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ASSESSMENT OF THE VIABILITY OF VEGETABLE OIL BASED FUELS

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This paper discusses :-

Part 1 Why vegetable oil should be used ahead of all alternatives

Part 2 Results of a literature survey, and

Part 3 Findings of a 42,000 km on-road trial using principally, 50/50 blends of unheated waste cooking oil with conventional diesel fuel.

PART ONE – WHY VEGETABLE OIL ?

ASSESSMENT OF THE VIABILITY OF VEGETABLE OIL BASED FUELS

Current fuels are fossilised biofuels

The growing solid biomass comprises cellulose, lignin and hemicellulose

Biomass growing regions are land, sea and land-sea margins

Species in these regions are plants, algae and halophytes

Current fuel types are solids (coal), liquids (petrol, diesel) and liquefied gases (LPG, LNG)

The current dominant fuel type by far is liquids therefore replacing fossil fuels will be by liquid biofuels produced from the growing biomass eg by

- Very complex chemical processing of lignins and celluloses
- Complex production from algae or waste plastics
- Complex and dangerous transesterification of vegetable oils to make biodiesel
- Complex conversion of solids to liquids eg Coal or Gases To Liquids (CTL, GTL)
- Simple use of straight vegetable oils

ASSESSMENT OF THE VIABILITY OF VEGETABLE OIL BASED FUELS

I am proposing that vegetable oils should replace ALL fuels, because

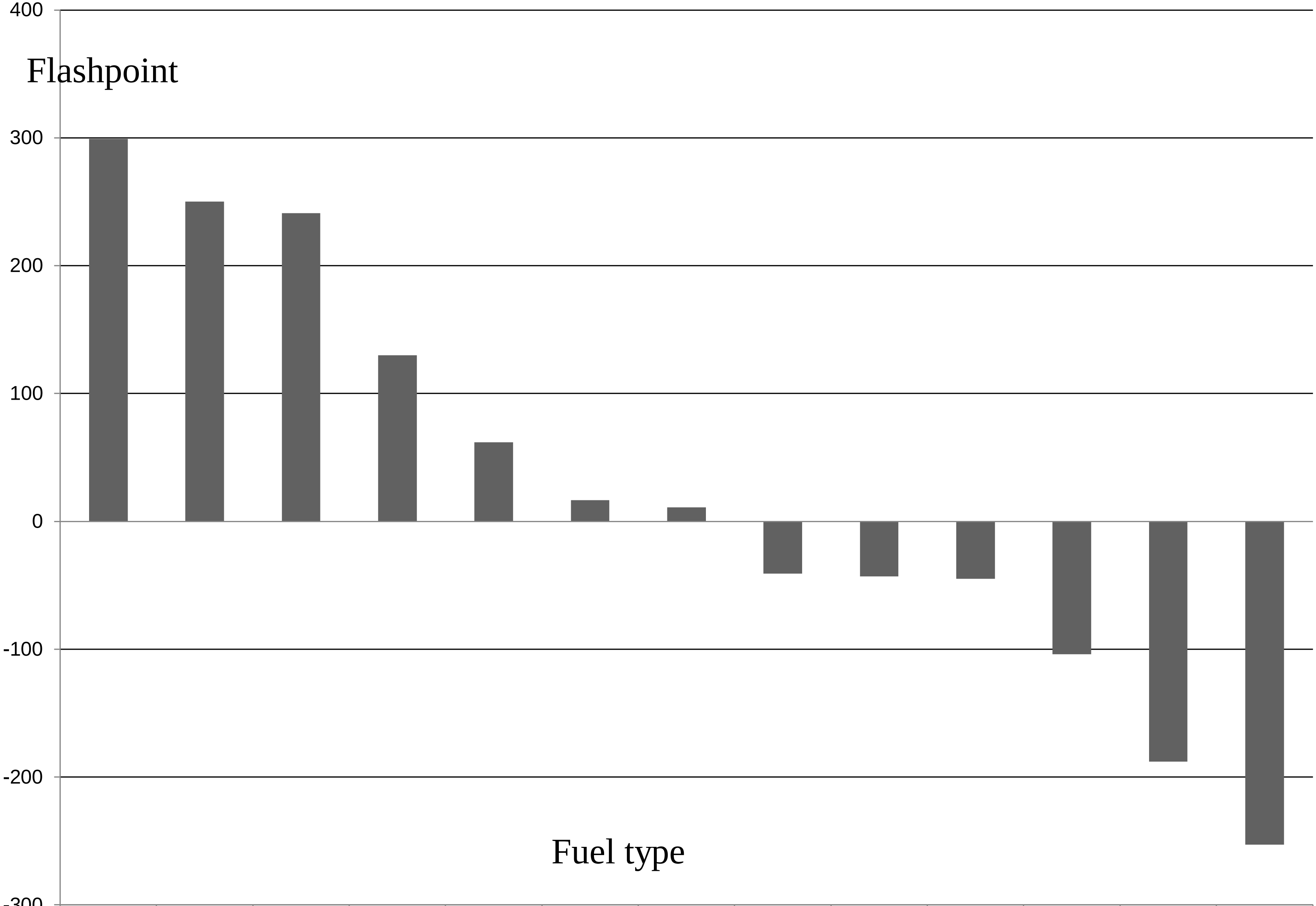
- fires & explosions involving flammable liquids or gases would largely become a thing of the past
- we wouldn’t need to drill
- we wouldn’t need refineries
- we wouldn’t need to have oil wars
- we wouldn’t need nuclear power

But we would still need to stabilise (or reduce) our world population –

remembering that humans are a cancer on the planet (David Suzuki)

ASSESSMENT OF THE VIABILITY OF VEGETABLE OIL BASED FUELS

- Unmodified vegetable oils are inherently safer than all alternatives because of their high flashpoints
- They can be used as sustainable fuels without modification.
- There is no need to deplete edible oil stocks to achieve this because
- literature searching to date has found 123 non-food, oil-producing species,
- many of which are arid area growing ‘weed’ species.
- Further, vegetable oils are self-lubricating and quieter in use,
- they contain combined oxygen in carboxyl groups which assists late combustion,
- some contain additional combined oxygen in hydroxyl or epoxide groups.
- They contain no sulphur and they are less toxic than current fuels



	Castor oil	Jatropha oil	Honge oil	Biodiesel	Diesel	Ethanol	Methanol	Dimethyl ether	Petrol	Diethyl ether	LPG	CNG/LNG	Hydrogen
Datenreihen1	299	250	241	130	62	16,5	11	-41	-43	-45	-104	-188	-253

ASSESSMENT OF THE VIABILITY OF VEGETABLE OIL BASED FUELS

The test vehicle engine is injected by mechanical fuel pumps and injectors at low pressure (500 bar)

Others have successfully tested vehicles with common-rail electronically injected engines using high injection pressures (2000 bar) [5] and [18]

We therefore need to encourage greater use of diesel engines and their further development to permit vegetable oil fuel to be used

Other sustainable fuels exist

OTHERS WITH SUCH HIGH INHERENT SAFETY DO NOT

for example,

ASSESSMENT OF THE VIABILITY OF VEGETABLE OIL BASED FUELS

If vegetable oil becomes the principal world fuel, lives saved in vapour cloud explosions alone would be 16.4 persons/year

Catastrophic accidents like Flixborough (UK 1974), Coode Island (1991), Longford (1998) and Buncefield (UK 2005),

WOULD BECOME A THING OF THE PAST

ASSESSMENT OF THE VIABILITY OF VEGETABLE OIL BASED FUELS

Almost no-one in the western world is working on this - certainly nowhere in Australia

Instead, current sustainability initiatives all use more dangerous fuels

With few exceptions, only developing countries are seriously considering vegetable oil use largely, because they have no choice

