Environmental factors that affect fuel system microbial growth

by

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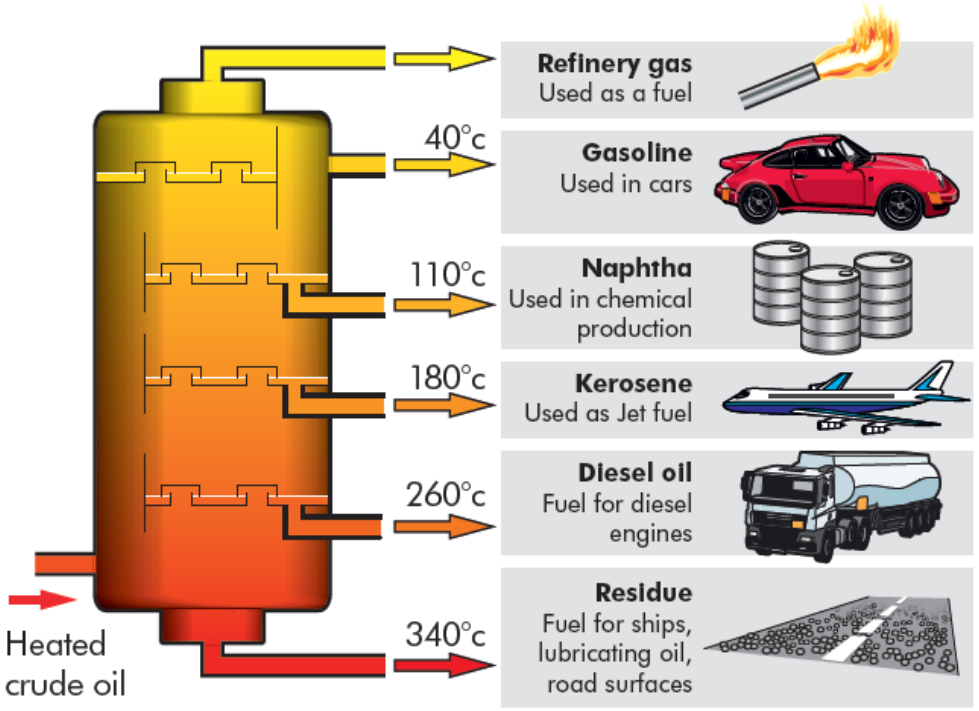
High distillation temperatures ensure fuel sterility

