DeWipe
Investigation report

Assessing DeWipes ability to remove inorganic pollutants from piston aircraft oil and road dust on varying surfaces

Report Number: R/DW002/D2

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Production history

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Executive Summary

Aim

The principal aim of this project was to undertake laboratory testing to assess the effectiveness of a decontamination wipe at removing inorganic pollutants that may impact employees working in mechanical and construction industries.

Approach

We undertook an investigation to assess the performance of the DeWipe in a controlled laboratory setting. This was achieved by adding a know amount of charecterised oil and road dust to skin, glass, metal, and plastic surfaces. Surfaces were then wiped using a DeWipe, extracted via an acid digest and analysed by ICP-OES, to test the removal efficiency of DeWipes. Inorganic pollutants analysed included; aluminium, arsenic, cadmium, chromium, cobalt, iron, lead, magnesium, manganese, molybdenum, nickel, sulphur and zinc.

Results

The results of this initial investigation indicated that the DeWipe was effective at removing inorganic pollutants from varying surfaces.

Conclusions

The results were highly encouraging and it is recommended that further investigation is undertaken to assess the effectiveness of the DeWipe in field studies.

(1) Introduction

Inorganic pollutants have been shown to cause adverse human health effects in a range of different occupations (Ngure and Kinuthia, 2020). They have been shown to exhibit serious health effects including; neurological disorders, skeletal, immune systems damage, toxicity in the kidney, neurologic and vascular systems, hypertension and strokes (Kristanti et al., 2021).

The following inorganic analytes were considered within this study; aluminium, arsenic, cadmium, chromium, cobalt, iron, lead, magnesium, manganese, molybdenum, nickel, sulphur and zinc. Table 1 shows health risks associated with each one of these elements.

Table 1: Toxicological summary of analytes

Inorganic analyte	Reported health effects
Aluminium	Increased risk of diseases that affect the immune nephrological, circulatory, skeletal, and neurological systems (Walton, 2019).
Arsenic	Bladder cancer (Vishwakarma et al., 2021). Skin hyperkeratosis, depigmentation, hyperpigmentation, and skin cancer, the central and peripheral neuro effects, including peripheral neuritis, Raynaud's Syndrome, gastroenteritis, hypertrophy and abnormal functions in liver, peripheral and cardiovascular effects, including myocardial ischemia, arrhythmia, pulmonary effects, hematological effects showing morphological changes and membrane damage in red blood cells, and Bowen's Disease and skin tumours (Ma et al., 1999).
Cadmium	Hazardous to both marine organisms and human tissues due to its toxic nature. May induce skeletal weakness, digestive disorders, mutations, and renal damage (El-Sherbiny and Sallam, 2021).
Chromium	Chromium deficiency can cause an imbalanced nutritional diet, or even diabetes. Some other health risks are nausea, headache, or even oral cavity cancer as well as genetic damage (Yang et al., 2019).
Cobalt	Cobalt deficiency leads to a decrease in the availability of B12, resulting in pernicious anemia and nerve damage (Linhares et al., 2019). Inhalation of cobalt dust may cause adverse respiratory effects, hearing loss, nausea and vomiting, visual impairment, tremor,

	incoordination, headaches, motor axonopathy, muscle weakness, slower conduction of sensory stimuli, dyesthesia in the extremities, gait disturbances, numbness and paresthesia, occupational contact dermatitis (OCD), lung cancer (Leyssens et al., 2017).
Iron	Increases the risk of diabetes. Liver function injury and lipid metabolism disorder. Induce bone loss, dizziness, abdominal discomfort, nausea, fatigue, diarrhoea, constipation, and headaches (Gao et al., 2021; Patino et al., 2020; Galloway and McGuire, 1994).
Lead	Developmental delay, learning difficulties, irritability, weight loss, abdominal pain, fatigue. Lead is neurotoxic. The target organ systems of significant concern are the heme-hemoprotein system, the kidney, and the nervous system (Needleman and Bellinger, 1991; Hammond, 1977; Ribeiro Sant'Ana et al., 2021).
Magnesium	Magnesium deficiency leads to hypertension, insulin resistance, and endothelial dysfunction, and is associated with an increased risk of cardiovascular events (Sakaguchi et al., 2018).
Manganese	Neurological disorders, increased dental caries, behavioural problems, reduced intelligence quotient (IQ) scores, difficulty with mathematics and reduced motor skills in children (Rose et al., 2017).
Molybdenum	Decreasing amounts of molybdenum results in thymus atrophy by interfering with ribosomal protein expression and protein metabolism (Zhang et al., 2021). Increased molybdenum exposure levels were found to be associated with increased risk of ischemic stroke and high blood pressure and reduced testosterone level in men (Zhao et al., 2021).
Nickel	Apoptosis, inflammation, lung toxicity, and oxidative stress, throat irritation, nasal congestion, posts nasal drip, facial flushing, skin reactions, headaches, respiratory manifestations, lung fibrosis, cardiovascular diseases, lung cancer, nasal cancer and epigenetic effects (Kumar et al., 2021).
Sulphur	Acute respiratory infections in children, chronic respiratory diseases in adults. Irritation to the lining membranes of the respiratory tract causing reflex bronchoconstriction, slowing of mucus flow, depression

