Vehicular motor emissions research: Systematic review of emerging trends and research landscape from 2007 to 2021

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Abstract The growing spate of greenhouse gas and pollutant emissions from gasoline and diesel vehicles (termed vehicular motor emissions, VME) has raised concerns about their impacts on human health and the environment. VME research has also provided insights into the transportation sector's impact on global warming and climate change. According to the Scopus database, VME research has produced over 60,000 documents. Given the significant data, conducting a systematic review of the published documents is imperative to present current and future researchers with critical information and a comprehensive understanding of research developments and scientific growth in the field. Therefore, this paper systematically reviews the publication trends, significant stakeholders, emerging developments, and research landscape on VME from 2007 to 2021 using Scopus data. The results showed that the number of published documents on VME research increased from 159 in 2007 to 551 in 2021, indicating an enormous 246.54% increase over the last 15 years. The field's most preferred document type and journal sources are "articles" (62.2%) and SAE Technical Papers. The field's most prominent researcher is Ye Wu, with 53 documents, whereas Tsinghua University is the most prolific affiliation. The analysis of the emerging developments and research landscape on VME examined by systematic literature review showed that VMEs comprise nano/ultrafine particulate matter (PM), oxides of carbon (COx), nitrogen (NOx), sulphur (SOx), secondary organic aerosols (SOA), and polyaromatic hydrocarbons (PAH), among others. Hence, studies have recommended designing, developing, and deploying control systems (comprising oxidation catalysts, particulate filters, and selective catalytic reduction), innovative technologies, and sustainable strategies to mitigate VMEs worldwide.

Keywords: systematic literature review, particulate matter, greenhouse gases, climate change, global warming

1. Introduction

Transportation is defined as the movement of people, goods, and services to and from various locations (Christiansen, 1979; Dinu, 2018). Consequently, it is considered an important driver of socioeconomic growth, infrastructural development, and the global economy (Delmelle & Casas, 2012; Short & Kopp, 2005). However, the transportation sector is a significant emitter of greenhouse gases and pollutant emissions annually (Li et al., 2016; Li & Tang, 2017). It is estimated that the transportation sector accounts for 16.2% of all greenhouse gases and secondary emissions generated globally from aviation, shipping, rail, pipelines, and road transport. Currently, it is projected that aviation is responsible for 1.9% of all GHG emissions generated, which primarily emanate from passenger travel and freight on both domestic and international levels (Ritchie, 2020b). The shipping or maritime sector accounts for 1.7% of all GHG emissions resulting from the combustion of fossil-based fuels on boats, canoes, ships, and other water vessels. Although low, the rail sector generates 0.4% of all GHG emissions, whereas pipeline transport emits 0.3%. On the other hand, road transportation accounts for 11.9% of all GHGs, which are generated from the burning emissions of petrol and diesel vehicles such as buses, cars, lorries, trucks, and motorcycles (Ritchie, 2020a; Ritchie, 2022).

The reported data show that the road transport sector is the largest transportation-based emitter of GHG gases. In view of this, there are growing calls to reduce or mitigate emissions from the sector, particularly with regard to the burning of fossil fuels such as gasoline and diesel in road vehicles. Hence, various sustainable, innovative, technological, and policy solutions to address the challenges posed by transport-based GHG emissions have been identified and proposed. For example, there are growing calls for the sustainable transition from fossil fuels to electrified road transport to decarbonize the sector and mitigate emissions (Ahmadi, 2019; Li et al., 2021). Likewise, the decarbonization of the transportation sector will also enhance human health, occupational safety, and environmental sustainability through the reduction or elimination of VMEs.
of GHG emissions. Various studies have reported that vehicular motor emissions (VME) generated from gasoline and diesel-operated vehicles consist of various toxic substances ranging from oxides of carbon, nitrogen, and sulphur to secondary organic aerosols (SOA), organic carbon emissions, polyaromatic hydrocarbons (PAHs), nanoparticles/ultrafine nanoparticles, and particulate matter (PM), among others (Adamiec et al., 2016; Greenblatt & Saxena, 2015; Jabali et al., 2012; Mohr et al., 2009; Morawska et al., 2008; Westerdahl et al., 2009). According to Gentner et al. (2012), gasoline and diesel-powered motor vehicles are primarily anthropogenic, reactive, and gas-phase organic carbon as well as precursors to SOAs. Adamiec et al. (2016) detected the presence of heavy metals (HMs) in vehicular motor emissions sampled from road dust on urban and motorways. The results showed that the significant sources of VMEs are emitted from tire, brake, and clutch wear, as well as road surface wear and road component breakdown. The detailed characterization of the selected road dust samples showed the presence of the HMs Ba, Cd, Cr, Cu, Fe, Ni, Pb, Pd, Se, Sr, Ti, and Zn. Overall, the study showed that urban dust samples contained higher concentrations of HM contaminants when compared to dust samples from motorways. Anenberg et al. (2017) examined the impacts and mitigation of excess diesel-related NOx emissions and found that VMEs are responsible for fine particulate matter and tropospheric ozone air pollution, which impacts human health and safety along with agricultural productivity and global climate. In addition, the authors reported that 20% of global anthropogenic emissions of nitrogen oxides (NOx – the major precursors of PM 2.5 and ozone destruction) are derived from on-road diesel vehicles (Anenberg et al., 2017).