Crude oil distillation

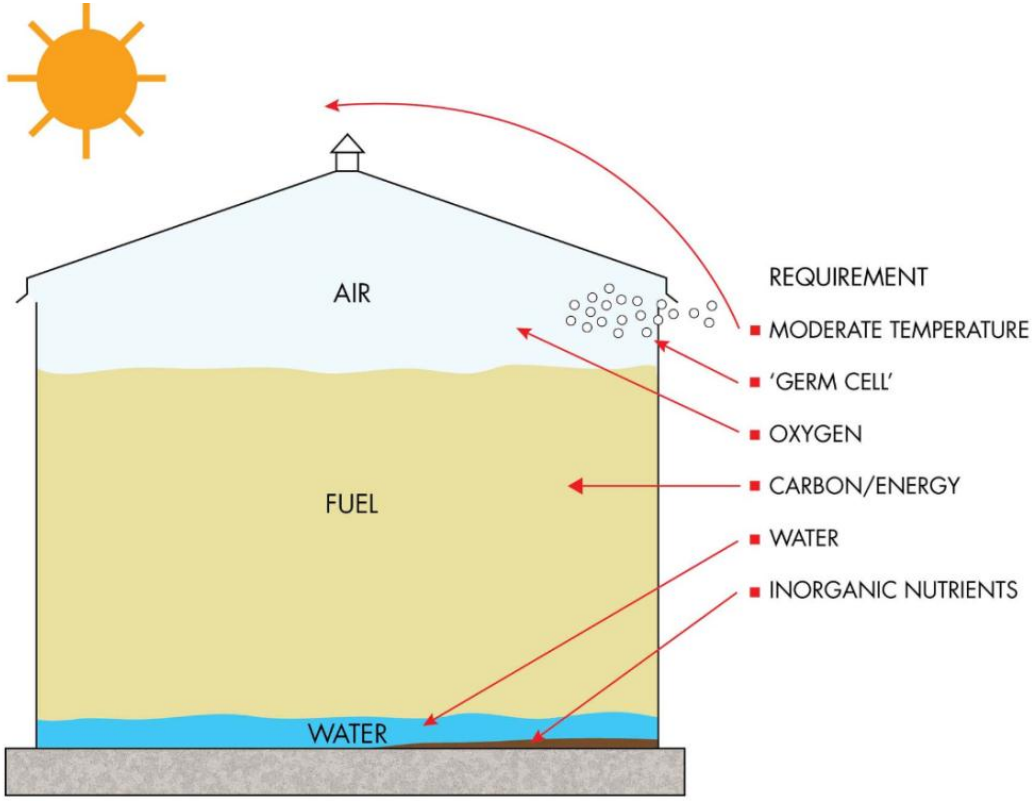


Diesel fuel's a mixture of hundreds of different hydrocarbons boiling between about 180°C to 380°C, with carbon chain lengths of around C9 to C20.

As well as C & H, it consists of S, N, O & other trace elements. S can be stripped out by heat treatment under pressure with H.

High distillation temperatures ensure fuel sterility, but when it is transferred into bulk refinery storage there is potential for microbial problems to develop.

Bulk refinery storage presents the first opportunity for microbial growth



Boroscope Video

Chesneau, H.L. & Dorris, M.M. (Eds.) (1988) Distillate Fuel: Contamination, Storage, and Handling, ASTM.

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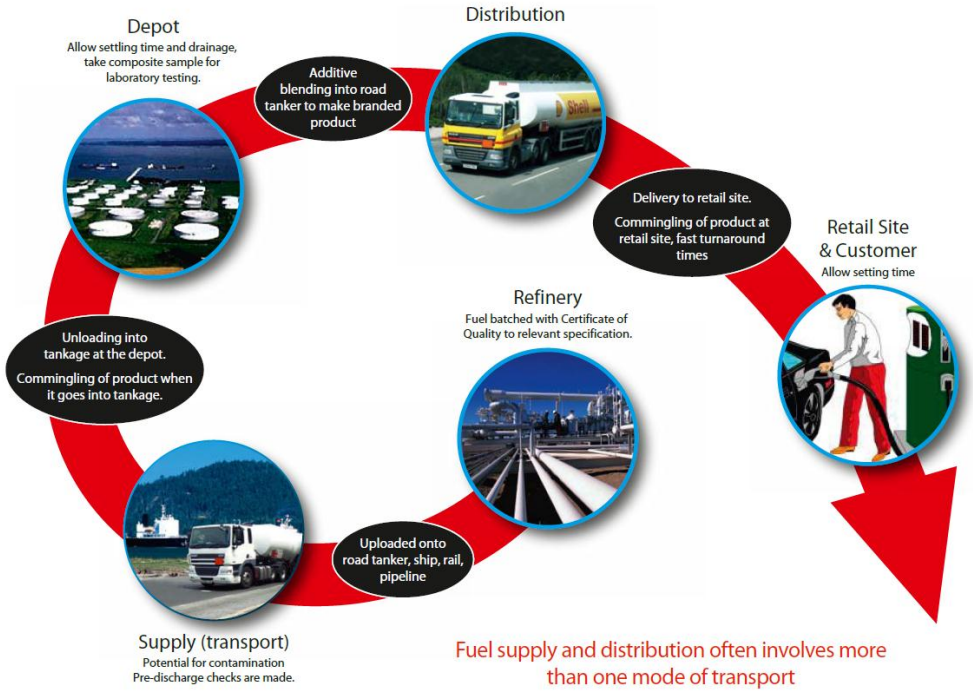
Microbes can grow during fuel transportation

Example supply & distribution chain



To ensure that fuel is delivered clean, dry and free from contamination to the customer, a range of measures are taken.

- Sequencing and interface management with multi-product pipelines.
- Allowance of sufficient settling time for contaminants to sink to the bottom of storage tanks.
- Where practical, tanks are engineered with low points or sumps to facilitate drainage of water and contaminants.
- Dedicated compartments (ships, road and rail) to avoid grade contamination.
- Filtration.
- Sampling and testing for visual appearance, density, etc.

