

Overview of the Biodiesel Tier I Report

- Biodiesel Background Information
- Biodiesel Life Cycle
  - Biodiesel Feedstock Collection/Production
  - Production of Biodiesel
  - Storage and Distribution of Biodiesel
  - Use of Biodiesel
- Release Scenarios
- Environmental Transport and Fate of Biodiesel
- Biodiesel Toxicity
- Biodiesel Life Cycle Impacts
- Conclusions about Key Information Gaps

Biodiesel Background

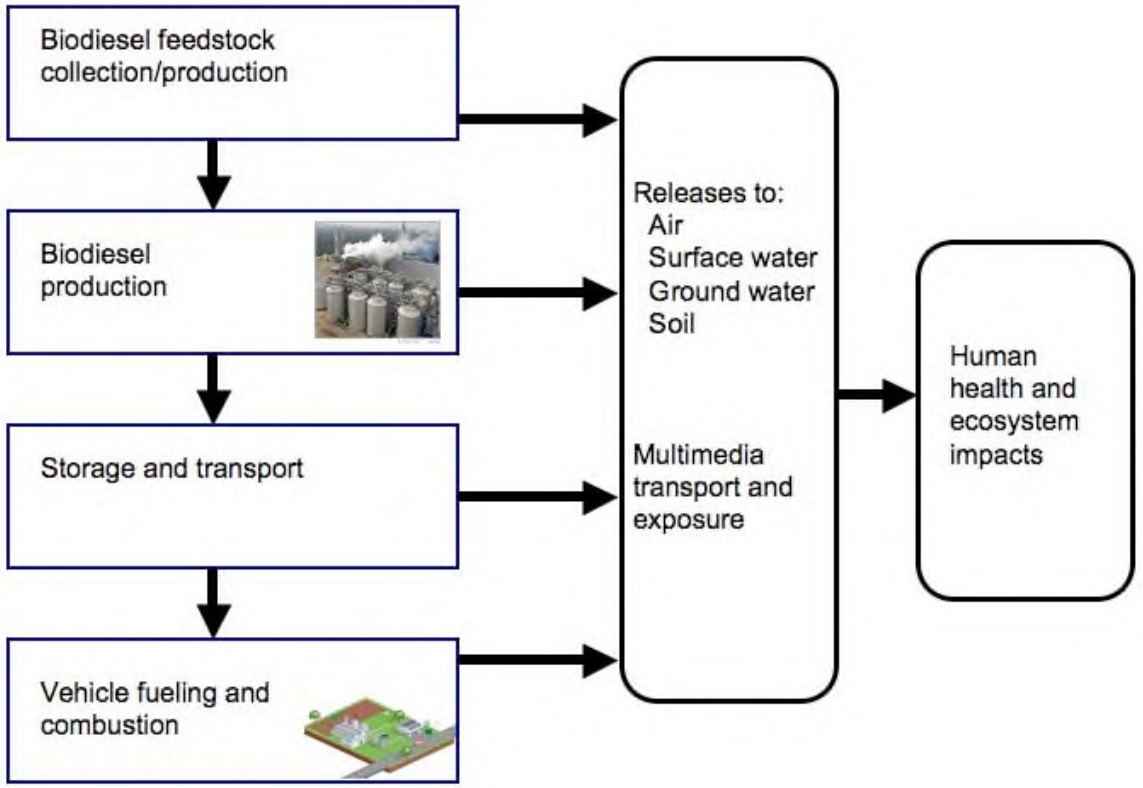
- **Biodiesel is composed of mono-alkyl esters of long chain fatty acids derived from:**
  - **a broad range of vegetable/seed oils**
  - **recycled cooking greases or oils**
  - **animal fats**
  - **algal oils**
- **Biodiesel can be used as a pure fuel or as a blend with petroleum diesel**
- **Our focus is on a blend of 20% biodiesel with 80% standard ULSD (B20) and on 100% biodiesel (B100), partial evaluation of B5**
- **A key goal of encouraging fuels such as biodiesel is to reduce California's carbon "footprint"**



Courtesy of C. Somerville, UC Berkeley

Biodiesel Life Cycle

- Biodiesel Feedstock Collection/Production
- Production of Biodiesel
- Storage and Distribution
- Use of Biodiesel