To address these challenges, several innovative and technological solutions have been proposed over the years. For example, Samaras and Meisterling (2008) proposed the design, development, and deployment of PHEVs. According to the authors, the proposed technology will employ not only sustainable or low carbon electricity grids to power transportation but also lower GHG emissions from the sector. Similarly, Saber and Venayagamoorthy (2010) proposed grid-able vehicles (GVs), also termed vehicle-to-grid (V2G) technology, as a practical approach to reducing GHG emissions and operational costs. In a separate study, Saber and Venayagamoorthy (2011) proposed that the use of plug-in vehicles such as PHEVs and vehicle-to-grid enabled EVs, or grid-able vehicles (GVs), could lower vehicular motor emissions. However, Franco et al. (2013) observed that a crucial step in reducing or mitigating vehicular motor emissions (VMEs) involves precisely estimating the magnitude of pollutant emissions, which is also needed to effectively design and efficiently implement air quality plans. Likewise, Reiştoolu et al. (2015) opined that the adoption and implementation of control systems for exhaust pollutant emissions as well as after treatment emission control technologies could be a panacea for the problems associated with diesel-based VMEs.

On the policy side, various nations have promulgated laws, guidelines, and policies to detect, reduce or mitigate VMEs over the years. Wu et al. (2017) reported that the geometric increase in the on-road vehicle fleet in China over the last quarter of a century aggravated the state of VMEs in the country. As a result, the authorities proposed and implemented several integrated emission policies and control measures, such as new vehicle emission standards, in-use vehicle inspection/maintenance programs, and fuel quality enhancements. Other strategies proposed over the years include sustainable transportation, traffic management, and alternative fuel vehicles (Wu et al., 2017). According to the authors, such controls could reduce VMEs such as CO, HC, NOx, and PM2.5 by ~ 57 - 84% by the year 2030. Likewise, Anenberg et al. (2017) called for the adoption and enforcement of next-generation standards in a bid to reduce or eliminate NOx emissions. The authors predicted that such measures could prevent ~ 174,000 global PM 2.5 and ozone-related premature deaths by the year 2040.

Furthermore, the review of literature on VME research in the Elsevier Scopus database overwhelmingly shows that over 61,675 document results are based on the TITLE-ABS-KEY search criteria. Although a large number of published documents indicate high research interest, they also present challenges for new and established researchers working in the field. Therefore, this paper seeks to present a systematic review of the emerging trends and research landscape of Vehicular Motor Emissions (VME) research based on data published documents in the Scopus database over the 15-period from 2007 to 2021. Furthermore, the findings will present the general publication trends, major contributors, benchmark publications and developments in the field. It is envisaged that the findings will avail researchers and scientists in academia, industry and policy circles with comprehensive information and understanding of the field.

2. Materials and Methods

The objective of the study was to identify and examine the emerging trends and research landscape of Vehicular Motor Emissions (VME) research between 2007 and 2021. Hence, the PRISMA technique was adopted and implemented to identify, screen, and analyze the emerging trends using published documents (Moher et al. 1996; Armenise et al. 2021) on VME research studies from the Elsevier Scopus database. To accomplish this, the search query ((TITLE ("vehicle*" OR "motor" OR "automobile" AND "emission*")) AND PUBYEAR > 2006 AND PUBYEAR < 2022)) was developed and implemented in the Scopus database to identify related documents on VME research.