PART TWO - THE LITERATURE SEARCH

ASSESSMENT OF THE VIABILITY OF VEGETABLE OIL BASED FUELS

119 papers were assessed – all showed that regardless of oil type and concentration when blended with diesel fuel, vegetable oil is viable

Emission and noise results varied :-

CO	6 up; 4 down
CO_2	1 up; 1 down; 1 same
HC	5 up; 3 down
PM	3 up; 1 down
NOx	1 up; 8 down; 1 same
Smoke	1 up; 5 down
Noise	3 down …… see overleaf

Table 1								
Reference	CO	CO_2	HC	PM	NOx	Smoke	Noise	Oil type etc
[1]	Up	Up	Up	-	Down	-	-	Jatropha
[4]	Up	-	-	-	Same	-	-	Karanja
[12]	Down	-	-	-	-	Down	-	WVO
[13]	Down	-	Down	-	-	Down	Down	Rapeseed
[18]	Up	-	Up	Up	Down	-	-	Canola
[20]	Up	-	Up	Up	-	-	-	Sunflower
[21]	-	-	-	-	Down	-	-	Rapeseed etc
[22]	Up	-	Up	Up	Down	-	-	traffic; Canola
[22]	Down	-	Down	Down	Down	-	-	country; ditto
[23]	-	-	-	-	-	Down	-	Rapeseed
[24]	-	-	-	-	Down	-	-	Saturated VOs
[25]	-	-	-	-	Down	-	Down	Cottonseed etc
[26]	-	-	-	-	-	Down	Down	Linseed etc
[27]	Up	Down	Up	-	Down	Up	-	Poon
[28]	Down	Same	Down	-	Up	Down	-	Jatropha

The overwhelming impression I have from reading all of these references, is summed up as follows :-

Vegetable oils and their products appear to be obvious choices as future fuels and are of exceptional importance [14]

Considering overall energy, health, environmental, and economic aspects, vegetable oils could be the fuel of the future [15]

PART THREE – THE ON-ROAD TRIAL

ASSESSMENT OF THE VIABILITY OF VEGETABLE OIL BASED FUELS

A 1996 turbo diesel utility vehicle was driven 42,000 km using the following fuels :-

100% used cooking oil	1000 km	1 trial
50/50 blend	9700 km	4 trials
50/50 blend + additives	23,800 km	19 trials
Diesel (control)	8000 km	7 trials

Additives used at 2L per 20L of 50/50 blend were :-

- isopropanol
- diethyl ether
- industrial perfume concentrates
- ethyl acetate
- methanol
- ethanol

The test vehicle, a 1996 Mitsubishi Triton

Disadvantages I have found using vegetable oil are :-

fuel filter blockage

fuel injector pump blockage

exhaust smoke &

variation in idling speed

Others have experienced problems with

polymerisation
high viscosity &
acidity

I have NOT experienced these

All difficulties can be overcome by using filtered oil free of fish bones, burned chips, fine solids and suspended high-melting point oils and fats

The most deleterious condition experienced required twice daily filter changes when the waste oil contained high melting point oils and fats

Preheating would overcome this, as would using oils which are liquid at ambient temperatures.

Using new (unused) vegetable oil would overcome all difficulties but this has not yet been attempted.

On-road trial uncontrolled variables were :-

- Vehicle load
- Route travelled
- Traffic density – light to rush-hour
- Weather – wind direction & strength, temperature, humidity
- Fuel temperature (ambient)
- Vegetable oil source
- Oil blend present
- Sub-trial duration
- Diesel fuel source

Uncontrolled variables were mitigated by :-

- Performing very many trials (total 42,000 km)
- Using two principal routes - a 116km cross-Melbourne trip and a 375km country trip
- Separately logging results for the country route
- Travelling the routes equally in both directions
- City travel principally outside of rush-hour with relatively constant load
- Sourcing waste oil mostly from one place

Some unmeasured variables were qualitatively assessed and noted eg

- Vehicle load - laden, unladen
- Smoke emission - good, bad
- General vehicle performance - normal, slow
- Country run wind direction - prevailing westerly

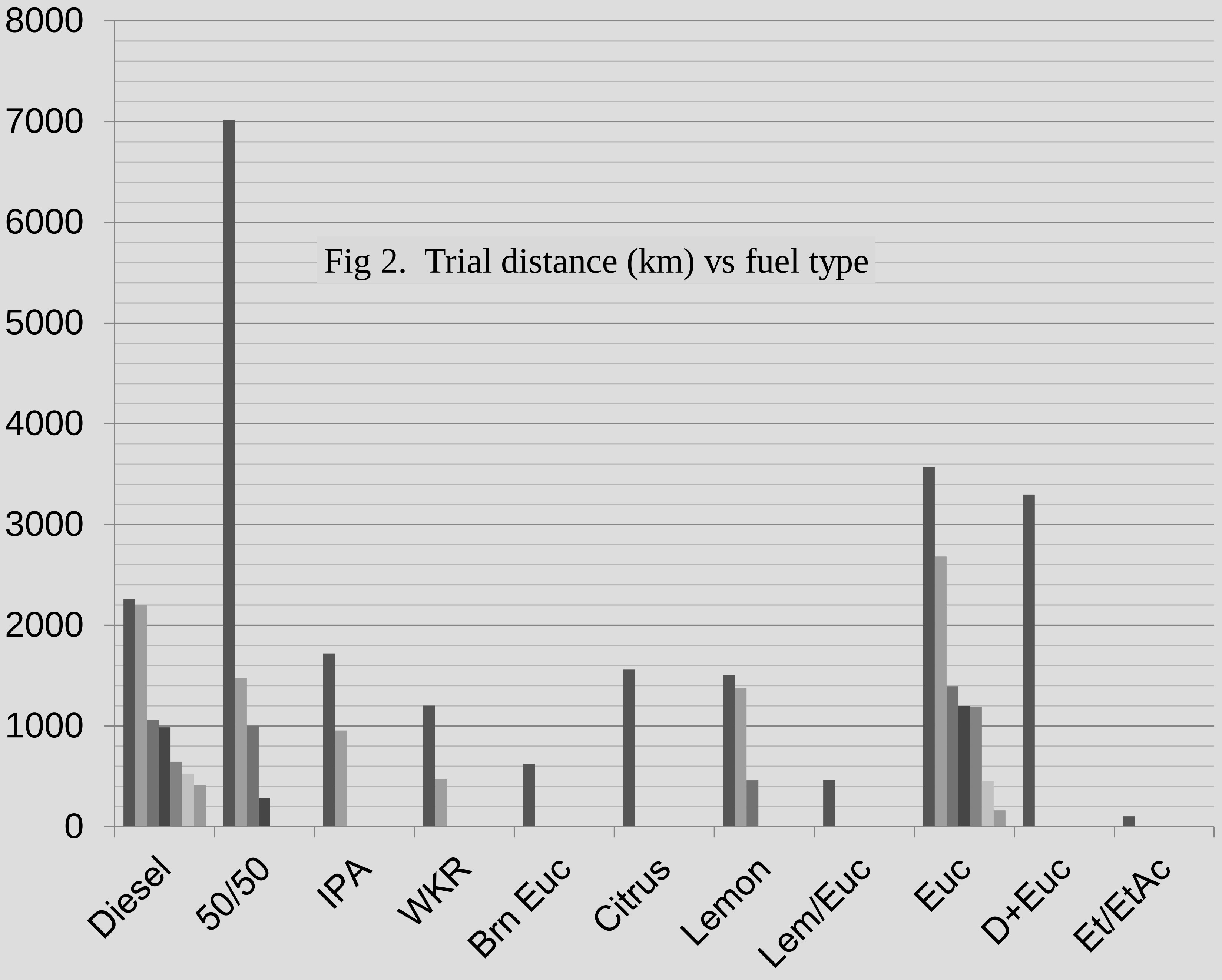


Fig 2. Trial distance (km) vs fuel type

Fuel formulation details

Diesel	*Conventional diesel fuel alone*
50/50	*50% waste vegetable oil and 50% conventional diesel*
IPA	*50/50 blend with isopropyl alcohol*
WKR	*50/50 blend with white king regular perfume**
Brn Euc	*50/50 blend with brown eucalyptus perfume**
Citrus	*50/50 blend with citrus perfume**
Lemon	*50/50 blend with lemon perfume**
Lem/Euc	*50/50 blend with lemon or eucalyptus perfume**
Euc	*50/50 blend with eucalyptus perfume**
D+Euc	*50/50 blend with eucalyptus perfume* or straight diesel*
Et/EtAc	*50/50 blend with ethanol and ethyl acetate*