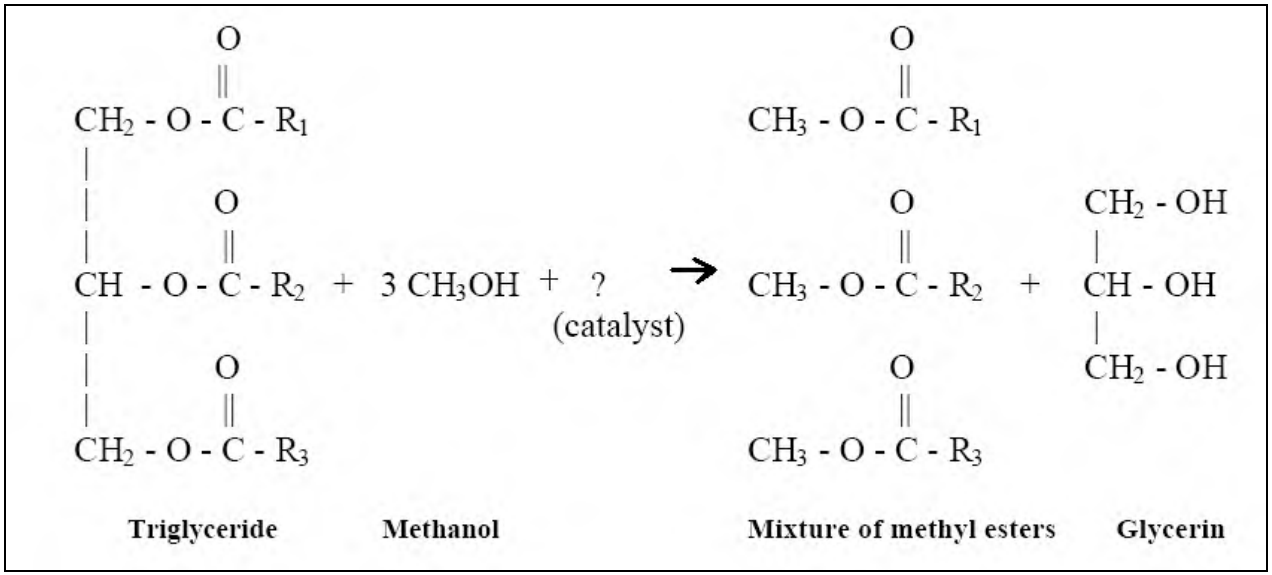
Biodiesel Feedstock Collection/Production

- **Primary biodiesel feedstocks expected to be used in California include:**
  - **soybean oil**
  - **animal tallow**
  - **yellow grease**
  - **canola**
  - **safflower**
  - **palm oil**
  - **algae**
  - **trap (brown) grease**

- **Biodiesel feedstocks are classified by their fatty acid profile**
- **Price, availability, origin, geography, and consistent quality generally dictate which feedstock biodiesel producers use**

Production of Biodiesel

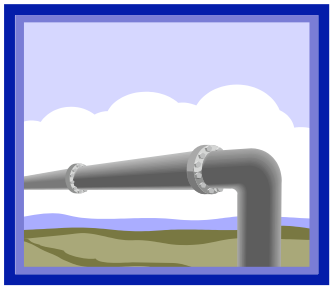
- To make biodiesel, a vegetable oil or fat is subjected to a chemical reaction known as transesterification

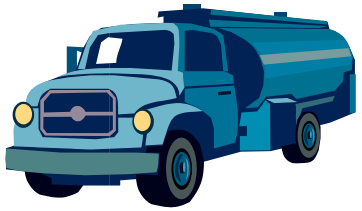


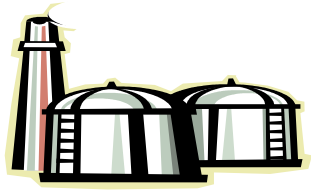
- Air emissions and hazardous wastes are important considerations for production operations

Storage and Distribution

- **Material compatibility is important to consider during the storage and distribution of biodiesel**
- **Biodiesel is susceptible to chemical changes during long-term storage**
- **Chemical additives to address**
  - **oxidative stability**
  - **microbial contamination**
  - **increased water affinity**
  - **cold-flow properties**
  - **increased NOx emissions of biodiesel**
- **Routine emissions and "off-normal" events (pipe-breaks, large spills) must be addressed**







Use of Biodiesel

- In the fuel-use stage, the releases of greatest concern are emissions to air
- But there are also potential releases to water and soil
- Several studies have determined biodiesel blends exhibit reductions in hydrocarbons (HC), particulate matter (PM) and carbon monoxide (CO) emissions
- There are also vehicle operability issues with biodiesel blends:
  - cold fuel flow
  - fuel foaming
  - water separation
  - fuel oxidative stability

