

**2020 年度**  
**JARI 研究論文集**  
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## アブストラクト

### <環境・エネルギー分野>

#### (1) 光化学オキシダントから見た大気環境保全政策立案に向けた課題

富田 幸佳 (JARI), 環境経済・政策研究 Vol.13, No.1, 2020 年 5 月  
[https://doi.org/10.14927/reeps.13.1\\_57](https://doi.org/10.14927/reeps.13.1_57)

我が国の光化学オキシダント(以下, 光化学 Ox)の大気環境基準達成率は, ほぼ 0%と極めて低い状態が続いている(環境省, 2019a). 光化学 Ox の大気環境基準達成率の改善に向け, 環境省(2019b)は, 2020 年度までの調査・検討スケジュール(以下, 検討スケジュール)を公表したが, 2021 年度以降について光化学 Ox の改善に繋がる具体的な記述はほとんどなく, 十分とは言えない.

本稿では, 今後の国内の光化学 Ox 対策に資するため, これまでの光化学 Ox 対策の検討経緯をまとめ, 分析を行った. その結果, 現状, 自然科学的エビデンスに基づく政策立案検討に重きが置かれており, 内閣官房行政改革推進本部が推進している EBPM (Evidence-Based Policy Making) の考え方と解離があることがわかり, 今後, EBPM の考え方に沿った具体策の実施に繋げるための課題を考察した.

#### (2) Diesel Particulate Filter 流路内のアッシュ移動モデルの構築

宮原 哲順, 福岡隆雄, 草鹿仁(早稲田大), 松野真由美, 北村高明 (JARI)  
自動車技術会論文集 Vol.52, No.1, 2020 年 11 月  
<https://doi.org/10.11351/jsaeronbun.52.19>

DPF 堆積アッシュの粒子径, かさ密度, 空隙率, 透過率が, DPF 流路内のアッシュの移動に与える影響をモデル化し, DPF 流路内のアッシュ堆積分布と, DPF 全体の圧力損失を予測するモデルを構築した. モデルによる計算結果と, DPG (Diesel Particulate Generator) でのアッシュ堆積実験での結果とを比較し, モデルの妥当性を検証したので報告する.

#### (3) Paradigm shift in aerosol chemical composition over regions downwind of China

Itsushi Uno, Zhe Wang (RIAM), Syuichi Itahashi (CRIEPI), Keiya Yumimoto (RIAM), Yuki Yamamura (FIHES), Ayako Yoshino, Akinori Takami (NIES), Byun-Gon Kim (Gangneung-Wonju National Univ.), Masamitsu Hayasaki (JARI)  
Scientific Reports Vol.10, 2020 年 4 月  
<https://doi.org/10.1038/s41598-020-63592-6>

A rapid decrease in PM<sub>2.5</sub> concentrations in China has been observed in response to the enactment of strong emission control policies. From 2012 to 2017, total emissions of SO<sub>2</sub> and NO<sub>x</sub> from China decreased by approximately 63% and 24%, respectively. Simultaneously, decreases in the PM<sub>2.5</sub> concentration in Japan have been observed since 2014, and the proportion of stations that satisfy the PM<sub>2.5</sub> environmental standard (daily, 35 µg/m<sup>3</sup>; annual average, 15 µg/m<sup>3</sup>) increased from 37.8% in fiscal year (FY) 2014 (April 2014 to March 2015) to 89.9% in FY 2017. However, the quantitative relationship between the PM<sub>2.5</sub> improvement in China and the PM<sub>2.5</sub> concentration in downwind regions is not well understood. Here, we (1) quantitatively evaluate the impacts of Chinese environmental improvements on downwind areas using source/receptor analysis with a chemical transport model, and (2) show that these rapid emissions reductions improved PM<sub>2.5</sub> concentrations both in China and its downwind regions, but the difference between SO<sub>2</sub> and NO<sub>x</sub> reduction rates led to greater production of nitrates (e.g., NH<sub>4</sub>NO<sub>3</sub>) due to a chemical imbalance in the ammonia–nitric acid–sulfuric acid–water system. Observations from a clean remote island in western Japan and numerical modeling confirmed this paradigm shift.