	of clearance of inert particles from the lung and in regions of high concentration, narrowing of airways from inflammatory swelling of membranes (Rall, 1974).
Zinc	Decreased immunological defences, foetus growth retardation, impaired psycho-social behaviours, disabilities and a high prevalence of upper gastrointestinal cancer as well as cardiovascular related conditions (Ngure and Kinuthia, 2020).

Inorganic pollutants can be present in both liquid and solid forms, to assess the effectiveness of DeWipes to remove inorganic pollutants from each of these matrices we used oil (aircraft oil) and particulate matter (road dust). Both sample types have been shown to have high levels of inorganic pollutants (Murakami et al., 2007) and represent materials that people from a wide range of different industries are likely to encounter.

(2) Method

A schematic overview of the surface wiping procedure and extraction method is illustrated in Figure 1.

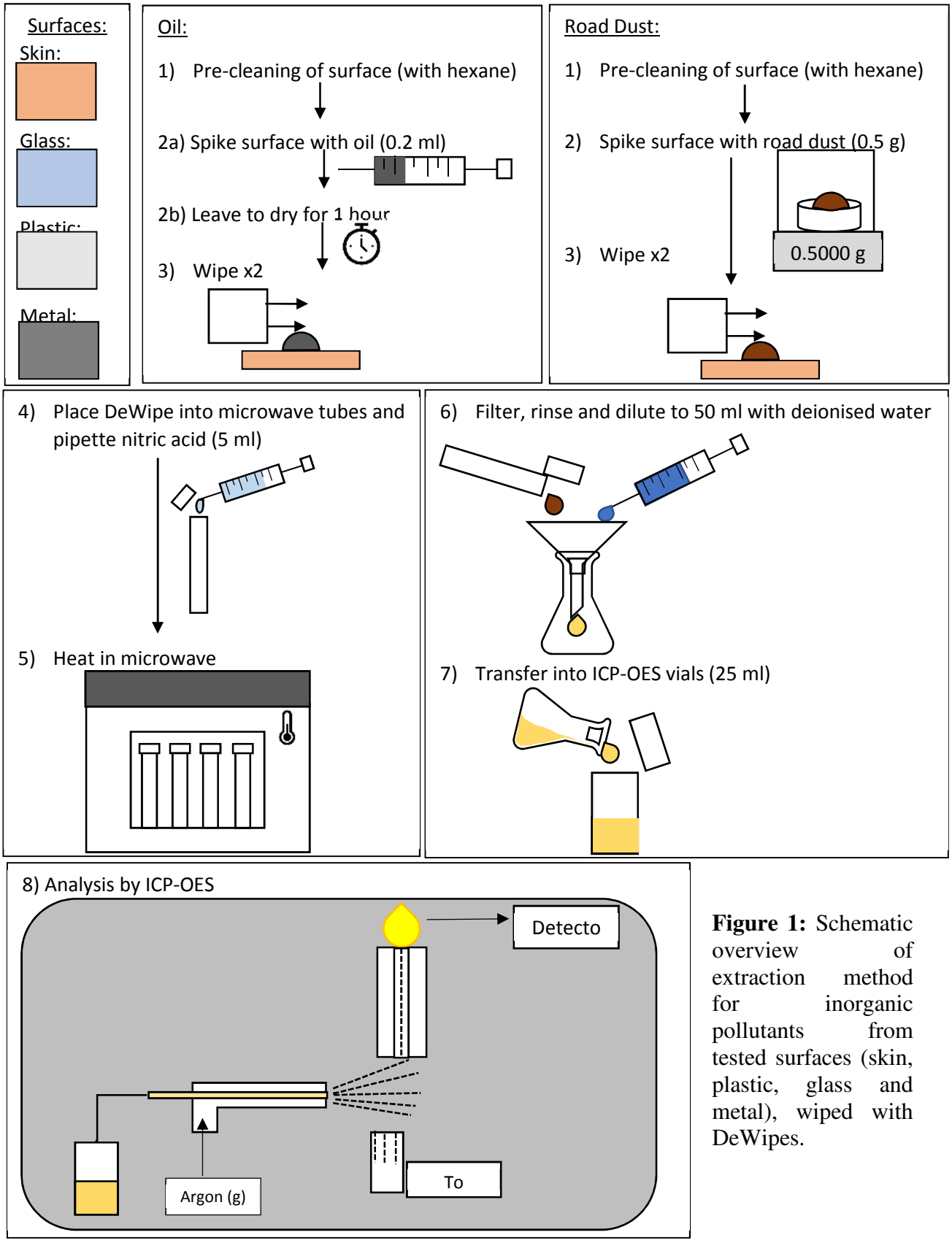

Figure 1: Schematic overview of extraction method for inorganic pollutants from tested surfaces (skin, plastic, glass and metal), wiped with DeWipes.