** Industrial perfume concentrates in ethanol*

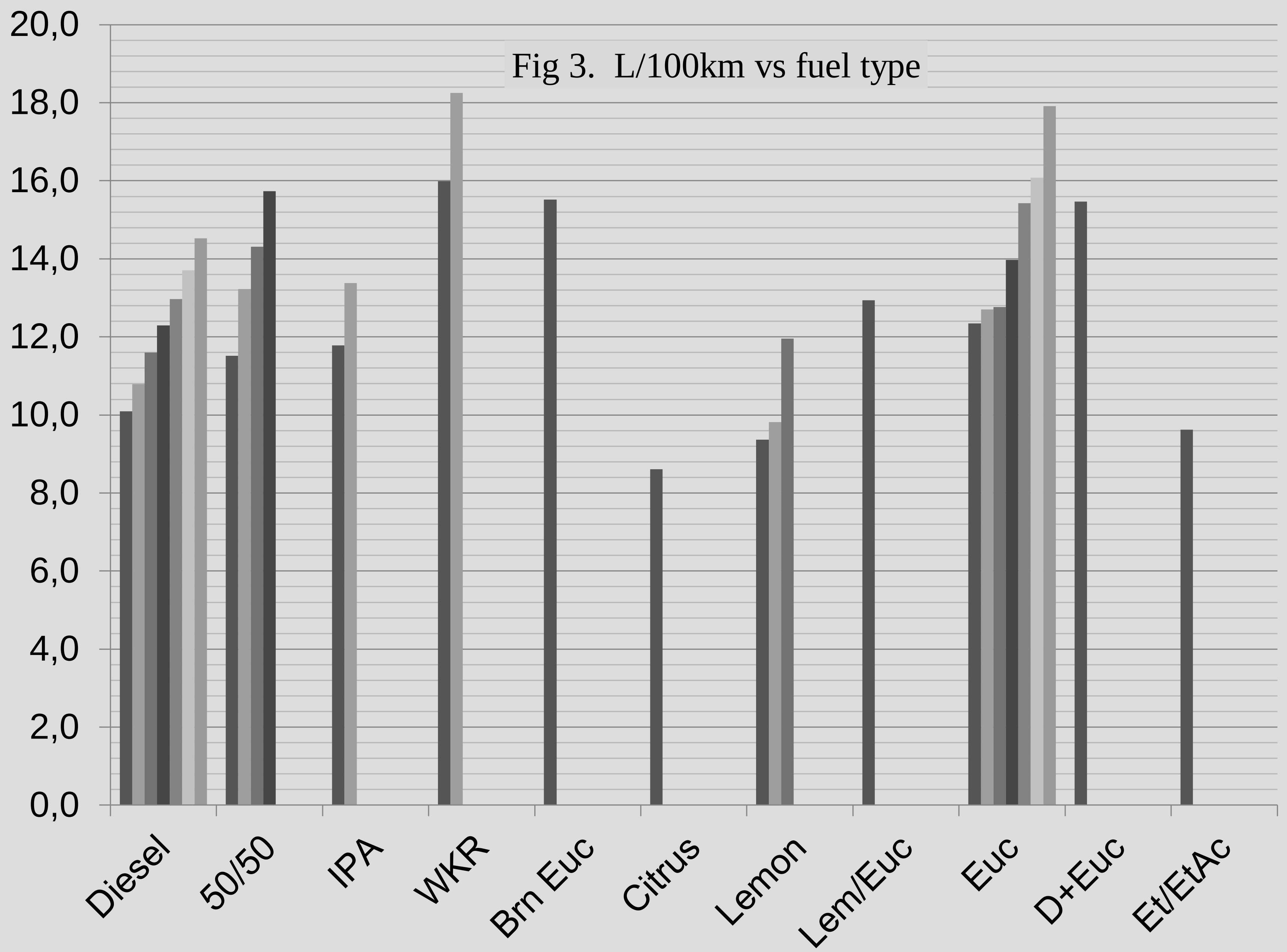


Fig 3. L/100km vs fuel type
20,0
18,0
16,0
14,0
12,0
10,0
8,0
6,0
4,0
2,0
0,0
Diesel
50/50
IPA
WKR
Brn Euc
Citrus
Lemon
Lem/Euc
Euc
D+Euc
Et/EtAc