The search query recovered 4,691 published documents, which were subsequently analyzed to examine the publication trends, top authors, and affiliations, as well as the primary funding organizations and national governments around the globe. Furthermore, the recovered data from Scopus were analyzed to examine the research landscape and
scholarly developments in VME research during the timeframe examined in the study. Finally, a systematic literature review was carried out to highlight technological developments in the field of VME research globally.

3. Results and Discussion

3.1. General Publication Trends

Figure 1 shows the trajectory of publications on VME research from 2007 to 2021. As observed, the trend showed that the number of publications on VME research increased from 159 to 551 between 2007 and 2021, which indicates an enormous increase of 246.54% over the time frame. Analysis on a 5-year basis showed that the number of published documents on VME increased from 159 to 258 between 2007 and 2011, although from 2012 to 2016, the growth plateaued (i.e., 286 to 299, which is a < 5% increase). However, the number of published documents experienced another upward trend from 324 to 551 between 2017 and 2021.

Overall, the high number and percentage increase in published documents on VME research show that scientific interest and research impact on the field has soared geometrically over the time frame examined in the study. The distribution of document types for the published documents on VME research was also examined to elucidate the preferences and reasons for the observed trends. As observed, the most preferred formats for the publication of findings on VME research are articles, conference papers, notes, reviews, and book chapters, which collectively account for 99.1% of the total publications on VME research. Further analysis showed that articles account for the most significant number of published documents, which is 62.2% (or 2916 publications), closely followed by conference papers (29.5%) and notes (4.0%), as depicted in Figure 2.
The preference for articles (62.2% or 2916 publications) stems from the fact that this publication format is considered the oldest and most common medium of communicating scientific discoveries in the world. Likewise, the preference for articles may be mainly due to the academic prestige and scholarly reputation of this form of publication (Otitolaiye et al., 2022). Numerous studies have also reported that the publication of articles or reviews in highly respected publications or so-called high-impact journals could result in career advancement, financial rewards, monetary incentives, scientific awards and recognition among peers worldwide (Backes-Gellner & Schlinghoff, 2004; Franzoni et al., 2011; Lee & Simon, 2018; Otitolaiye & Abd Aziz, 2023). To further examine this assertion, the documents per year by source were examined, as shown in Figure 3.

Figure 3 Journal sources for published documents on VME research (2007-2021).

The most common journals or sources for VME publications are SAE Technical Papers, Federal Register, Atmospheric Environment, Environmental Science & Technology, and Transportation Research Part D Transport & Environment. Further analysis showed that these journal sources collectively account for 1058 publications or 22.55% of the total publications on VME research. Hence, it could be reasonably surmised that the journals are the top sources of published documents in the field. Due to their reputation, the journals are typically used by the top researchers and organizations actively participating in the field. Section 3. II will highlight the significant contributors to research in VME research and examine their impact on progress in this research field.

3.2. Major Contributions

The analysis of the significant research contributors (comprising authors/researchers, affiliations/institutions, funding organizations, and countries) is critical to evaluating the research landscape on any given topic in the scientific literature (Otitolaiye & Abd Aziz, 2023; Wang & Hong, 2020). Likewise, it presents insights into the research impact of the network of active contributors/tions on the field over a given timeframe (Donthu et al., 2021; Durieux & Gevenois, 2010). In this study, the top 5 most prolific researchers on VME research were deduced from the Scopus database from 2007 to 2021, as depicted in Figure 4.

Figure 4 Top 5 most prolific researchers on VME Research (2007-2021).
As observed, the most prolific researcher in the field is Ye Wu, who has 53 published documents or the equivalent of 1.13% of the total publications on VME research over the timeframe under examination. Next in line among the most prolific researchers are Christopher H. Frey and Georgios Karavalakis, who account for 50 and 46 publications, respectively. Further analysis shows that the top 5 most prolific researchers in the field have published 221 (or 4.71% of TP).

The productivity of these researchers could be attributed to various factors, including but not limited to affiliation/institution support, financial availability, and technical/scientific resources, among others. Figure 5 shows the top 5 most prolific research institutions on VME research between 2007 and 2021. As observed, Tsinghua University (China) is the most prolific affiliation with 159 published documents, which is closely followed by the Beijing Institute of Technology (China) and European Commission Joint Research Centre (European Union), which have 78 and 77 publications, respectively. Other notable research-active institutions are the Chinese Academy of Sciences and the Chinese Research Academy of Environmental Sciences, with 72 and 67 published documents, respectively.

![Figure 5 Top 5 most prolific research institutions on VME Research (2007-2021).]