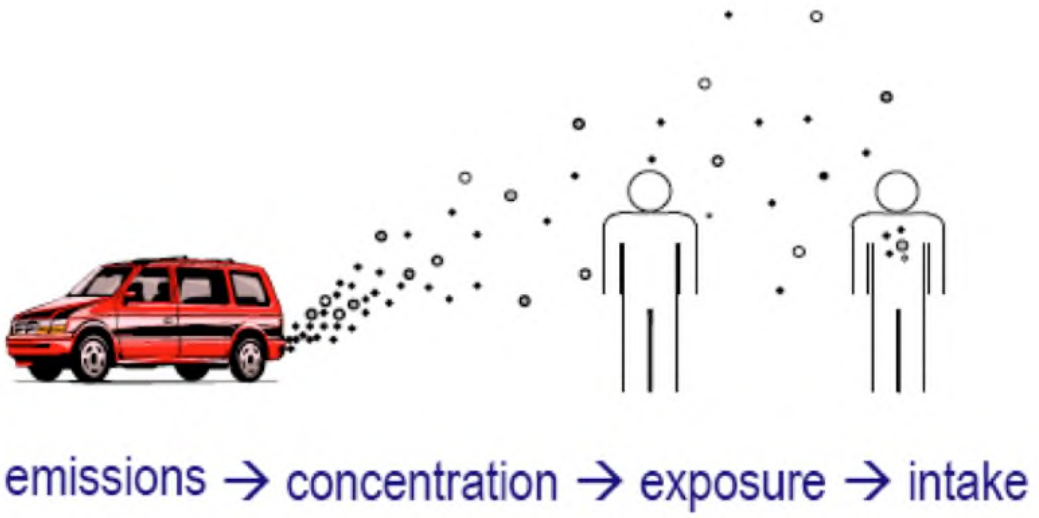
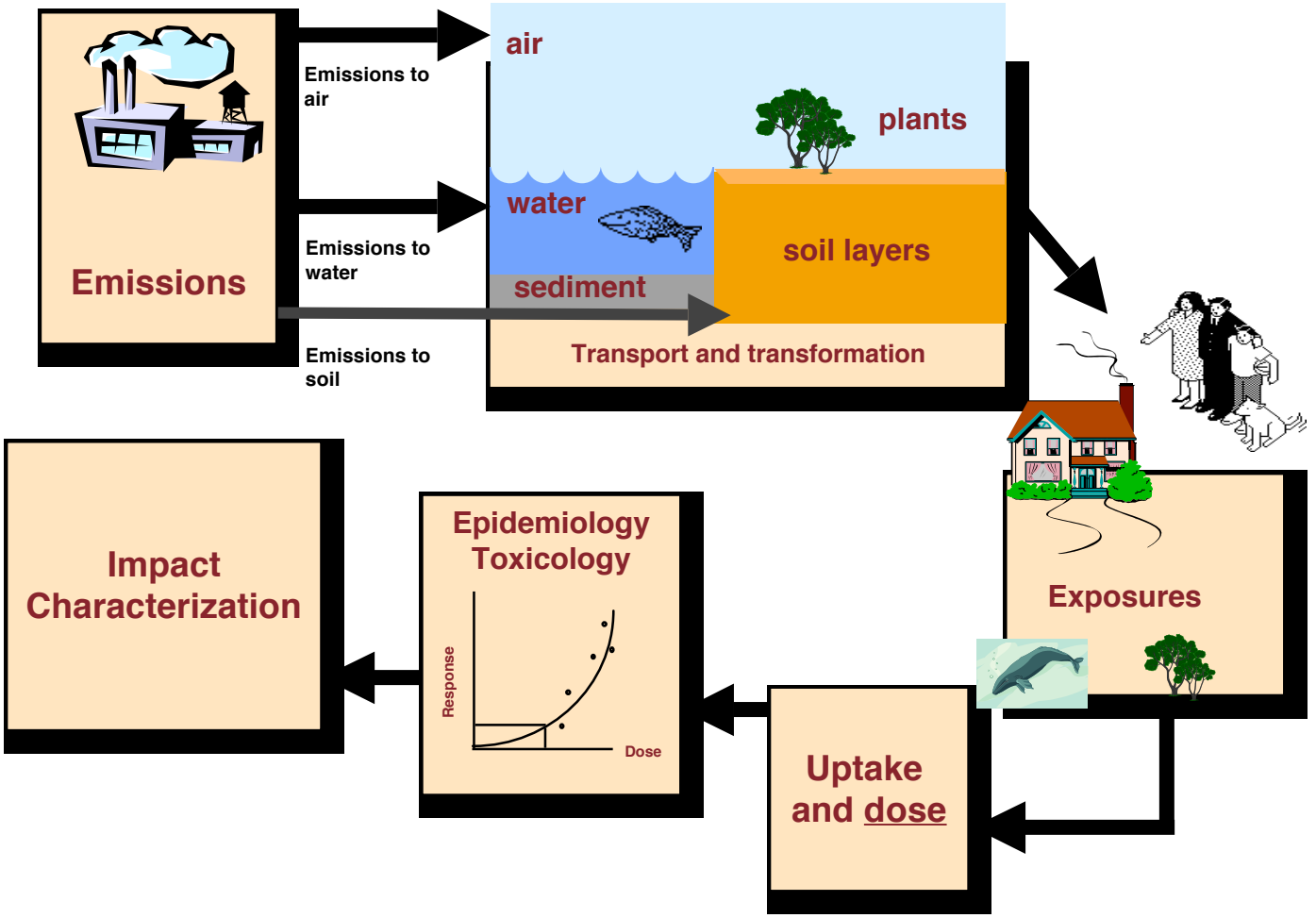