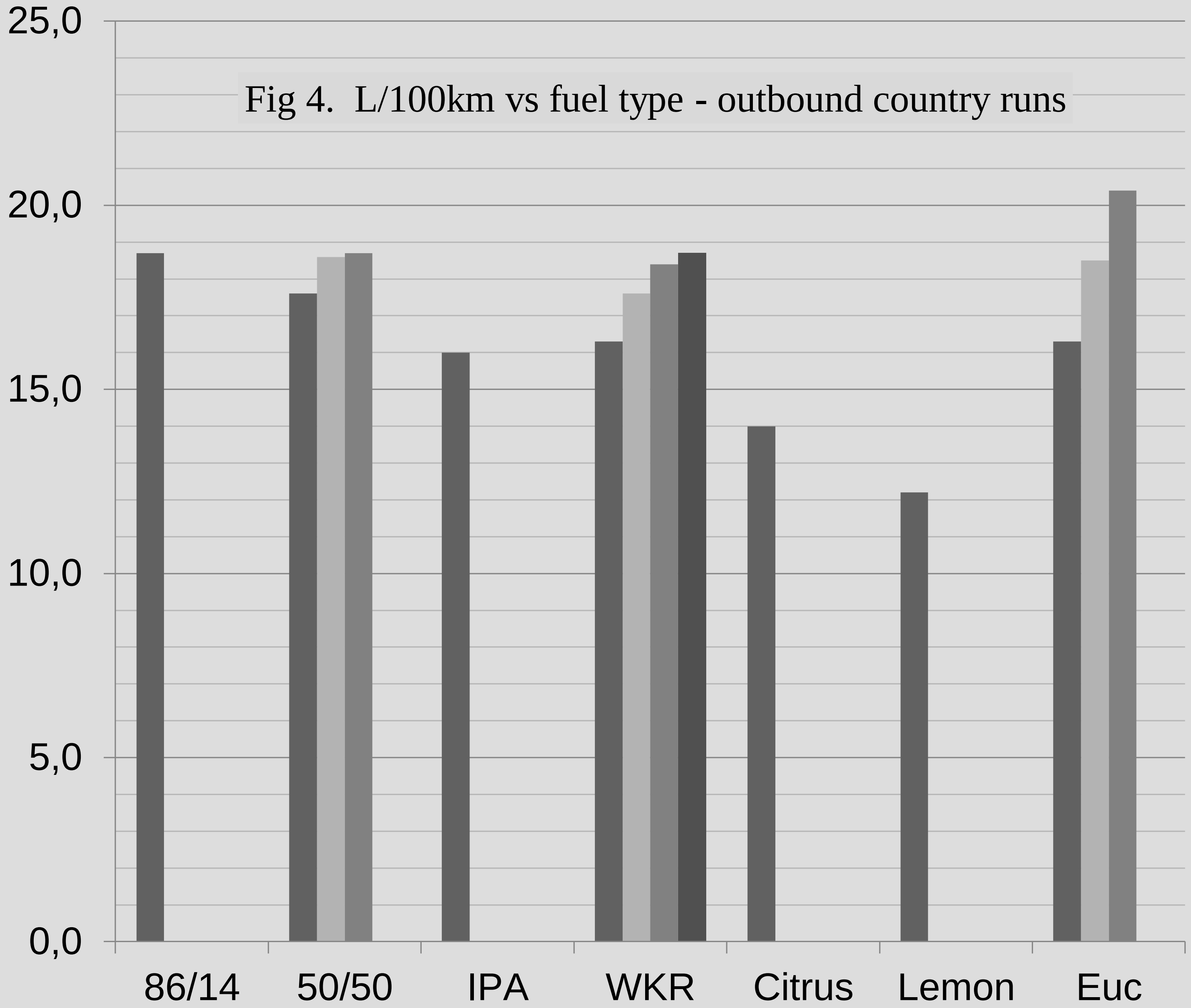
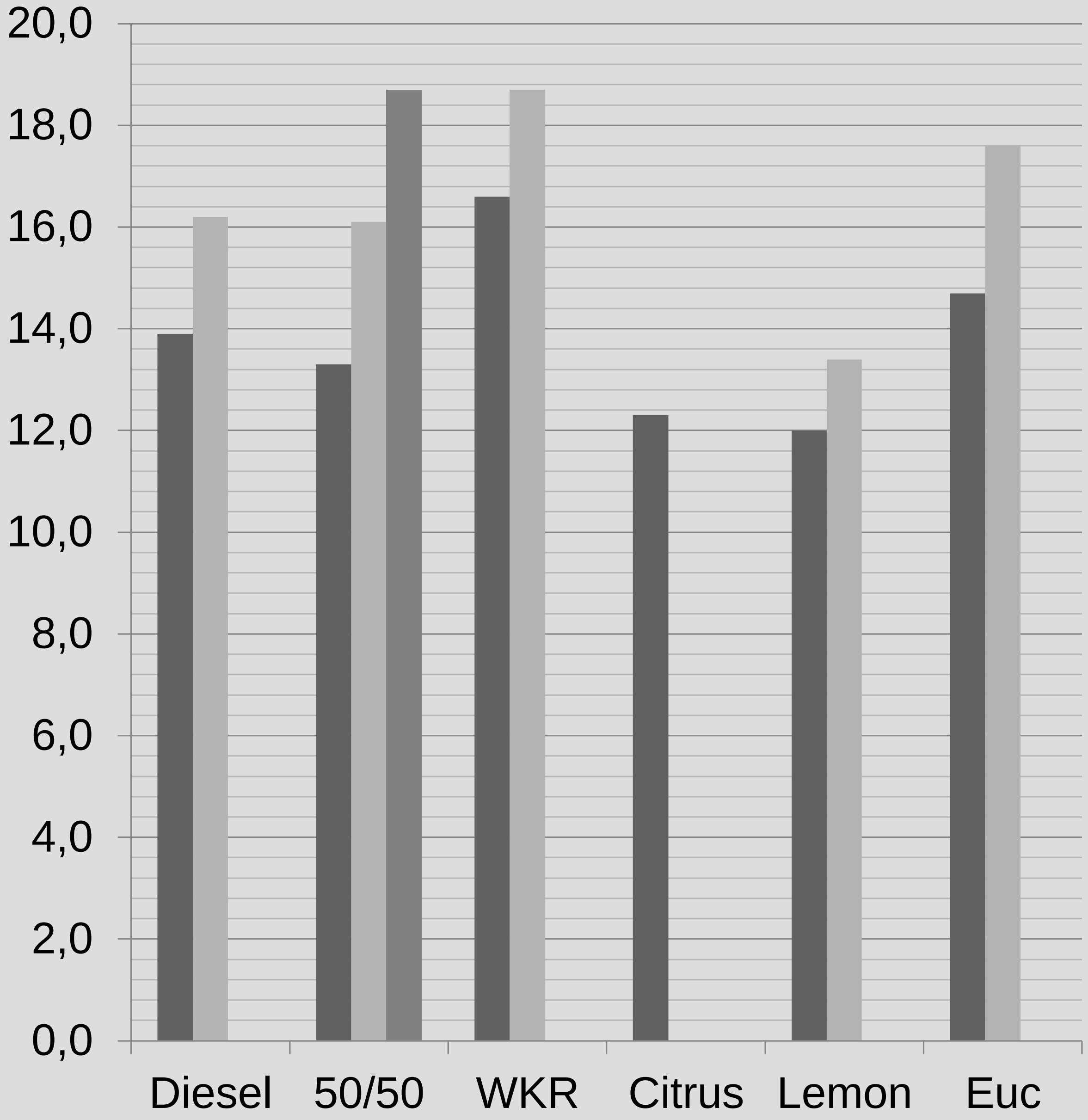


Fig 4. L/100km vs fuel type - outbound country runs
25,0
20,0
15,0
10,0
5,0
0,0
86/14
50/50
IPA
WKR
Citrus
Lemon
Euc

Fig 5. L/100km vs fuel type return country runs



Statistical analysis

**	Diesel fuel surrogate (86% diesel, 14% WVO)
† & *	at 95% confidence level

Table 2 t-test outcomes		L/100km		No of samples		Significant ? *
1st variable	2nd variable	1st mean †	2nd mean †	1st	2nd	
All trials						
Diesel	All other	12.3+/-1.5	13.4+/-1.1	7	23	No
Diesel	Citrus/Lemon	12.3+/-1.5	9.9+/-2.3	7	4	Yes
Diesel	Cit/Lem/LemEuc	12.3+/-1.5	10.5+/-2.3	7	5	No
Diesel	IPA/C/L/Et-EtAc	12.3+/-1.5	10.6+/-1.6	7	7	No
Diesel	W/L-Eu/Eu/D-Eu	12.3+/-1.5	14.9+/-1.4	7	11	Yes
Diesel	50/50	12.3+/-1.5	13.7+/-2.8	7	4	No
Diesel	Euc	12.3+/-1.5	14.5+/-1.9	7	7	Yes
Outbound country runs						
86/14**	WKR	18.7	17.8+/-1.7	1	4	No
86/14**	All other	18.7	17.2+/-1.3	1	13	No
86/14**	All additives	18.7	16.8+/-1.7	1	10	No
Return country runs						
Diesel	All other	15.0+/-14.5	15.3+/-1.8	2	10	No
Diesel	All additives	15.0+/-14.5	15.1+/-2.4	2	7	No
All country runs						
D+86/14	50/50	16.2+/-5.9	17.2+/-2.2	3	6	No
D+86/14	Lemon	16.2+/-5.9	12.6+/-1.9	3	3	No (Yes 90%)
D+86/14	WKR	16.2+/-5.9	17.7+/-1.1	3	6	No
D+86/14	Euc	16.2+/-5.9	17.5+/-2.7	3	5	No
D+86/14	All other	16.2+/-5.9	16.4+/-1.1	3	23	No
D+86/14	All additives	16.2+/-5.9	16.1+/-1.3	3	17	No
All outbound vs All return runs						
Outbound	Return	17.3+/-1.2	15.3+/-1.5	14	12	Yes
City runs						
Diesel	50/50	12.2+/-1.4	13.2+/-2.7	7	5	No
Diesel	Euc/B Euc/D+Eu	12.2+/-1.4	13.3+/-2.2	7	5	No
Diesel	All other	12.2+/-1.4	13.0+/-1.1	7	18	No
Diesel	All additives	12.2+/-1.4	12.9+/-1.4	7	13	No

Conclusions of the on-road trials

● For all 30 trials inclusive of both city and country driving, (a) there is no significant difference between mean fuel consumption using 100% diesel fuel and the 50/50 blend of WVO and diesel fuel (b) 50/50 blends containing eucalyptus perfume concentrate performed significantly worse than diesel fuel alone and (c) 50/50 blends containing citrus or lemon perfume concentrate performed significantly better than diesel fuel alone.