The findings show that China is a leading country in VME research, which could be due to the nation’s bid to reduce greenhouse gas (GHG) emissions from the transportation sector. Globally, the sector accounts for over 16% of all related GHG emissions into the environment worldwide (COP21, 2015; Rhodes, 2016; Robbins, 2016). In response to the threats posed by GHGs, over 190 nations, including China, pledged to reduce emissions from 50 billion tonnes to zero by the year 2050. The so-called Paris Accords or the Paris Climate Accords are also aimed at reducing dependence on fossil-based fuels and related emissions as well as limiting global warming to below 1.5 °C (UNFCCC 2022). As a result, nations such as China have allocated significant resources in the form of grants, incentives, and research funding for the citizenry, academia, industry, and government sectors to achieve the objectives of lowering emissions.

For example, the National Natural Science Foundation of China has a budget allocation of over US$4 billion for research annually, which supports low carbon, high efficiency, and climate-friendly research in the country (NSFC, 2022). To examine the impact of research funding on VME research, the top funding organizations in the field were deduced from the Scopus database. Figure 6 shows the top 5 most active research funding organizations on VME research worldwide.

![Figure 6 Top 5 funding organizations on VME Research (2007-2021).]
As observed, the top funder of VME research is the National Natural Science Foundation of China (NSFC), with over 350 published documents. The lead of the NSFC is followed by the National Science Foundation (80), the National Key Research and Development Program of China (74), the European Commission (65) and the Ministry of Science and Technology of the People's Republic of China (65). The findings confirm that China is a leading funder of research and development in the area of VME, which accounts for the high productivity of researchers such as Ye Wu (the most published researcher on VME see Figure 4) based at Tsinghua University (Beijing, China) and Lei Yu (among the top 5 most published researchers on VME see Figure 4) of Beijing Jiaotong University (Beijing, China). The findings again show the dominance of Chinese-based researchers and institutions in the field. However, on a national or country-based level, the United States leads the group of the top 5 most active nations in VME research globally. Figure 7 shows the top 5 most active countries on VME research between 2007 and 2021.

![Figure 7](image)

**Figure 7** Top 5 most active countries on VME Research (2007-2021).

The US's lead is closely followed by China, the United Kingdom, Germany, and Italy in decreasing order. The top 10 countries (which includes Japan, India, Poland, South Korea, and Canada) account for 3667 published documents or 78.17% of the total publications on VME research. Further analysis shows that the top 10 nations are the most industrialized nations of the world and hence significant signatories to the Paris Accords ratified in 2015. Based on the accord, nations have made concrete steps to accomplish the objectives through investments in scientific research, emissions reduction/mitigation technologies, social awareness, and environmental sustainability initiatives. The results have numerous publications, citations, patents, and technologies, among others. Section 3III presents an overview of the benchmark publications in the area that can serve as the yardstick for analyzing research growth and scientific developments in the area of VME research over the timeframe from 2007 to 2021.

3.3. Benchmark Publications

The top-cited publications in any given area present critical insights into research growth and scientific developments in the area over time (Aslam-Pervez & Lubek, 2018; Ho, 2013). In this study, the benchmark papers were selected based on the number of citations accruing by each published document. Table 1 presents the top 10 publications of VME research between 2007 and 2021. The results show that the top 10 most cited publications have accumulated citations ranging from 278 to 639 (or 387.6 on average) with a total of 3876 citations over time. The most cited publication is "Plug-in vehicles and renewable energy sources for cost and emission reductions" by Saber and Venayagamoorthy (2011). According to the data in the Scopus database, the paper published in the journal "IEEE Transactions on Industrial Electronics" has gained 639 citations over the years.

The second most cited publication is "Life cycle assessment of greenhouse gas emissions from plug-in hybrid vehicles: Implications for policy" Samaras and Meisterling (2008) published in the journal "Environmental Science and Technology" (EST) with 527 citations. As previously reported, the EST journal is among the top 5 most essential journal sources for publications on VME research, as illustrated in Figure 3. In addition, it was observed that the journal "Atmospheric Environment" has published two out of the top 10 most cited publications: "Ambient nano and ultrafine particles from motor vehicle emissions: Characteristics, ambient processing, and implications on human exposure" Morawska et al. (2008) and "Road vehicle emission factors development: A review" by Franco et al. (2013). The two studies have been cited a total of 773 times over the years from 2007 to 2021. Overall, the findings reveal that the area of VME has a high rate and number of citations, which indicates high scientific interest and research impact.

https://www.malque.pub/ojs/index.php/mr
3.4. Systematic Literature Review

The systematic review of literature is also another crucial technique for analyzing scientific growth and technological developments in any field (Otitolaiye et al., 2023; Paschou et al., 2020). Based on the PRISMA technique, the top publications over 200 and above were selected for literature analysis. Table 2 presents a systematic overview of the review of critical literature on VME research from 2007 to 2021.