- (4) How are automobile fuel quality standards guaranteed? Evidence from Indonesia, Malaysia and Vietnam

Keiko Hirota(JARI), Shigeru Kashima(Chuo Univ.)  
Transportation Research Interdisciplinary Perspectives Vol.4, Article 100089,  
2020年5月

<https://doi.org/10.1016/j.trip.2019.100089>

This paper aims to demonstrate the governance of gasoline/diesel supply policies and fuel quality management policies in Asia (Indonesia, Malaysia and Vietnam). We highlight two aspects of fuel quantity and quality management by looking at 1) automobile fuel supply policy and refinery development, and 2) emission regulation and fuel quality monitoring systems (FQM). This research allows us to visualize emission regulation time schedules with refinery updates and fuel quality regulations (Tables 2, 3 and 4). We composed specific data from the real world to create tables on the time schedule from refinery update, vehicle emission introduction to fuel quality. This enables us to understand why fuel quality regulations were delayed in the past and when they will be improved in the future, from a realistic point of view. We also visualized the flow of FQM operation (Figs. 1, 2 and 3) which can be developed from the different market structure of each country. FQM can be summarized as 4 incentives and disincentives: trace causes, sample size, frequency of inspection and strict punishment as a design of FQM operation. Our specific case studies may suggest policy direction and influence scenario analysis on fuel quality improvement.

- (5) Modeling transition metals in East Asia and Japan and its emission sources

Mizuo Kajino(MRI), Hiroyuki Hagino(JARI), Yuji Fujitani(NIES), Tazuko Morikawa(JARI),  
Tetsuo Fukui(IFS), Kazunari Onishi (St. Luke's International Univ.), Tomoaki Okuda (Keio  
Univ.), Tomoki Kajikawa (Waseda Univ.), Yasuhito Igarashi(Kyoto Univ.)  
GeoHealth Vol.4, Issue 9, 2020年9月

<https://doi.org/10.1029/2020GH000259>

Emission inventories of anthropogenic transition metals, which contribute to aerosol oxidative potential (OP), in Asia ( $\Delta x = 0.25^\circ$ , monthly, 2000–2008) and Japan ( $\Delta x = 2$  km, hourly, mainly 2012) were developed, based on bottom-up inventories of particulate matters and metal profiles in a speciation database for particulate matters. The new inventories are named Transition Metal Inventory (TMI)-Asia v1.0 and TMI-Japan v1.0, respectively. It includes 10 transition metals in  $PM_{2.5}$  and  $PM_{10}$ , which contributed to OP based on reagent experiments, namely, Cu, Mn, Co, V, Ni, Pb, Fe, Zn, Cd, and Cr. The contributions of sectors in the transition metals emission in Japan were also investigated. Road brakes and iron-steel industry are primary sources, followed by other metal industry, navigation, incineration, power plants, and railway. In order to validate the emission inventory, eight elements such as Cu, Mn, V, Ni, Pb, Fe, Zn, and Cr in anthropogenic dust and those in mineral dust were simulated over East Asia and Japan with  $\Delta x = 30$  km and  $\Delta x = 5$  km domains, respectively, and compared against the nation-wide seasonal observations of  $PM_{2.5}$  elements in Japan and the long-term continuous observations of total suspended particles (TSPs) at Yonago, Japan in 2013. Most of the simulated elements generally agreed with the observations, while Cu and Pb were significantly overestimated. This is the first comprehensive study on the development and evaluation of emission inventory of OP active elements, but further improvement is needed.

- (6) Simulation of the transition metal-based cumulative oxidative potential in East Asia and its emission sources in Japan

Mizuo Kajino (MRI), Hiroyuki Hagino (JARI), Yuji Fujitani (NIES), Tazuko Morikawa (JARI), Tetsuo Fukui (IBS), Kazunari Onishi (St. Luke's International Univ.), Tomoaki Okuda (Keio Univ.), Yasuhito Igarashi (Kyoto Univ.)