● Outbound country runs performed best using the 50/50 blend with lemon or citrus perfume and return runs performed best with the same perfume blends and the straight 50/50 blend. However, there is (a) no significant difference between fuel types used in outbound runs or in fuel types used in return runs, (b) a significant difference in the mean overall fuel consumption outbound vs the mean overall fuel consumption in return runs consequent upon different wind and load conditions (c) a significant difference at 90% confidence level for combined country runs between diesel fuel and the 50/50 blend containing lemon perfume concentrate.

● There is no significant difference between any of the fuel types for city runs.

● Fuel filter blockage was caused almost exclusively by suspended fats present in the waste vegetable oil used. These comprise higher melting point components of the vegetable oil blend used by the source fish-and-chip shop, hotel or restaurant, together with introduced fats from pre-cooked foodstuffs.

● Smoke emission is increased when the fuel filter is partially blocked, when the fuel injectors are worn and as the vehicle ages.

SOME VAPOUR CLOUD EXPLOSIONS
CAUSED BY VOLATILE FUELS

The following lists 132 major accidents which occurred in the period 1921 to 2009. Of these, 26 are for gasoline or gasoline-like flammable liquid chemicals and 106 are for flammable gases. Of the flammable gases, seven involved hydrogen.

348 of the 1439 fatalities caused involved flammable liquids and 1091 involved flammable gases.

8 vapour cloud explosions involving automotive gasoline (petrol) courtesy, the author

23rd October	*2009*	*Caribbean Petroleum*	*Bayamon*	*San Juan*	*Puerto Rico*
29th October	*2009*	*Indian Oil Corporation Ltd*	*Sitapur*	*Jaipur*	*Rajasthan*
11th December	*2005*	*Hertfordshire Oil Storage Ltd*	*Buncefield*	*Hertfordshire*	*UK*
23rd March	*2005*	*BP Texas City*	*Texas City*	*Texas*	*USA*
7th January	*1983*	*Texaco*	*Newark*	*New Jersey*	*USA*
21st December	*1985*		*Naples*		*Italy*
December	*1985*	*Dutch State Mines*	*Beek*		*Netherlands*
October	*1991*	*Edouard Herriot port*	*Saint Herblain*		*France*

20 vapour cloud explosions involving liquid and gaseous fuels as stated courtesy, Marsh

26th July	*1996*	*LPG*	*Cactus*	*Reforma*	*Mexico*
9th November	*1992*	*Total Refinery, light HCs*	*La Mede*		*France*
3rd November	*1990*	*Refinery*	*Chalmette*	*Louisiana*	*USA*
24th December	*1989*	*ethane and propane*	*Baton Rouge*	*Louisiana*	*USA*
23rd October	*1989*	*ethylene and isobutane*	*Pasadena*	*Texas*	*USA*
7th June	*1989*	*propylene*	*Morris*	*Illinois*	*USA*
5th May	*1988*	*hydrocarbons*	*Norco*	*Louisiana*	*USA*
14th November	*1987*	*butane*	*Pampa*	*Texas*	*USA*
15th August	*1987*	*propane*	*Ras Tanura*		*Saudi Arabia*
5th November	*1985*	*propane*	*Mont Belvieu*	*Texas*	*USA*
19th November	*1984*	*LPG*	*Mexico City*		*Mexico*
30th September	*1984*	*propane*	*Basile*	*Louisiana*	*USA*
21st October	*1980*	*HCs and polymer*	*New Castle*	*Delaware*	*USA*
20th January	*1980*	*propane*	*Borger*	*Texas*	*USA*
21st July	*1979*	*liquid and gaseous HCs*	*Texas City*	*Texas*	*USA*
3rd October	*1978*	*propane*	*Denver*	*Colorado*	*USA*
8th December	*1977*	*ethylene*	*Brindisi*		*Italy*
15th April	*1977*	*gas pipeline*	*Abqaiq*		*Saudi Arabia*
7th November	*1975*	*HCs and propylene*	*Beek*		*Netherlands*
29th November	*1974*	*liquid and gaseous HCs*	*Beaumont*	*Texas*	*USA*

99 vapour cloud explosions involving liquid and gaseous fuels (as listed) courtesy, Gugan

20th	February	1977	isobutane	Dallas	Texas	USA
21st	September	1976	propylene	New Jersey		USA
		1976	pentanes	Puerto Rico		USA
	February	1976	LPG	Texas		USA
		1976	ethylene	Texas		USA
		1975	light hydrocarbons			Czechoslovakia
		1975	hydrogen		California	USA
		1975	naphtha and hydrogen			W Germany
10th	February	1975	Union Carbide, ethylene	Antwerp		Belgium
18th	July	1974	Dow Chemical, propylene	Plaquemine	Louisiana	USA
		1974	pentanes		Texas	USA
12st	September	1974	butadiene	Houston	Texas	USA
13th	September	1974	propane	Griffith	Indiana	USA
		1974	ethylene			UK
5th	September	1974	Solvay, dichlorethylene/VC	Barcelona		Spain
25th	August	1974	butane	Petal	Missouri	USA
19th	July	1974	rail tank car, propane	Decatur	Illinois	USA
29th	June	1974	vinyl choride	Climax	Texas	USA
1st	June	1974	Nypro Ltd, cyclohexane	Flixborough	Lincolnshire	UK
	January	1974	road tanker, propane		Florida	USA
23rd	February	1973	pipeline, LNG	Austin	Texas	USA
28th	October	1973	vinyl chloride	Shinetsu		Japan
		1973	ethylene			Japan
19th	March	1972	propane	Lynchburg	Virginia	USA
		1972	butane		Montana	USA
	September	1972	LNG			France
14th	May	1972	Exxon, crude oil	Hearne	Texas	USA
		1972	butane			Brazil
22nd	January	1972	rail tank cars, propylene	East St Louis	Illinois	USA
	September	1971	butadiene		Texas	USA
		1971	ethylene		Texas	USA

26th	February	1971	ethylene	Longview	Texas	USA
19th	January	1971	road tanker, ethylene		Louisiana	USA
9th	December	1970	Franklin Co, propane	Port Hudson	Mo	USA
12th	November	1970	LPG	Hudson	Ohio	USA
23rd	October	1970	road tanker, propane	Hull	N Humberside	UK
2nd	June	1970	rail tank cars, propane	Crescent City	Illinois	USA
		1970	heavy HCs and hydrogen		New Jersey	USA
14th	May	1969	ICI, cyclohexane	Wilton		UK
11th	September	1969	vinyl chloride	Black Bayou	Mississippi	USA
28th	December	1969	Esso, naphtha and hydrogen	Fawley	Hampshire	UK
5th	December	1968	pipeline, LPG	Yutan	Nebraska	USA
		1968	vinyl chloride		Louisiana	USA
		1968	light HCs and acid		Texas	USA
20th	January	1968	Shell, light HCs	Pernis		Holland
8th	August	1967	Cities Serv Oil, isobutylene	Lake Charles	Louisiana	USA
23rd	May	1966	Gulf,cumene/benzene/propane		Pennsylvania	USA
		1966	light HCs			W Germany
		1966	butadiene		Louisiana	USA
	January	1966	pipeline, ethylene			W Germany
16th	January	1966	Caltex, methane	Raunheim		W Germany
4th	January	1966	propane	Feyzin		France
		1965	butane		Texas	USA
24th	October	1965	Escambia Chem Corp, hydrogen, carbon monoxide			
		1965	Ethyl Corp, ethyl chloride	Baton Rouge	Louisiana	USA
13th	July	1965	Cities Serv, methane/ethylene	Lake Charles	Louisiana	USA
		1964	ethylene		Texas	USA
9th	January	1964	NRDS, hydrogen	Jackass Flats	Nevada	USA
		1963	Dow, methane/ethylene	Plaquemine	Louisiana	USA
4th	August	1962	propane			Middle East
25th	July	1962	road tanker, LPG	Berlin	New York	USA
17th	April	1962	ethylene oxide	Doe Run	Kentucky	USA
		1961	cyclohexane		Texas	USA
28th	June	1959	rail tank car, LPG	Meldrin	Georgia	USA