Figure from Julian Marshall University of Minnesota

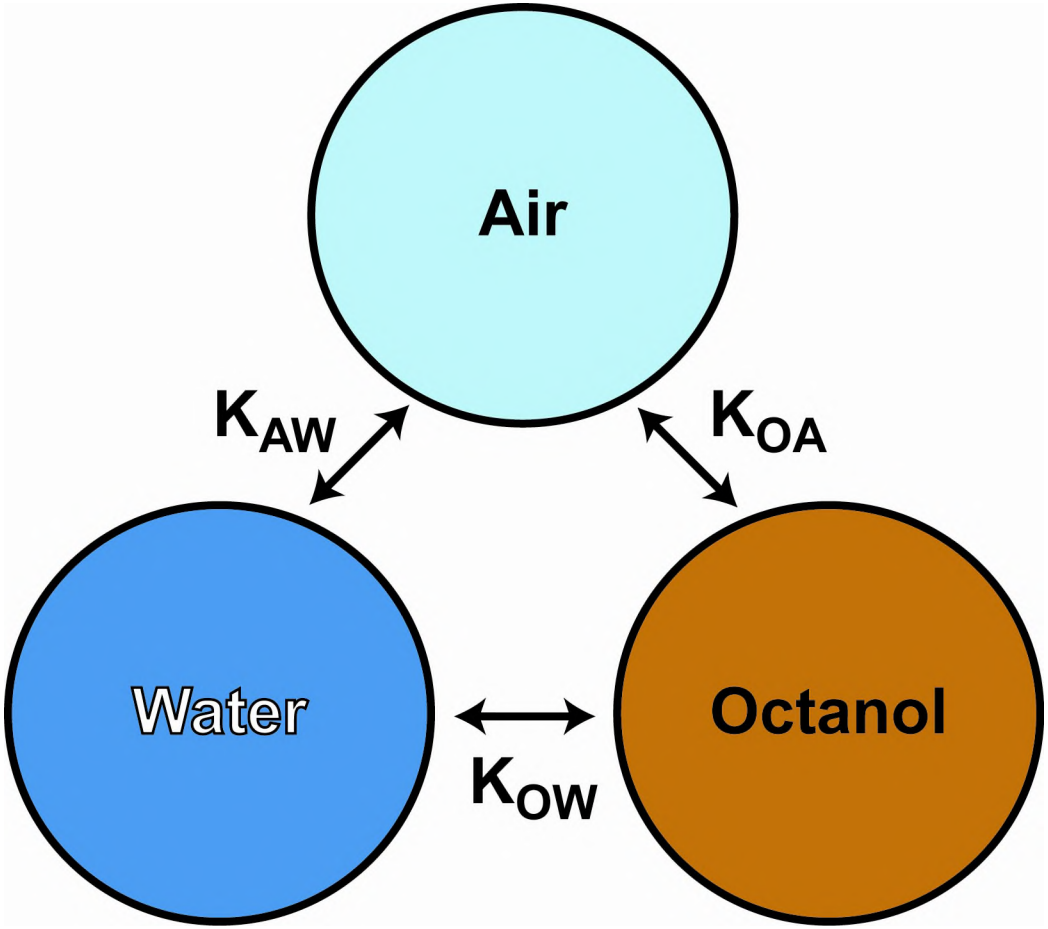
Defining Release Scenarios

- Selection of biodiesel feedstock
- Selection of additives mix
- Identify normal (routine) releases during production for example
  - Hexane or CO2 released to the air during seed extraction.
  - Odors associated with waste biomass
  - Methanol releases to air or water
  - Used process water discharges of various pH and trace-chemical composition
- Normal releases during use include tailpipe emissions, both to air and to surface waters (marine vehicles)
- Identify off-normal releases, such as leak or rupture of:
  - an above-or below-ground storage tank and associated piping,
  - rail tank car, tanker truck, or tanker ship.
  - bulk fuel transport pipeline