Scientific Reports Vol.11, Article Number:6550, 2021 年 3 月

<https://doi.org/10.1038/s41598-021-85894-z>

The aerosol oxidative potential (OP) is considered to better represent the acute health hazards of aerosols than the mass concentration of fine particulate matter (PM<sub>2.5</sub>). The proposed major contributors to OP are water soluble transition metals and organic compounds, but the relative magnitudes of these compounds to the total OP are not yet fully understood. In this study, as the first step toward the numerical prediction of OP, the cumulative OP (OP<sub>tm</sub><sup>\*</sup>) based on the top five key transition metals, namely, Cu, Mn, Fe, V, and Ni, was defined. The solubilities of metals were assumed constant over time and space based on measurements. Then, the feasibility of its prediction was verified by comparing OP<sub>tm</sub><sup>\*</sup> values based on simulated metals to that based on observed metals in East Asia. PM<sub>2.5</sub> typically consists of primary and secondary species, while OP<sub>tm</sub><sup>\*</sup> only represents primary species. This disparity caused differences in the domestic contributions of PM<sub>2.5</sub> and OP<sub>tm</sub><sup>\*</sup>, especially in large cities in western Japan. The annual mean domestic contributions of PM<sub>2.5</sub> were 40%, while those of OP<sub>tm</sub><sup>\*</sup> ranged from 50 to 55%. Sector contributions to the OP<sub>tm</sub><sup>\*</sup> emissions in Japan were also assessed. The main important sectors were the road brake and iron–steel industry sectors, followed by power plants, road exhaust, and railways.

#### <電動モビリティ分野>

- (7) A study of decrease burst strength on compressed-hydrogen containers by drop test  
Shunsuke Masuda, Jun-ichi Tomioka, Hiroaki Tamura, Yohsuke Tamura (JARI)  
International Journal of Hydrogen Energy Vol.46, Issue 23, 2021 年 3 月

<https://doi.org/10.1016/j.ijhydene.2020.09.256>

We investigate an initial burst pressure and residual burst pressure at the end of life (EOL) of compressed hydrogen containers and report that a container damage caused by a drop test has a large influence on burst pressure. The container damage induced through hydraulic sequential tests is investigated using nondestructive evaluations to clarify a strength decreasing mechanism. An ultrasonic flaw detection analysis is conducted before and after the drop test and indicated that the damage occurred at the cylindrical and dome parts of the container after the drop test. An X-ray computed tomography imaging identifies a delamination inside laminated structure made of carbon fiber reinforced plastics (CFRP) layer, with some degree of delamination reaching the end boss of the container. Results suggest that a load profile fluctuates in the CFRP layer at the dome part and that a burst strength of the dome part decreases.

- (8) Degradation diagnosis of lithium-ion batteries using AC impedance technique in fixing the state of charge of an electrode

Keisuke Ando, Tomoyuki Matsuda, Daichi Imamura (JARI)  
Journal of Energy Chemistry Vol.53, 2021 年 2 月

<https://doi.org/10.1016/j.jechem.2020.04.072>

We developed a technique to evaluate the degree of degradation of the electrode using an EIS in fixing the SOC of an electrode, not the cell voltage or SOC.

## <安全分野>

### (9) 新たな前面衝突試験方法に関する研究

中嶋 太一, 新井 勇司 (JARI), 渡辺 泰介, 黒田 一平, 國司 大地 (自工会)  
自動車技術会論文集 Vol.51, No.3, 2020 年 5 月  
<https://doi.org/10.11351/jsaeronbun.51.537>

前面衝突試験時の更なる乗員保護性能の向上を図るため, 欧州 EuroNCAP では 2020 年より車対 MPDB の実車衝突試験を開始予定である. 同試験では世界初となるコンパティビリティ評価も導入予定であるが, その評価方法の妥当性について車対車の実車衝突試験を実施して検討したので, その結果を述べる.

### (10) ペダル操作に関するロコモティブシンドローム及び注意機能の影響分析

細川 崇, 橋本 博 (JARI), 平松 真知子, 寸田 剛司, 石田 肇 (自工会)  
自動車技術会論文集 Vol.52, No.1, 2021 年 1 月  
<https://doi.org/10.11351/jsaeronbun.52.177>

高齢者によるアクセルとブレーキの踏み間違い事故が社会問題化している. 本研究は, 加齢の影響が想定される人的要因とペダル操作エラーの関係を検討した. モックアップ実験により, ブレーキの教示でアクセルを踏んだ場合のエラーと人的要因指標間で分散分析を実施した結果, 歩行能力と注意機能が有意であることが示された.