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30th	*July*	*1958*	*LPG*	*Augusta*	*Georgia*	*USA*
3rd	*July*	*1958*	*LPG*	*Boron*	*California*	*USA*
15th	*April*	*1958*	*propane*	*Ardmore*	*Oklahoma*	*USA*
		1958	*oil froth*	*California*		*USA*
		1958	*butane*		*Michigan*	*USA*
24th	*October*	*1957*	*road tanker, LPG*	*Sacramento*	*California*	*USA*
		1957	*butane*		*Quebec*	*Canada*
8th	*January*	*1957*	*butane*	*Montreal E*	*Quebec*	*Canada*
		1956	*ethylene*		*New York*	*USA*
22nd	*July*	*1955*	*butane*	*Wilmington*	*North Carolina*	*USA*
		1954	*rail tank car, acrolein*		*W Virginia*	*USA*
18th	*October*	*1954*	*LPG*	*Portland*	*Oregon*	*USA*
	January	*1954*	*isopropyl alcohol*		*Tennessee*	*USA*
21st	*July*	*1952*	*butane*	*Bakersfield*	*California*	*USA*
24th	*June*	*1952*	*LPG*	*Kansas City*	*Kansas*	*USA*
2nd	*January*	*1952*	*rail tank car, propane*			
6th	*March*	*1951*	*Koppers Co, butadiene*	*Kobuta*	*Pennsylvania*	*USA*
7th	*October*	*1950*	*LPG*	*Woodbury*	*Georgia*	*USA*
23rd	*August*	*1950*	*road tanker, propane*	*Wray*	*Colorado*	*USA*
27th	*October*	*1949*	*rail tank car, LPG*	*Winthrop*	*Missouri*	*USA*
23rd	*June*	*1949*	*California Ref, hydrocarbons*	*Perth*	*New Jersey*	*USA*
28th	*July*	*1948*	*BASF, dimethyl ether*	*Ludwigshafen*		*W Germany*
13th	*October*	*1948*	*road tanker, butane*	*Sacramento*	*California*	*USA*
		1945	*crude oil*		*New Jersey*	*USA*
25th	*April*	*1945*	*butane*	*Los Angeles*	*California*	*USA*
21st	*November*	*1944*	*butane*	*Dennison*	*Texas*	*USA*
15th	*November*	*1944*	*methane*	*Cleveland*	*Ohio*	*USA*
10th	*August*	*1943*	*Home Gas Corp, propane*	*Palmer*	*Massachusetts*	*USA*

18th	*January*	*1943*	*road tanker, butane*	*Los Angeles*	*California*	*USA*
11th	*June*	*1941*	*road tanker, butane*	*Los Angeles*	*California*	*USA*
2nd	*January*	*1939*	*butane*	*Newark*	*New Jersey*	*USA*
22nd	*October*	*1936*	*butane*	*Crowley*	*Louisiana*	*USA*
2nd	*June*	*1934*	*butane*	*Huntington B*	*California*	*USA*
17th	*December*	*1932*	*LPG*	*Detroit*	*Michigan*	*USA*
23rd	*August*	*1921*	*Dirigible ZR-2, hydrogen*	*Hull*	*N Humberside*	*UK*

5 major incidents not reported above courtesy of the author

25th	*September*	*1998*	*Esso/BHP, methane, propane*	*Longford*	*Victoria*	*Australia*
21st	*August*	*1991*	*Terminals P/L, acrylonitrile*	*Coode Island*	*Victoria*	*Australia*
6th	*July*	*1988*	*Piper Alpha oil rig, propane*	*nr Aberdeen*	*Aberdeenshire*	*UK*
25th	*February*	*1982*	*Goodrich, vinyl chloride*	*Altona*	*Victoria*	*Australia*
11th	*July*	*1978*	*Road tanker, propylene*	*San Carlos*	*Barcelona*	*Spain*

SOME COMMON OIL PRODUCING SPECIES

123 principally non food-crop oil-producing species in the following 52 families

Amaranthaceae Anarcadiaceae Apocynaceae Arecaceae Asclepiadoideae Asteraceae Betulaceae Bombacaceae Brassicaceae Burseraceae Calophyllaceae Cannabaceae Caesalpinioideae Capparaceae Caryocaraceae Cornaceae Crysobalanaceae Clusiaceae Combretaceae Cucurbitaceae	Dipterocarpaceae Euphorbiaceae Fabaceae Facaceae Guttiferae Irvingiaceae Lamiaceae Linaceae Leguminosae Magnoliaceae Magnoliopsida Malvaceae Meliaceae Moraceae Moringaceae Myrtaceae Ochnaceae Olacaceae Oleaceae Papaveraceae	Pinaceae (Turpentine oil source species) Pistacia Poaceae Pittosporaceae Putranjivaceae Rosaceae Rutaceae Salicaceae Salvadoraceae Sapindaceae Sapotaceae Simmondsiaceae Solanaceae Sterculiaceae Zygophyllacea

13 common examples are shown overleaf

Some common non-food oil producing species are :-

- Panicum virgatum; Switchgrass; Australia
- Ximenia americana; Yellow Plum or Sea Lemon; Australia
- Pongamia pinnata; Karanja oil, Honge oil; Australia
- Calophyllum elatum; Teitai tree
- Sesbania bispinosa; prickly sesban tree
- Jatropha gossypifolia; Bellyache bush; Australia
- Jatropha curcas; Purging Nut tree
- Ricinus commulis; Castor Oil tree; weed in Australia
- Brassica juncea; Mustard greens
- Camelina sativa; Wild Flax
- Cynara cardunculus; artichoke thistle; weed in Australia
- Livistona mariae; Central Australian Cabbage Palm
- Salicornia bigelovii; sea asparagus; salt-tolerant

Panicum virgatum; Switchgrass; Australia

Ximenia americana; Yellow Plum or Sea Lemon; Australia

Pongamia pinnata; Karanja oil, Honge oil; Australia

Calophyllum elatum; Teitai tree

Sesbania bispinosa; prickly sesban

Jatropha gossypifolia; Bellyache bush; Australia

Jatropha curcas; Purging Nut tree; tropical

Ricinus commulis; Castor Oil tree; weed in Australia

(weed in Australia; exotic plant in Europe)