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Microbes can grow during fuel transportation

Dirty Diesel Video

Biomass at the fuel/water interface

Biomass clogging a filter

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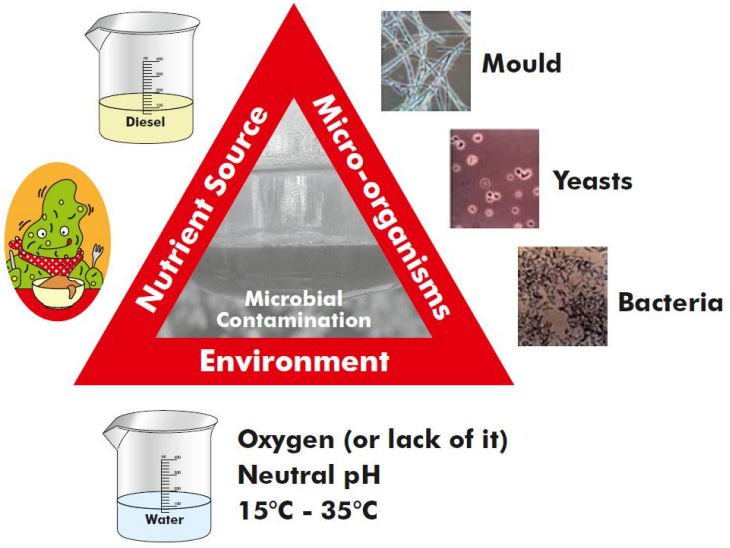
Main factors affecting growth



Nutrient availability
Oxygen availabilty
Temperature
Water availability
pH
Osmotic pressure
Salinity

Time Lapse Video

Some reports suggest that biodiesel does not necessarily increase microbial growth.

Implications of biofuels on microbial spoilage and corrosion within the fuel distribution chain and end use, (2008) Energy Institute.

Susceptibility to microbial growth can also vary with FAME content.

Effect of nutrient availability on microbial growth

Macro-nutrients

- Carbon (energy source, cell material)
- Hydrogen (cell water)
- Oxygen (cell water)
- Nitrogen (proteins, enzymes)
- Sulphur (enzymes)
- Phosphorus (membranes, ATP)

Micro-nutrients

- Trace elements (calcium, sodium, potassium, iron, magnesium, manganese, copper, cobalt, nickel)

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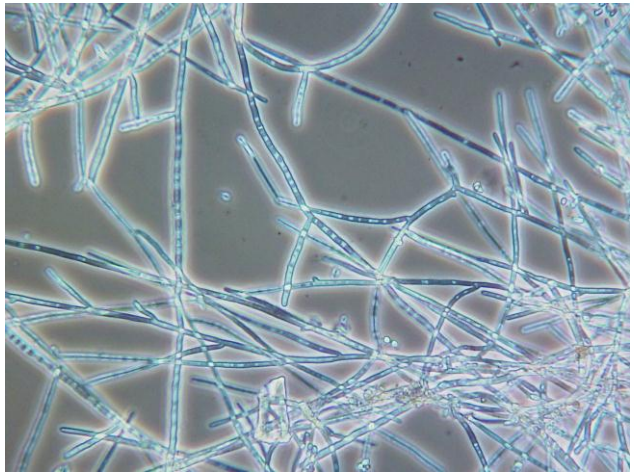
Effect of oxygen availability on microbial growth

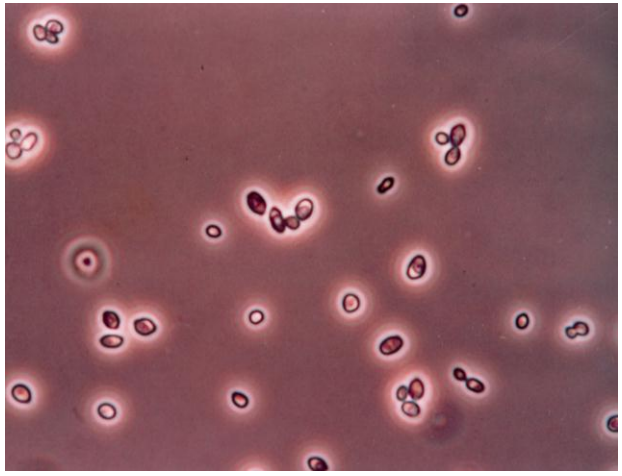
Aerobic environment – free oxygen (O_2) present

