Evaluation of PM Emissions of a Diesel Engine Fueled with Waste Cooking Oil Biodiesel: A Systematic Review

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Objective and PICO Statement

OBJECTIVE

Application of the Navigation Guide Systematic Review Methodology developed by Johnson et al. to answer the study question: ***Does the replacement of petroleum diesel for waste cooking oil biodiesel reduce hazardous PM emissions?***

PICO STATEMENT

Population – Heavy duty petroleum diesel engines.

Intervention – Waste Cooking Oil (WCO) Biodiesel.

Experimental intervention studies were selected that used a 20% WCO-biodiesel blend in replacement on standard petroleum diesel in 6-cylinder heavy-duty compression ignition engines under similar experimental conditions.

Comparator – Petroleum Diesel

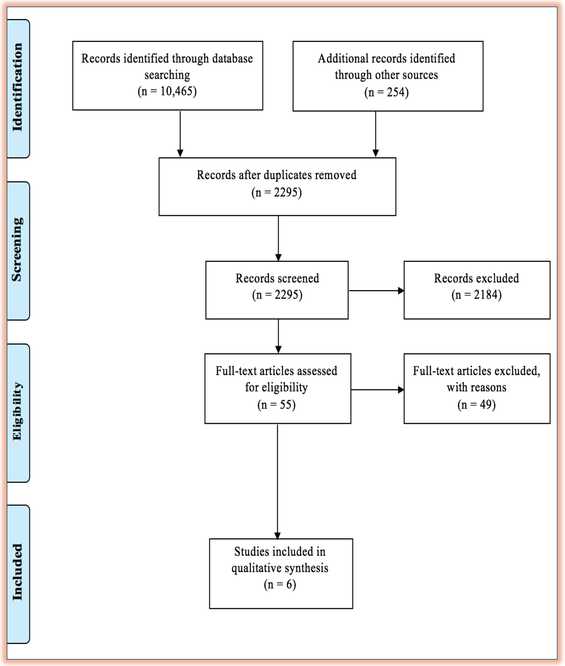
Outcome – PM emission levels. A quantitative analysis including the percentage of PM emitted was recorded in each study.

Search Strategy and Study Selection

PICO statement used as a guide to coin terms and synonyms addressing the intervention and outcome of interest.

The data sources primarily utilized were **ScienceDirect** and **Scopus** between 20th September and 3rd October 2017. Search was limited to studies written in English and published after 2010. Additional exclusion criteria included:

- Study did not contain original data and observations.
- Failure to mention 20% blend ratio and PM emission observance in title/abstract.
- Engines were not tested under the same experimental conditions.



Methods

The Navigation Guide is an environmental health sciences review methodology tool used to evaluate and support evidence-based health and policy recommendations. The use of this guide required that each of the selected studies was reviewed and rated based on the investigations of the associations between PM emissions and the use of petroleum diesel versus WCO-biodiesel.

Evaluation of individual studies and across the body of studies took place to determine if and what risk of bias may have occurred during completion of the study. Risk of bias domains included:

- Recruitment strategy
- Use of blinding
- Confounding variables
- Exposure assessment
- Selective outcome reporting
- Possible conflict of interest.

The rating scale utilized was "low risk", "probably low risk", "probably high risk", "high risk" and "not applicable". The quality of evidence, rated as 'high', 'moderate', or 'low', was determined after assessment of the risk domains.

Results and Conclusion

Across the six studies identified and assessed, there was an overall PM emission reduction of **28%** when petroleum diesel was substituted for WCO-biodiesel. The overall risk of bias was determined to be **'low'.**

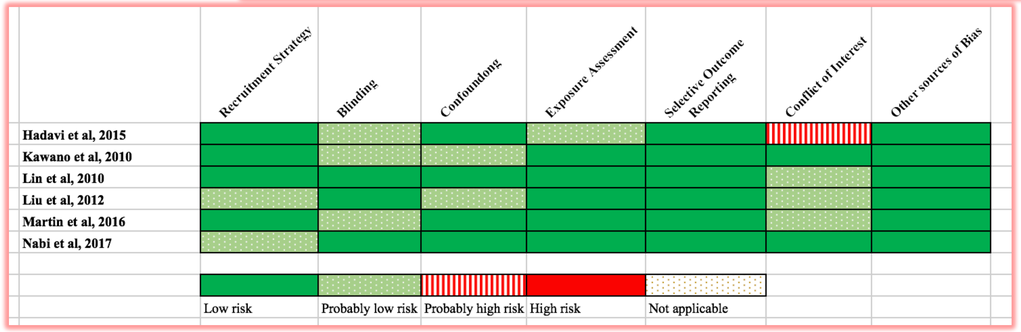
CONCLUSION

Based on the application of the Navigation Guide methodology, it was determined that:

- ***The overall quality of evidence was 'high'.***
- ***The overall strength of the evidence provided was 'sufficient'.***

This would suggest that there is an association between WCO-biodiesel and PM emission reductions.