(3) Results

(3.1) Inorganic pollutants in oil

The analytical accuracy and precision of the measurements were determined by 4 repeat measurements for each surface, then analysed using ICP-OES in triplicate. This enabled averages and relative standard deviation (RSD) to be calculated for each surface. All data shown below contains RSD values of ≤ 2 %, proving the results were precise. These RSD values were used for the error bars on graphs and demonstrated small error among the data obtained. Five point calibration curves were produced for each individual analyte. The calibration curves were all linear with R^2 values ≥ 0.998.

Cadmium, lead and nickle were the only analytes present at detectable levels in the oil samples. Only results from these three elements are therefore reported for oil. The DeWipes successfully removed an average of 97.1 % of cadmium, 84.2 % of lead, and 63.8 % of nickel from the four surfaces. There was no appreciable difference in effectiveness between each surface type which indicates the DeWipe is effective at removing inorganic pollutants from oil from a varitety of different surfaces.

Table 2: Percentage removal of inorganic pollutants from oil on different surfaces.

Surfaces	Cadmium	Lead	Nickel
Metal	89.7	84.7	55.6
Glass	93.5	87.5	58.0
Plastic	97.8	80.3	60.4
Skin	99	84.5	63.8

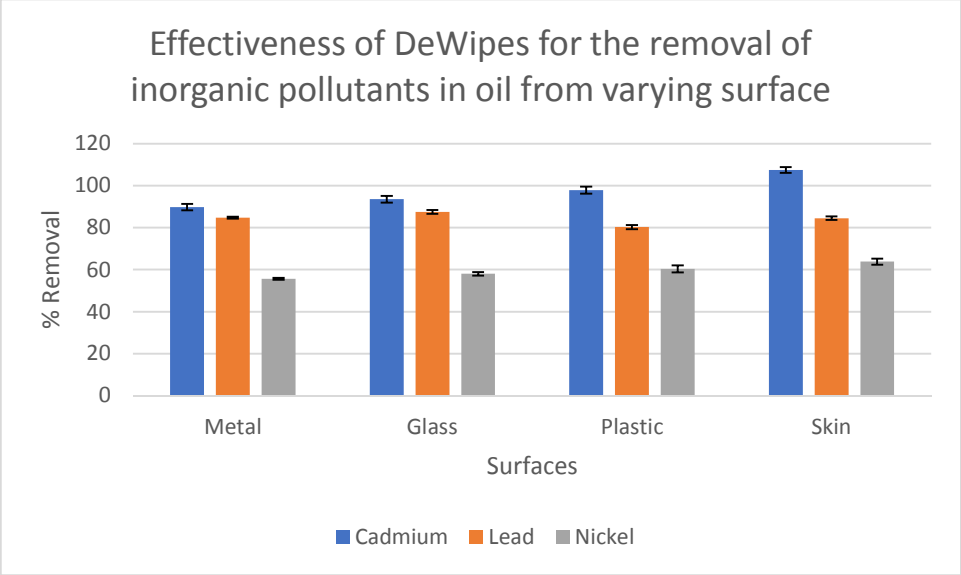

Figure 2: The percentage removal of inorganic pollutants from oil on the metal, glass, plastic and skin surfaces.

(3.2) Inorganic pollutants in particulate matter

The analytical accuracy and precision of the measurements were determined by 4 repeat measurements for each surface, then analysed using ICP-OES in triplicate. This enabled averages and relative standard deviation (RSD) to be calculated for each surface. All data shown below contains RSD values of ≤ 7 %, proving the results were precise. These RSD values were used for the error bars on graphs and demonstrated small error among the data obtained. Five point calibration curves were produced for each individual analyte. The calibration curves were all linear with R^2 values ≥ 0.998.

Aluminium, arsenic, cadmium, chromium, cobalt, iron, lead, magnesium, manganese, molybdenum, nickel, sulphur and zinc were all present in detectable concentrations in the road dust. Only results from these elements are therefore reported. The DeWipes successfully removed over 80 % of all inorganic pollutants from all surfaces. There was no appreciable difference in effectiveness between each surface type which indicates the DeWipe is effective at removing inorganic pollutants from oil from a varitety of different surfaces.

Table 3: Percentage removal of inorganic pollutants from particulate matter on different surfaces.