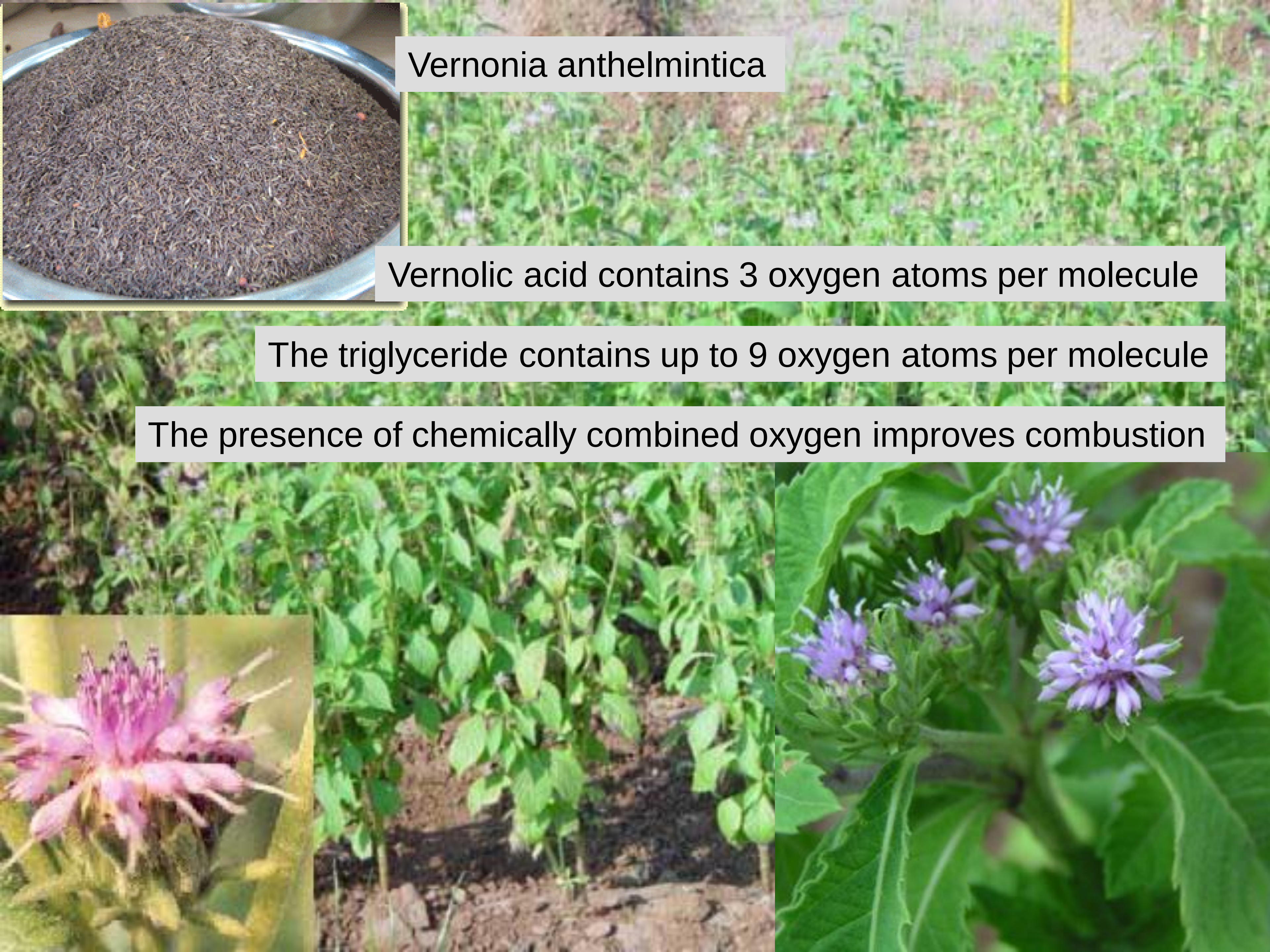
Brassica juncea; Mustard greens

Camelina sativa; Wild Flax

Cynara cardunculus; artichoke thistle; Australia

Livistona mariae; Central Australian Cabbage Palm

Salicornia bigelovii; sea asparagus; salt-tolerant


Vernonia anthelmintica
Vernolic acid contains 3 oxygen atoms per molecule
The triglyceride contains up to 9 oxygen atoms per molecule
The presence of chemically combined oxygen improves combustion

ASSESSMENT OF THE VIABILITY OF VEGETABLE OIL BASED FUELS

SOME SLIDES SHOWING :-

VISCOSITY DIFFERENCES

BLOCKED FILTER CONTENTS

INJECTOR COMPONENTS

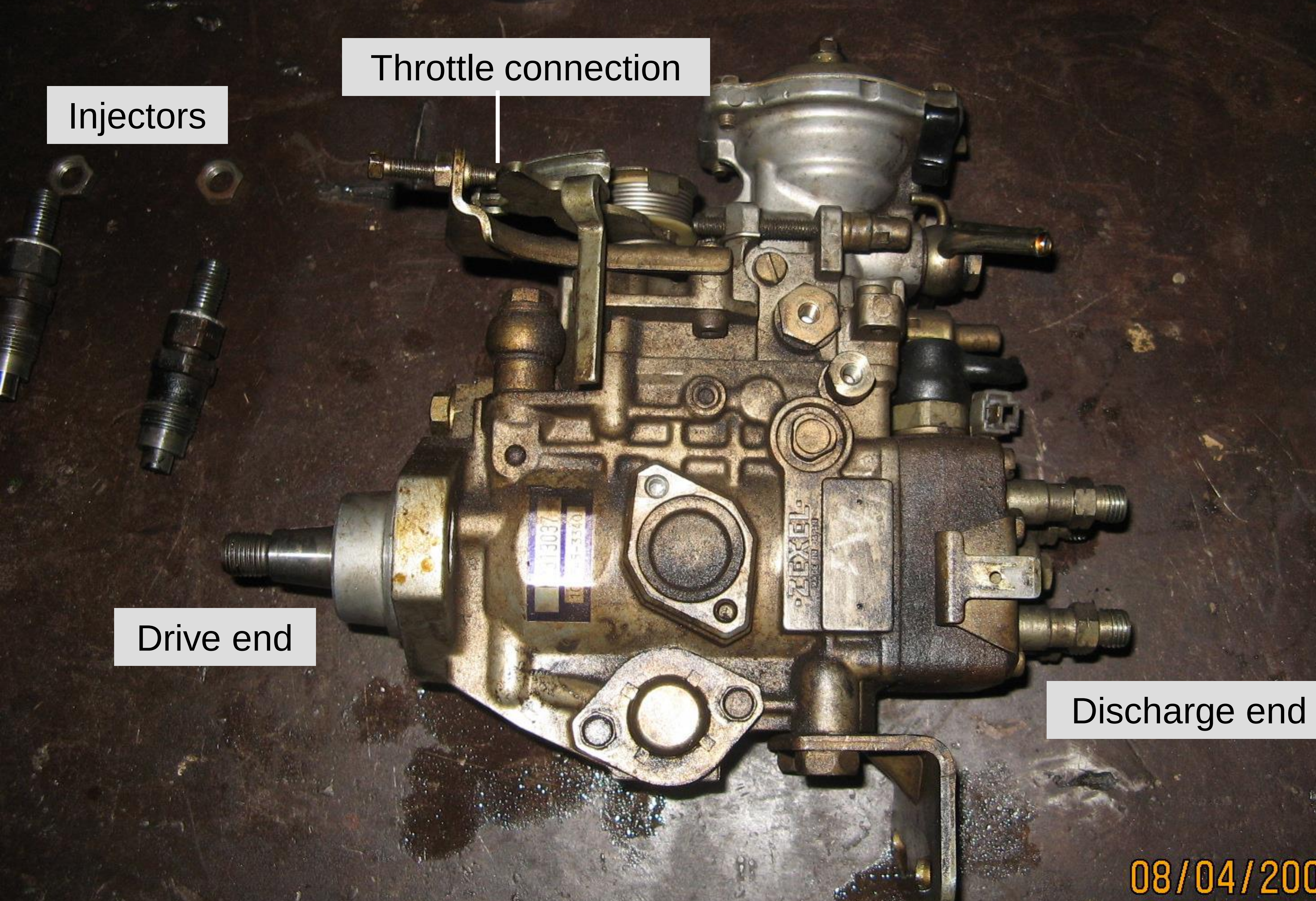
THE EFFECT OF INJECTION PRESSURE ON SPRAY PATTERN