Anaerobic environment – lack of free oxygen, but contains atomic oxygen (nitrate NO_3, nitrite NO_2, sulphite SO_3)

Facultative microbes can switch between aerobic and anaerobic systems



filamentous fungi



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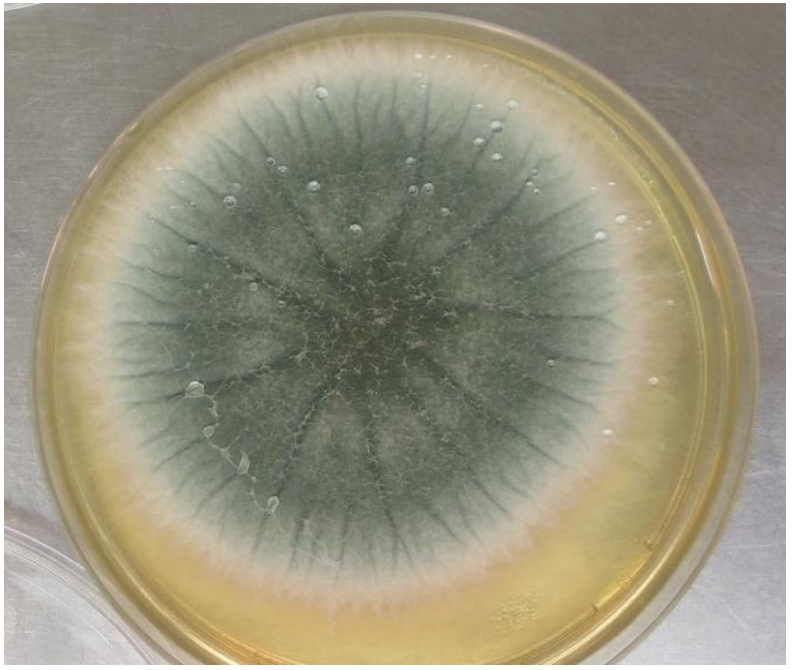
Effect of temperature on microbial growth

Microbes are generally classified into three groups depending on their temperature requirements:

Psychrophiles	grow optimally	~0-5°C
Mesophiles	grow optimally	~15-35°C
Thermophiles	grow optimally	~ >55°C



Aspergillus fumigatus

http://nl.wikipedia.org/wiki/User:Jankaan

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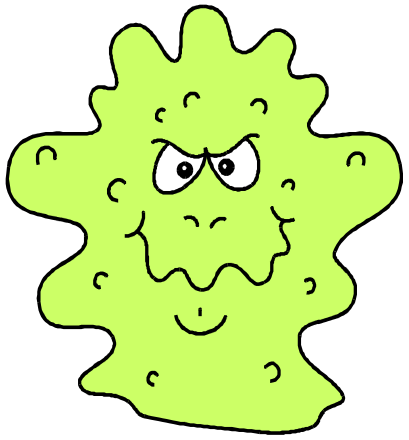
Effect of water availability on microbial growth

"To a microbe, a one millimetre film of water is the same as a six foot person standing in 1,500 feet of water"

Howard Chesneau, President of Fuel Quality Services Inc.



Microbes require free, chemically unbound water for cellular activity. Water activity (a_w) is a measure of the amount of free water present and is the ratio of water vapour pressure over the sample (P) to that over pure water(P_0).

$$a_w = P/P_0$$

a_w pure water = 1.0
a_w honey = 0.6

Most bacteria require a_w = >0.95
Most moulds require a_w = >0.80
Most yeasts require a_w = >0.85

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Adopt good housekeeping to reduce microbial growth

Water is always present because:

- Dissolved water in the fuel condenses on the tank walls.
- Moisture in the air can enter through floating tank lids.
- Efficient tank draining is not always possible.
- Water may be added as ballast (on ships) or to purge the delivery system.

Good housekeeping procedures that eliminate water as much as possible WILL reduce microbial growth

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