### (11) Optimization of female head-neck model with active reflexive cervical muscles in low severity rear impact collisions

I Putu A. Putra, Johan Iraeus, (Chalmers Univ. of Technology), Fusako Sato (JARI),  
Mats Y. Svensson, Robert Thomson, Astrid Linder (Chalmers Univ. of Technology)  
Annals of Biomedical Engineering Vol.49, No.1, 2021 年 1 月  
<https://doi.org/10.1007/s10439-020-02512-1>

ViVA Open Human Body Model (HBM) is an open-source human body model that was developed to fill the gap of currently available models that lacked the average female size. In this study, the head-neck model of ViVA OpenHBM was further developed by adding active muscle controllers for the cervical muscles to represent the human neck muscle reflex system as studies have shown that cervical muscles influence head-neck kinematics during impacts. The muscle controller was calibrated by conducting optimization-based parameter identification of published-volunteer data. The effects of different calibration objectives to head-neck kinematics were analyzed and compared. In general, a model with active neck muscles improved the head-neck kinematics agreement with volunteer responses. The current study highlights the importance of including active muscle response to mimic the volunteer's kinematics. A simple PD controller has found to be able to represent the behavior of the neck muscle reflex system. The optimum gains that defined the muscle controllers in the present study were able to be identified using optimizations. The present study provides a basis for describing an active muscle controller that can be used in future studies to investigate whiplash injuries in rear impacts

### (12) Numerical analysis of bicycle helmet under blunt behavior

David Sepulveda-Lopez (Univ. Carlos III of Madrid), Jakobo Antona (JARI), Ignacio Rubio, Marcos Rodriguez-Millán (Univ. Carlos III of Madrid)  
Applied Sciences Vol.10, No.11, 2020 年 6 月  
<https://doi.org/10.3390/app10113692>

This study evaluates various safety aspects of standardized impacts that cyclists may suffer while wearing a bicycle helmet, by combining a partially validated finite element model of the cranio-cervical region and a newly developed commercial bicycle helmet model. Under EN

1078 standardized impact conditions, the results of simulated impact tests show that the helmet can absorb 40% to 50% of the total impact energy at impact velocities above 4 m/s. Further, based on a relationship between the head injury criterion and the risk of injury from field data, the results of the simulations suggest that minor injuries may occur at impact velocities of 10 km/h, serious injuries at 15 km/h, and severe injuries at 20 km/h. Fatal injuries will likely occur at impact velocities of 30 km/h and higher.

(13) Development of a Porcine Thigh Finite Element Model for Evaluating the Soft-Tissue Injuries Caused by Blunt Impacts during Human-Robot Interactions

Yu-ki Higuchi (JARI), Tatsuo Fujikawa (Nagoya Univ.), Ryuji Sugiura, Tetsuya Nishimoto(Nihon Univ.), Fusako Sato(JARI)

2021 IEEE International Conference on Intelligence and Safety for Robotics (ISR), 2020 年 3 月  
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The data concerning the tolerance of slight injuries during human-robot interactions is essential for setting necessary safety measures for robots. In this study, to provide a tool for investigating bruise tolerance, a porcine thigh finite element (FE) model was developed based on quasi-static and dynamic compression tests with living porcine subjects. The FE model demonstrated that strain concentrations occurred in the corresponding region, where the haematoxylin-eosin staining showed blood leaks in the harvested soft-tissue specimens from the impacted porcine subjects. Based on this correlation, the maximum principal strain has potential of being a tissue-level bruise injury metric.

<自動運転・IT・エレクトロニクス分野>

(14) 高度自動運転状況下におけるドライバーへの情報伝達方法 (第 4 報) –運行設計領域外を伝達するための視覚表示内容–

大谷 亮, 江上 嘉典, 栗山 あずさ, 佐藤 健治 (JARI), 石井 啓介 (自工会)  
自動車技術会論文集 Vol.52, No.1, 2021 年 1 月

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運転シミュレータに低次の自動運転状況を模擬し, 回避操作が必要な状況下におけるドライバーの主観評価と運転行動を分析した. その結果, 実験の設定の範囲内では, 視聴覚表示に気づくドライバーは多くなく, 運転行動に遅延が見られた. 今後, システム状態を適切に理解するための情報伝達方法を検討する必要がある.

(15) 自動運転車の Minimum Risk Maneuver の違いが後続車へ与える影響 (第 2 報) –交通量の異なる状況における後続車への影響要因の実験検討–

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レベル 3 自動運転の権限委譲時にドライバーの対応がない場合, システム制御 (MRM) でのリスク低減が検討されている. 渋滞走行時と交通量の少ない状況において, MRM のハザード提示有無, 減速度, 停止位置等の違いが, 後方からの接近車両へ与える影響を DS 実験で調査した. リスク低減に有用な条件から, MRM の配慮事項をまとめた.