Surfaces	Aluminium	Arsenic	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Molybdenum	Nickel	Sulphur	Zinc
Metal	100	98.8	100	87.2	100	88.3	100	92.6	100	97.8	91.2	100	97.8	87.2
Glass	94.8	88.1	88.1	71.6	94.7	90.0	84.6	97.3	89.7	84.0	101	88.0	87.0	91.2
Plastic	94.7	90.2	90.5	72.8	91.6	94.8	86.5	105	88.2	85.6	81.3	97.2	86.9	88.4
Skin	97.9	80.8	89.6	90.6	97.1	80.4	89.1	84.1	86.4	81.2	81.6	88.7	86.2	127

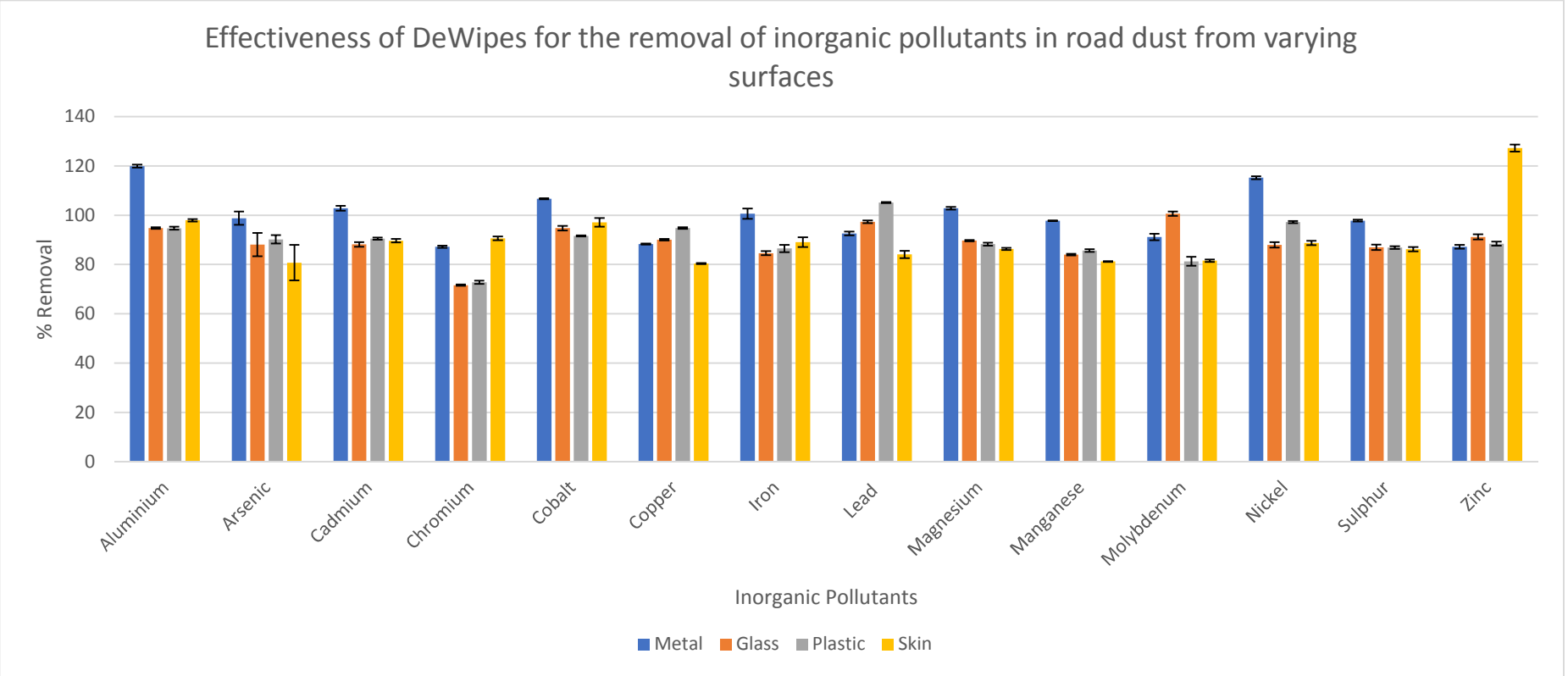

Figure 3: The percentage removal of inorganic pollutants from particulate matter on metal, glass, plastic and skin surfaces.

(4) Conclusions and recommendations

The results are highly encouraging and indicate that the DeWipe was able to remove majority of inorganic pollutants from oil and particulate matter on a different surfaces. It is recommended that further investigation is undertaken to validate performance, particularly in field trials. Further testing could include:

- Analysis of more replicates under laboratory conditions to perform a statistical significance assessment of performance.
- Testing the product under 'real-world' applications, i.e. wiping of mechanics skin and equipment after use.
- Perform testing on a wider range of different liquid and particulate matter samples known to contain inorganic pollutants.

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