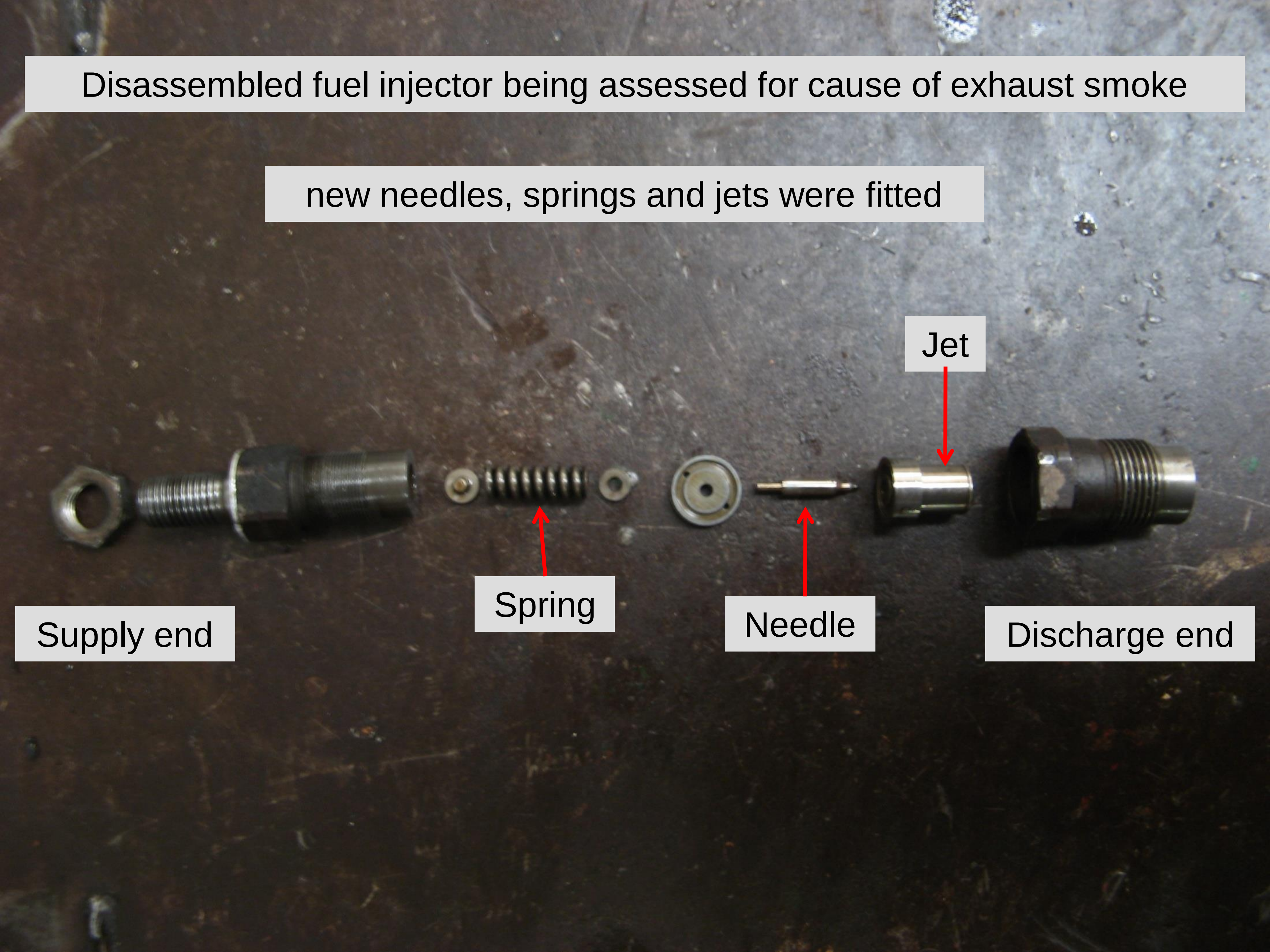

Preparing a fuel blend
Waste vegetable oil
Laminar flow and very slow
Viscosity eg peanut oil = 42 cP @ 38°C
28/10/2009

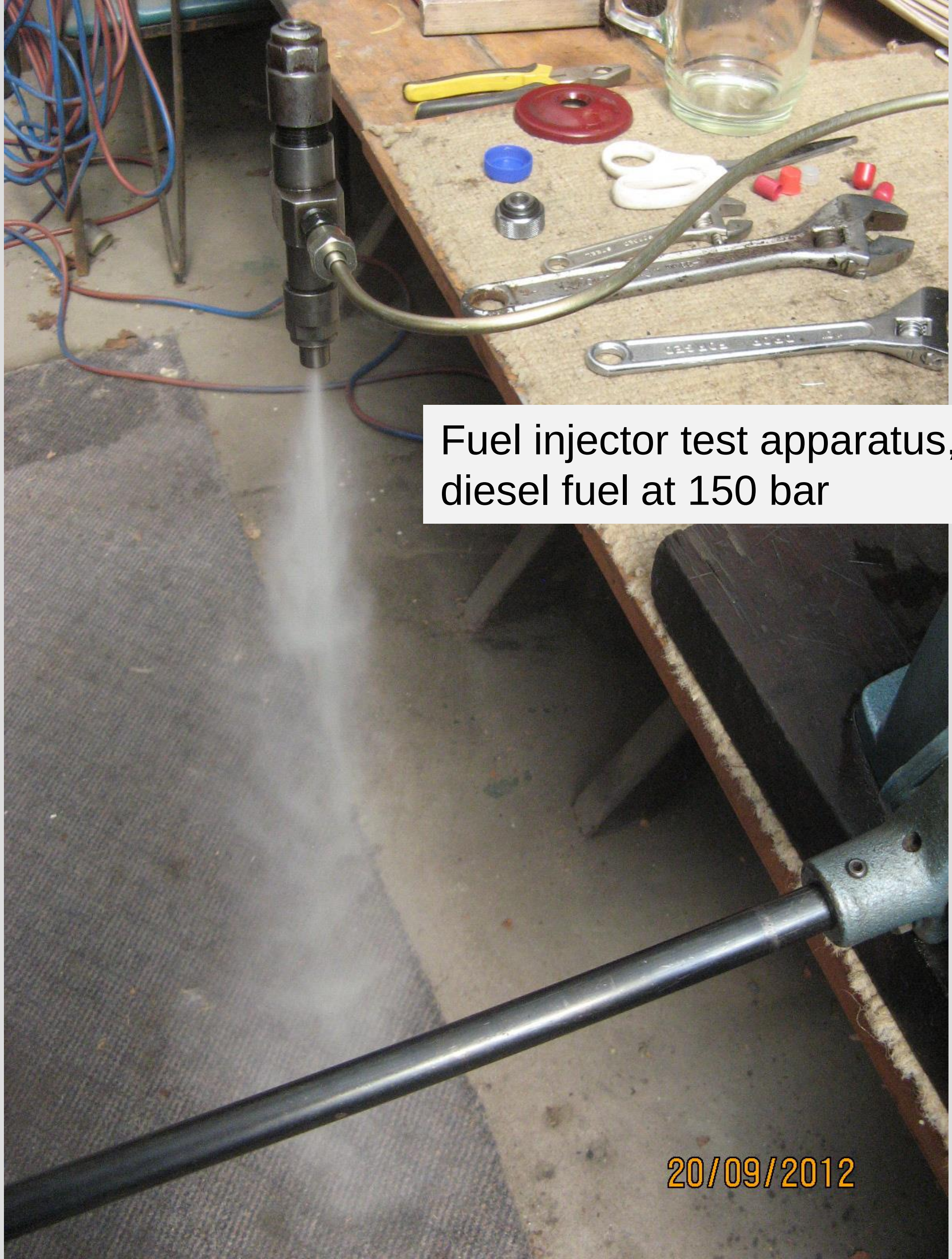

Preparing a fuel blend
Diesel fuel
Turbulent and fast
Viscosity eg Diesel fuel 3D = 12 cP @ 38°C


Typical filter sludge
Fuel filter
Sludge is mostly solid oils and fats
09/05/2009

The Zexel 500 MPa fuel injector pump removed to assess blockage




Disassembled fuel injector being assessed for cause of exhaust smoke
new needles, springs and jets were fitted
Jet
Spring
Needle
Supply end
Discharge end



Fuel injector test apparatus, diesel fuel at 150 bar

Fuel injector test apparatus, vegetable oil at 350 bar