<table>
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<tr>
<th>References</th>
<th>Title</th>
<th>Journal</th>
<th>Findings</th>
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<tbody>
<tr>
<td>Samaras and Meisterling (2008)</td>
<td>Life cycle assessment of greenhouse gas emissions from plug-in hybrid vehicles: Implications for policy</td>
<td>Environmental Science and Technology</td>
<td>The study showed that the reduction of GHG emissions from the transport sector could be enhanced by the adoption of plug-in hybrid electric vehicles (PHEVs). However, this is contingent on the availability and accessibility of low-carbon electricity. The study also showed that PHEVs reduce GHG emissions by 32% compared to conventional vehicles based on life cycle analysis.</td>
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<td>Mohr et al. (2009)</td>
<td>Characterization of primary organic aerosol emissions from meat cooking, trash burning, and motor vehicles with high-resolution aerosol mass spectrometry and comparison with ambient and chamber observations</td>
<td>Environmental Science and Technology</td>
<td>The study examined the emission of organic aerosol (OA) from motor vehicles using high-resolution aerosol mass spectrometry. The findings showed that the aerosols emitted by combustion engines and plastic burning are primarily characterized by hydrocarbon-based organic compounds.</td>
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<td>Saber and Venayagamoorthy (2010)</td>
<td>Intelligent unit commitment with vehicle-to-grid -A cost-emission optimization</td>
<td>Journal of Power Sources</td>
<td>The study showed that vehicle-to-grid (V2G) technologies could help humanity reduce dependency on existing fossil fuel-based power systems. The V2Gs could also result in lower operational costs and vehicular emissions while enhancing the reserves and reliability of the current power infrastructure.</td>
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<td>Otitolaiye et al. (2023)</td>
<td>Scenario analysis of alternative fuel/vehicle for China’s future road</td>
<td>Energy Policy</td>
<td>The authors reported that the rapid vehicular use in China had not stemmed the demand for fossil fuels in the country. In the developed model was used to examine the historical and future trends. The best-case scenario could reduce ED and GHG emissions.</td>
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<td>Saber and Venayagamoorthy (2011)</td>
<td>Plug-in vehicles and renewable energy sources for cost and emission reductions</td>
<td>IEEE Transactions on Industrial Electronics</td>
<td>The study revealed that electricity and transportation are the major causes of GHG emissions. Renewable energy technologies such as plug-in hybrid electric vehicles (EVs) and EVs with vehicle-to-grid capability, referred to as gridable vehicles (GVs), can reduce emissions from the transportation industry.</td>
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<td>Gentner et al. (2012)</td>
<td>Elucidating secondary organic aerosol from diesel and gasoline vehicles through detailed characterization of organic carbon emissions</td>
<td>Proceedings of the National Academy of Sciences of the United States of America</td>
<td>The study showed that the emission of pollutants from the utilization of gasoline and diesel in vehicles are significant sources of anthropogenic pollutants. The most notable class include reactive gas-phase organic carbon as well as other crucial precursors to secondary organic aerosol (SOA) in cities and towns. The authors observed that aerosol formation remains an integral part of air quality control policy and public health. The findings also showed that diesel accounts for 65% - 90% of vehicular-derived SOA, along with significant contributions from aromatic and aliphatic hydrocarbons. The study showed that critical information on emissions from vehicles could enhance fuel regulations, pollution control policies, and methodologies for addressing emissions challenges in many regions.</td>
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<td>Franco et al. (2013)</td>
<td>Road vehicle emission factors development: A review</td>
<td>Atmospheric Environment</td>
<td>The authors showed that pollutant emissions require proper quantification to back up strategies for air quality control. Hence, the concept of emission factors (EFs) was proposed to assess the empirical functional links between activity and pollutant emissions. Furthermore, various techniques for measuring road vehicle emissions were examined based on EFs existing in emission models typically adopted to create emission inventories.</td>
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<td>Reşitoğlu et al. (2015)</td>
<td>The pollutant emissions from diesel-engine vehicles and exhaust aftertreatment systems</td>
<td>Clean Technologies and Environmental Policy</td>
<td>The study showed that the four main pollutant emissions from diesel engines (carbon monoxide, hydrocarbons, particulate matter, and nitrogen oxides). However, the emissions are typically reduced or mitigated using various control systems that consist of oxidation catalyst, particulate filter, and selective catalytic reduction. Last, the authors revealed that the regulation of exhaust-gas emissions can be enhanced by the introduction and implementation of legal restrictions as well as human health, safety, and environment.</td>
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<td>Dunn et al. (2015)</td>
<td>The significance of Li-ion batteries in electric vehicle life-cycle energy and emissions and recycling’s role in its reduction</td>
<td>Energy and Environmental Science</td>
<td>The findings showed that electric vehicles (EV) enhance energy and environmental performance when compared to internal combustion-engine vehicles (ICV). On the whole, EVs consume less petroleum and emit fewer greenhouse gases (GHG) than an ICV on a life-cycle basis. However, the emissions of SOx was found to be four times higher for EVs when compared to ICVs.</td>
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<td>Adamiec et al. (2016)</td>
<td>Heavy metals from nonexhaust vehicle emissions in urban and motorway road dusts</td>
<td>Environmental Monitoring and Assessment</td>
<td>The findings showed that the finest dust fractions of urban and motorway are significantly contaminated with Ti, Cu, and Cr, which are considered the major tracers of nonexhaust brake wear. It was also observed that urban dust is more contaminated than the motorway variant. The study concluded that road dust is largely contaminated by brake lining and tire wear from vehicular use worldwide.</td>
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<td>Wu et al. (2017)</td>
<td>On-road vehicle emissions and their control in China: A review and outlook</td>
<td>Science of the Total Environment</td>
<td>The findings showed that there has been a 26-fold increase in vehicular traffic over the last over the past 25 years in China, which has increased concerns about issues such as air pollution prevention and climate change. Hence, numerous integrated emission technologies and control policy measures have proposed since the 1990s. For example, China including implementation of emission standards for new vehicles, inspection and maintenance programs for in-use vehicles, fuel...</td>
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Anenberg et al. (2017) | Impacts and mitigation of excess diesel-related NOx emissions in 11 major vehicle markets | Nature |
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Moro and Lenza (2018) | Electricity carbon intensity in European Member States: Impacts on GHG emissions of electric vehicles | Transportation Research Part D: Transport and Environment |