Source	Location of Study	Major Results
Hadavi et al, 2015	Ashby, UK	**69.5%** reduction in $PM_{2.5}$ emissions from petroleum diesel (1.77 mg/m^3) to C2G ultra biofuel (0.53 mg/m^3)
Kawano et al, 2010	Kyoto, Japan	**19.2%** average reduction in PM emissions from petroleum diesel (0.026 g/kWh) to WCO-biodiesel (0.021 g/kWh)
Lin et al, 2010	Kaohsiung, Taiwan	**7.4%** reduction in PM emissions from petroleum diesel (0.229 g BHP^{-1} h^{-1}) to WCO-biodiesel (0.212 g BHP^{-1} h^{-1})
Liu et al, 2012	Kaohsiung, Taiwan	**15.5%** reduction in PM emissions from petroleum diesel (0.103 g BHP^{-1} h^{-1}) to WCO-biodiesel (0.087 g BHP^{-1} h^{-1})
Martin et al, 2016	Keene, New Hampshire, USA	**8.6%** reduction in $PM_{2.5}$ emissions from petroleum diesel (58 ug/m^3) to WG-biodiesel (53ug/m^3)
Nabi et al, 2017	Perth, Australia	**47%** average PM reduction from petroleum diesel to WCO-biodiesel across different speeds and loads.



Discussion

Diesel engines are one of the largest sources of PM emissions, contributing to adverse effects seen in the environment and to human health including; chronic and acute cardiopulmonary health risks like lung and cardiovascular inflammation, exacerbation of asthma and development of lung cancer.

The potential scope of influence for switching to a cleaner burning fuel source is a major consideration for implementation of this biodiesel. There have been growing global environmental concerns regarding the depletion of natural petroleum crude oil resources and the associated greenhouse gas emissions with high petroleum usage. Petroleum oil accounts for 40% of the total energy usage in the United States, with diesel constituting 21% of the petroleum consumed in the U.S. transportation sector. Additionally, using WCO is an attractive sustainable solution, as it can be locally sourced more easily and contribute to a large reduction in waste production. Hotels and restaurants in the U.S. alone generate up to 3 billion gallons of WCO a year.

Feasibility and life-cycle assessments should be further conducted to cover gaps in knowledge and to aid in determining whether mass production, distribution and collection of this form of biodiesel can be transitioned to over the discernable future.

References

Agarwal, Avinash Kumar. 2015. dx.doi.org/10.1016/j.enconman.2014.12.094
Balshem, H. 2011. PMID: 21208779
Bhalla, Kavi. 2014. ISBN: 978-0-9894752-9-7
Hadavi, S. 2015. dx.doi.org/10.4271/2015-01-0905
Johnson, Pl. 2014. PMID: 24968389
Kawano, D. 2010. DOI: 10.4271/2010-01-2276
Lin, Yuan-Chung. 2010. DOI: 10.1016/j.energy.2010.10.045
Liu, Shou-Heng. 2012. DOI: 10.4209/aaqr.2011.09.0144
Martin, Nathan. 2016. dx.doi.org/10.1016/j.scitotenv.2016.12.041
Nabi, Nurun. 2017. dx.doi.org/10.1016/j.jclepro.2017.08.096
Pope, C. Arden. 2009. DOI: 10.1056/NEJMsa0805646
Reşitoğlu I, Altinişik K, Keskin A. 2014. The Pollutant Emissions from Diesel-Engine Vehicles and Exhaust Aftertreatment Systems. Clean Technologies and Environmental Policy 17: 15-27.
U.S. EIA (Energy Information Administration). 2016a. U.S. Energy Facts Explained. Available: https://www.eia.gov/energyexplained/?page=us_energy_home
U.S. EIA (Energy Information Administration). 2016b. Learn About Biodiesel. Available: http://www3.epa.gov/region9/waste/biodiesel/questions.html
U.S. EIA (Energy Information Administration). 2017a. Petroleum Consumption: Transportation and Electric Power Sectors. Available: https://www.eia.gov/totalenergy/data/monthly/index.php#petroleum
U.S. EIA (Energy Information Administration). 2017b. Diesel Fuel Explained. Available: https://www.eia.gov/energyexplained/index.cfm?page=diesel_use
U.S. EPA (Environmental Protection Agency). 2002. Health Assessment Document for Diesel Engine Exhaust.
U.S. EPA (Environmental Protection Agency). 2012. Air Quality Communication Workshop. Available: http://www.epa.gov/sites/production/files/2014-05/documents/huff-particle.pdf

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