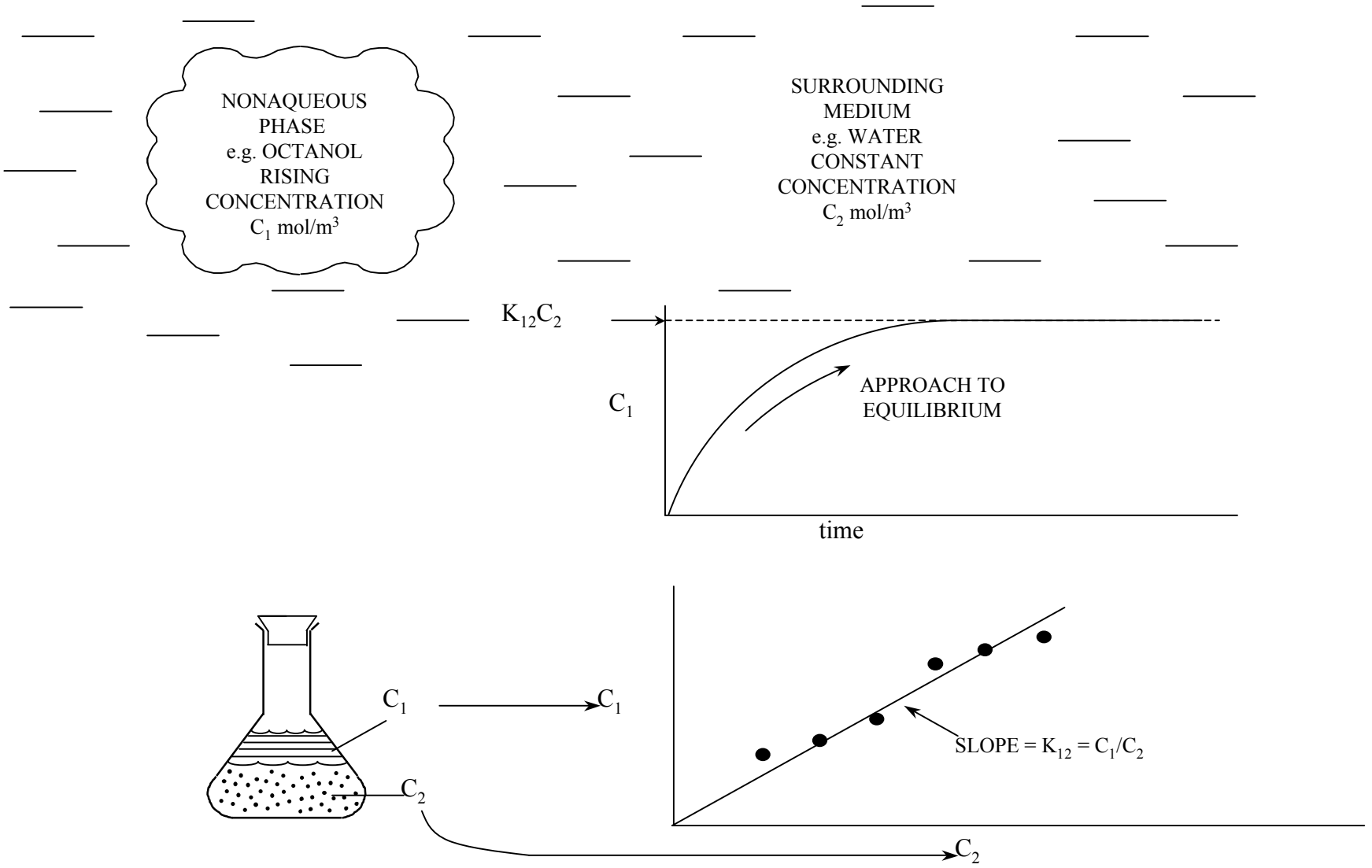
Environmental Transport and Fate



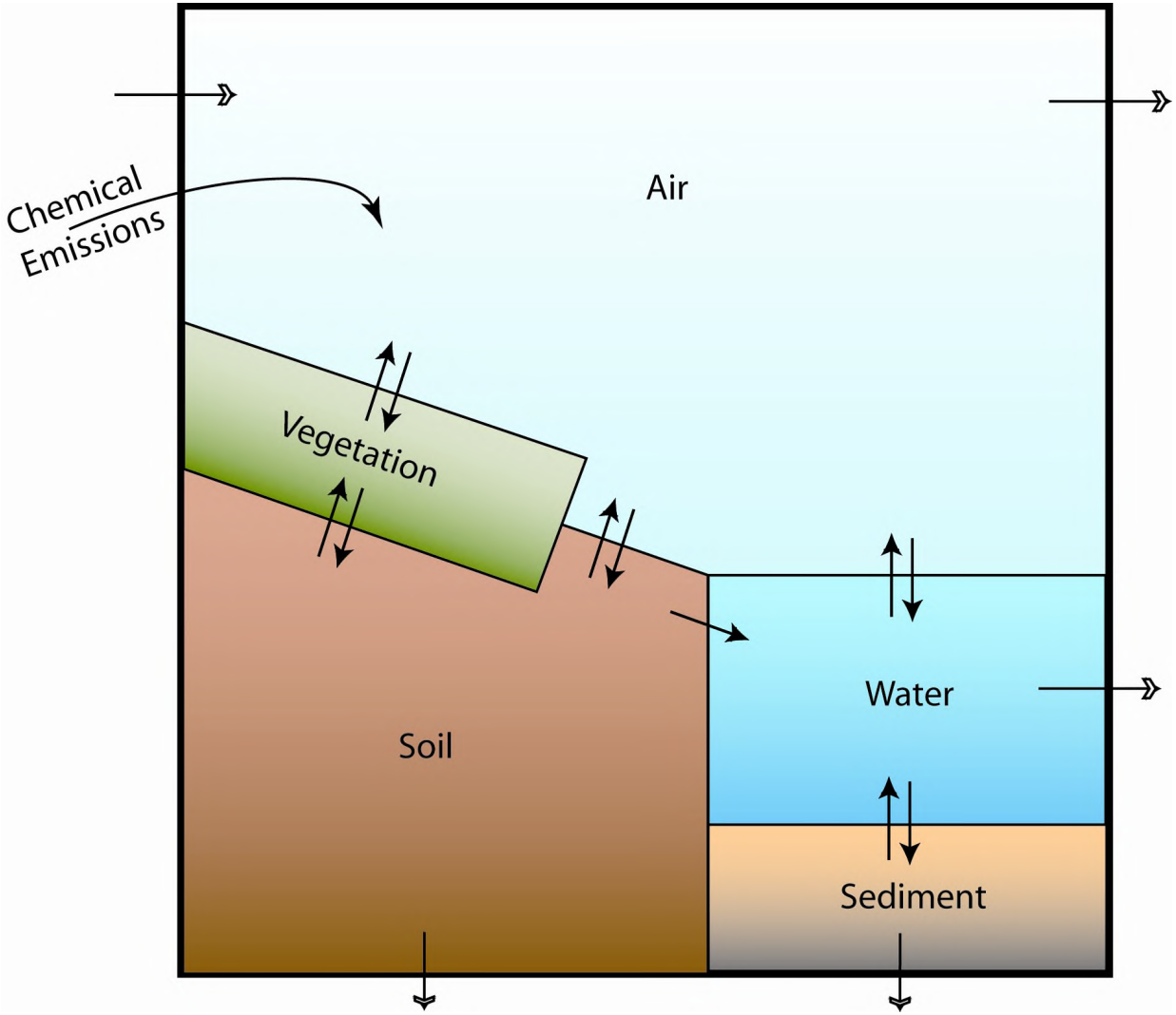
The long-term behavior chemicals in the environment is determined by their partitioning between three primary media:



Experimental Determination of Partition Coefficients



Level III multimedia contaminant fate model

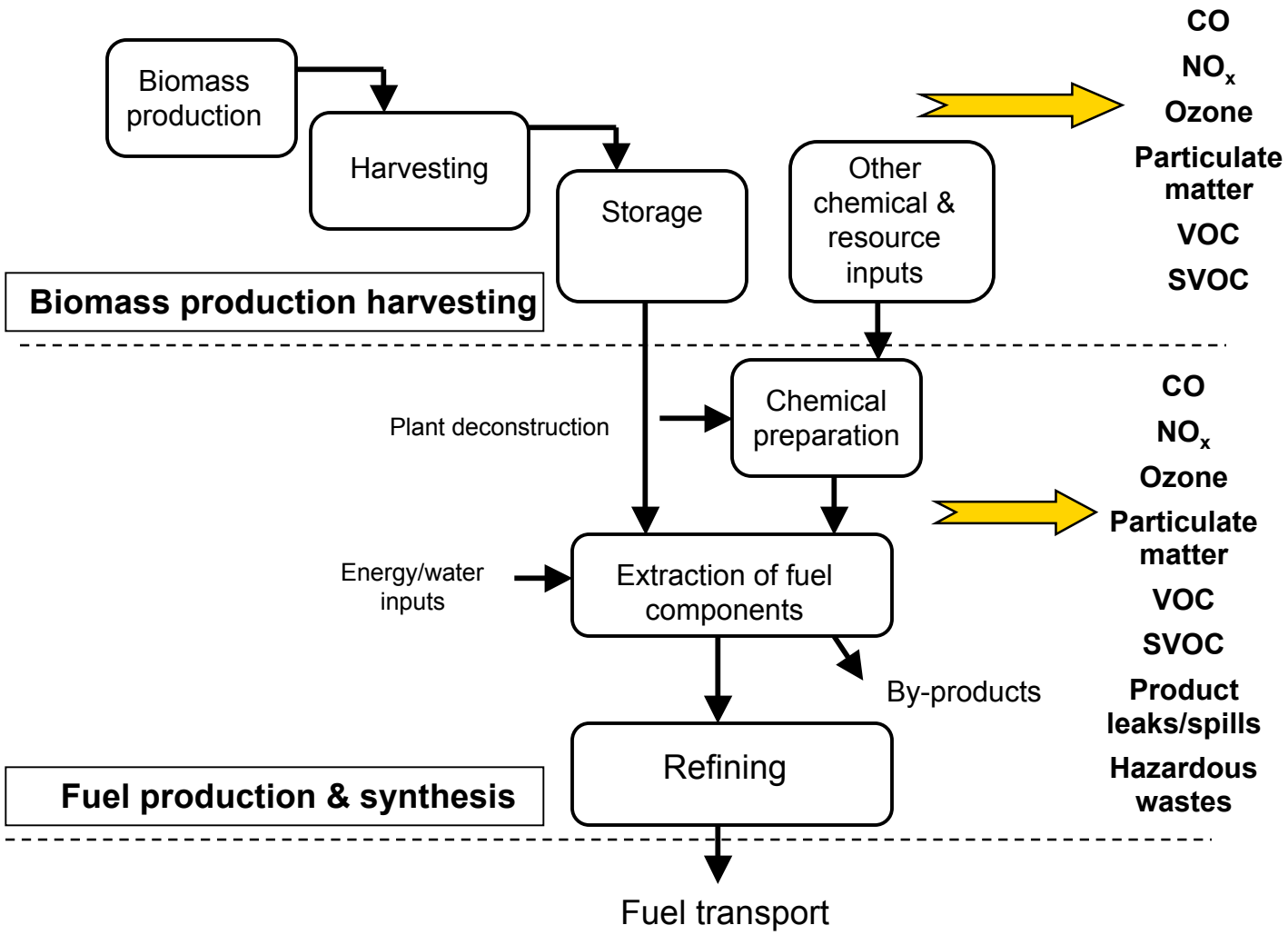


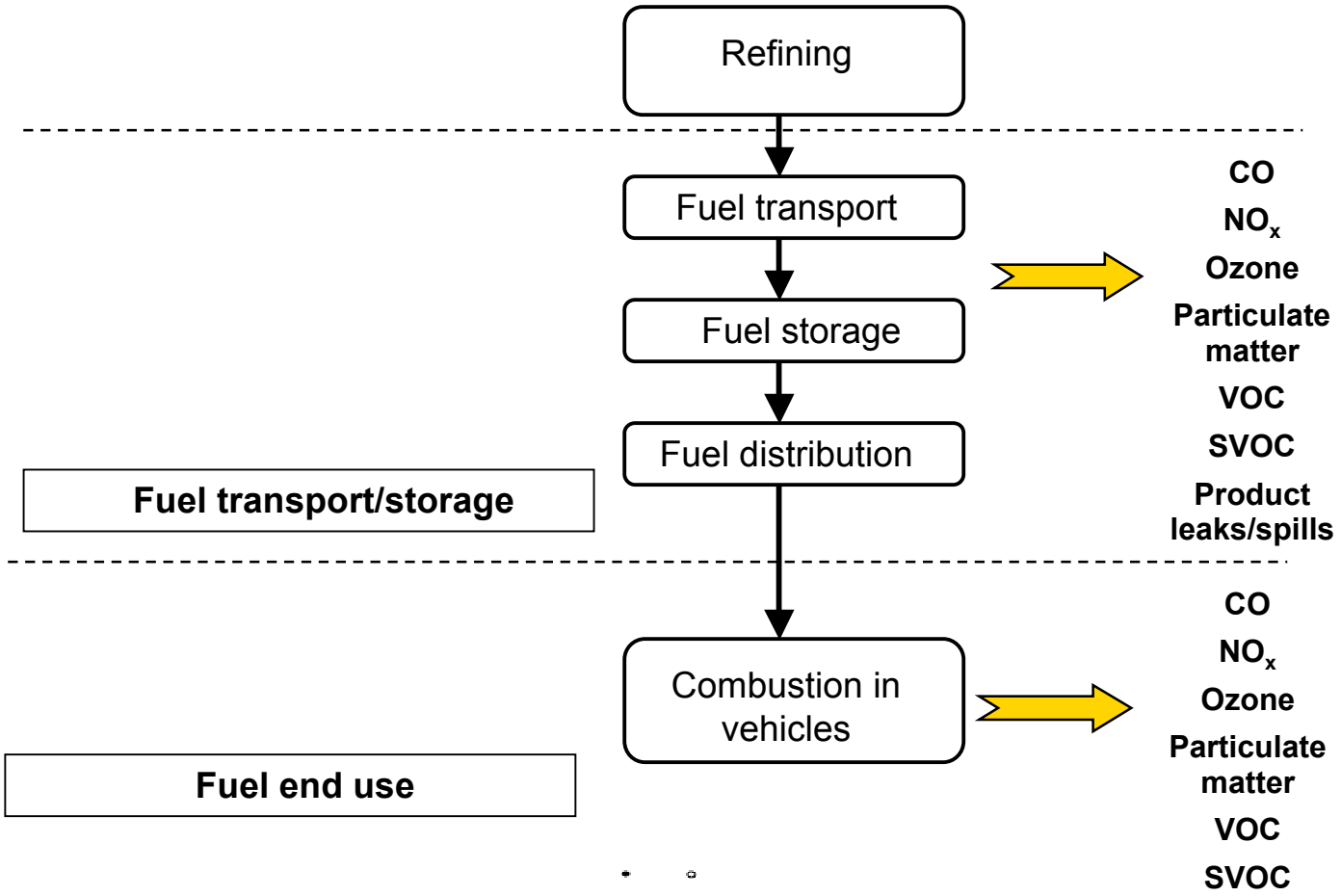
Biodiesel Toxicity

- **Human and ecological risk**
  - Hazard identification
  - Toxicity (dose-response)
  - Potential for exposure
  - Sensitive populations
- **Toxic air pollutants**
- **Toxicity assessment to fill data gaps**

Biodiesel Life-Cycle Impacts

- **Life-Cycle Approach**
  - **Biomass production and harvesting or feedstock collection**
  - **Fuel production**
  - **Fuel transport and distribution**
  - **Fuel combustion**
- **Pollutant releases at each life stage**
- **Transport and fate**
- **Exposure and dose**
- **Toxicology and risk**


Biomass production
Harvesting
Storage
Other chemical & resource inputs
CO
NOx
Ozone
Particulate matter
VOC
SVOC
Biomass production harvesting
Plant deconstruction
Chemical preparation
Energy/water inputs
Extraction of fuel components
By-products
Refining
Fuel production & synthesis
Product leaks/spills
Hazardous wastes
Fuel transport



Graphic courtesy of
Julian Marshall
University of Minnesota

Life Cycle Impact

Disability adjusted life years (DALYs)

Potential disease burden

Biofuel production & location

Biodiesel from:
- **Waste oil**
- **Plant oil**

Renewable diesel from:
- **Plant oil**
- **Other sources**

Emissions [kg per joule fuel processed]

1) Aldeyhdes
2) US EPA Criteria Pollutants (PM2.5, CO, etc.)
3) Other Air Toxics (e.g., PAHs)
4) Hazardous wastes

Pollutant intake based on release scenario/location

DALYs per joule biofuel processed

Urban

Rural

Total DALYs

Total DALYs

DALYs per joule conventional diesel processed

Conclusions About Key Information Gaps

- **Additives composition, use, and impact**
  - **How biocides and anti-oxidants impact biodegradation**
  - **How priority additive impact human and ecosystem health**
  - **How cold flow property controllers impact multiphase transport**
  - ***toxicity***
- **Subsurface fate and transport properties**
- **Releases - Material Compatibility**
- **Biodegradation of all biodiesel components in soils and aquifers**
- **More information on air emissions**
- **Missing toxicological data**