(16) Evaluation of acceptability of adaptive proactive braking intervention system based on risk map for elderly drivers

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International Journal of Automotive Engineering Vol.11, No.2, 2020 年 6 月  
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This study aims to confirm the usefulness of adaptation of proactive braking intervention systems to the risk level of the driving environment for improving the reactive factors of acceptability. First, we develop prototypes of adaptive proactive braking intervention systems around non-signalized intersections on community roads. Then, to confirm the effectiveness of adaptation, we conduct user tests, in which 45 elderly drivers participate, on public roads. From comparisons between constant setting and adaptive setting, we confirm that the adaptive setting improves the reactive factors of acceptability, such as reduction in the feeling of impatience and strangeness.

(17) Effects of demographic characteristics on trust in driving automation  
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With the successful introduction of advanced driver assistance systems, vehicles with driving automation technologies have begun to be released onto the market. Because the role of human drivers during automated driving may be different from the role of drivers with assistance systems, it is important to determine how general users consider such new technologies. The current study has attempted to consider driver trust, which plays a critical role in forming users' technology acceptance. In a driving simulator experiment, the demographic information of 56 drivers (50% female, 64% student, and 53% daily driver) was analyzed with respect to Lee and Moray's three dimensions of trust: purpose, process, and performance. The statistical results revealed that female drivers were more likely to rate higher levels of trust than males, and non-student drivers exhibited higher levels of trust than student drivers. However, no driving frequency-related difference was observed. The driver ratings of each trust dimension were neutral to moderate, but purpose-related trust was lower than process- and performance-related trust. Additionally, student drivers exhibited a tendency to distrust automation compared to non-student drivers. The findings present a potential perspective of driver acceptability of current automated vehicles.

(18) Effects of a driver assistance system with foresighted deceleration control on the driving performance of elderly and younger drivers  
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It is imperative to enhance the safety of elderly individuals on the roads to ensure the quality of their daily life. Near-miss incidents or accidents at blind intersections often result from a conflict between the behaviors of the driver and of other road users (pedestrians and cyclists). The failure to search for potential conflict in the context of blind intersections is a concern pertaining to road safety. The proposed assistance system performs a proactive braking intervention to achieve a referenced velocity in uncertain situations, such as one in

which an unobserved pedestrian might initiate a road crossing. The proactive braking intervention attempts to manage the potential risk of crashing with respect to covert hazards. Because an automated system may impair a human's ability to perceive and respond to hazardous situations while driving, this study was designed to examine the effects of proactive braking intervention and visual support cues on elderly and younger drivers' ability to respond to information about potentially hazardous situations. We conducted a public-road driving experiment involving 108 elderly and younger drivers from two non-overlapping age groups. It was observed that the vehicle slowdown realized through the proactive braking intervention enabled the drivers to perform safety confirmation near blind spots and caused them to be more sensitive to and wary of potential hazards. This approach could be effective not only for elderly drivers, but also for young or inexperienced ones.

(19) Relationship between pedestrian detection specifications of parking sensor and potential safety benefits

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Measures to protect vulnerable road users during low-speed maneuvers are required. For example, systems that use cameras to display the vehicle's rearview are popular. However, some vehicles are difficult to equip with a rear view camera system. To avoid a crash when driving in reverse, it is also effective to identify the presence of pedestrians via an audible warning using a device (e.g., clearance sonar). It may be cheaper to install than a rearview camera system. Installation cost is also important for the spread of equipment that reduces a crash. It is necessary to clarify the minimum specifications that balance cost and reduce crashes. Device specifications (e.g., detection distance and response delay) may affect the crash reduction rate. There should be a detection distance required for the sonar to have the same crash reduction effect as the rear view camera system. Thus, in this study, we conducted experiments and obtained data about how a vehicle moves and driver reactions to audible warnings when driving in reverse. Based on the acquired data, a numerical simulation was performed to determine whether a driver could avoid a crash under various circumstances. As a result, it was shown that the clearance sonar must have a detection distance of 0.8 m or more to expect the same effect as a rearview camera system. In other words, to expect sonar to have the same performance as a rearview camera, a detection distance of at least 0.8 m should be set as a specification.

以上