4. Final considerations

This paper presented a systematic review of the emerging trends and research landscape on vehicular motor emissions (VME) from 2007 to 2021. The publication trends showed that the number of published documents on VME research increased progressively from 159 to 551 over the time frame examined in the paper. This observation reveals that scientific interest in the field has soared geometrically. The high output could be attributed to the significant efforts of selected researchers, such as Ye Wu, Christopher H. Frey, and Georgios Karavalakis, who have published over 149 documents comprising articles, reviews, and conference proceedings. Further analysis showed that the published documents can be found in SAE Technical Papers, Atmospheric Environment, and Environmental Science & Technology, which are considered high impact journals or sources. The authors’ preferences for articles and high-impact journal sources could be attributed to the academic rewards, scholarly prestige, and monetary incentives associated with publishing in such sources. The systematic review of benchmark publications and major literature on VME research showed that vehicular emissions have a complex composition that includes but is not limited to particulate matter (PM), secondary organic aerosols (SOA), carbon dioxide (CO2), carbon monoxide (CO), hydrocarbons (HC), polyaromatic hydrocarbons (PAH), nitrogen oxides (NOx), and sulphur oxides (SOx), among others. Hence, the studies recommended the design, development, and deployment of innovative technologies and sustainable strategies that could lower/mitigate vehicular emissions through control systems comprising oxidation catalysts, particulate filters, and selective catalytic reduction. Based on the study findings, a few theoretical implications are suggested. First, the study findings can help researchers comprehend the existing scope and boundaries of the field. Thus, scholars can use the study findings to focus on less explored areas to understand VME research. Second, identifying prominent institutions and researchers in this area as likely partners and steering forces for advancing research may benefit academics. This study has limitations. First, it covers only studies in the Scopus database and does not cover studies in other databases, such as Web of Science. Second, this study only selected English-language articles, which are the majority, eliminating important contributors from other languages. Future studies may include studies written in other languages to extend broad global insight into VME research.

Ethical considerations

Not Applicable.

Conflict of Interest

The authors declare no conflicts of interest.

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