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THE IMPACT OF THE IMO-2020 SHIPPING REGULATION ON THE ATMOSPHERIC DEPOSITION OF SULFUR AROUND THE WESTERN ENGLISH CHANNEL AND THE USE OF THE V/NI RATIO AS A SHIPPING MARKER

Laurence WINDELL[1,3], Thomas BELL[1,2], Caroline WHITE[1], Angela MILNE[1], Jaroslav SCHWARZ[3], Simon USSHER[1]

[1] Biogeochemistry Research Centre, University of Plymouth, Plymouth, UK, windell@icpf.cas.cz
[2] Plymouth Marine Laboratory, Plymouth, UK
[3] Institute of Chemical Process Fundamentals of the CAS, Prague, Czech Republic

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INTRODUCTION

Anthropogenic aerosols are shown to have a great impact on marine ecosystems and human health, with the shipping industry contributing as a significant source of these emissions, and annual growth on the rise. In the marine environment, shipping emissions often dominate atmospheric deposition of sulfur. With around 70% of shipping activity being carried out within 400 km of the coast, its contribution to atmospheric sulfur is of great interest. The International Maritime Organisation (IMO) introduced a regulation on 01/01/2020 restricting global marine fuel sulfur content from 3.5% to 0.5% w/w.

The vanadium/nickel (V/Ni) ratio has been widely used as a marker of shipping emissions, with the range of 2.5 to 4 indicating shipping activity. The regulation has called into question the viability of the earlier use of the V/Ni ratio.

EXPERIMENTAL SETUP

The present study investigated the changes in marine aerosol chemical character around Penlee Point Atmospheric Observatory (PPAO; 50°19′ N, 4°11′ W) to gain insight into the efficacy of the IMO-2020 regulation. The observatory in Southwest England is ideally located next to a shipping lane with high marine traffic. Aerosol filter samples were collected from 2020-2021 (n=53). Filter samples were water-leached and subsequent leachates analysed for major ions using Ion Chromatography (IC), and trace elements using Inductively Coupled Plasma – Mass Spectrometry (ICP-MS). Concentrations of V/Ni and calculated non-sea-salt sulfate (nss-SO_4^{2-}) were compared to PPAO datasets from 2015-16 (n=56) and 2017-18 (n=51) respectively. Where possible, HYSPLIT air mass back trajectories were run (Stein et al., 2015).

RESULTS AND CONCLUSIONS

Trace element analysis showed a drop in median V from 2.91 pmol/m^3 to 1.44 pmol/m^3, and Ni increase from 0.95 pmol/m^3 to 4.8 pmol/m^3 with the decrease of V being in line with a similar post-IMO-2020 study in China (Guangyuan et al., 2021). Median V/Ni ratio post-IMO decreased from 3.3 to 0.28.

Post-IMO-2020 nss-SO_4^{2-} concentrations were significantly lower than pre-IMO-2020 values (n=109, $p<0.05$), which was observed throughout all classified air masses,

with total median nss-SO_4^{2-} concentration dropping from 1.35 μg/m³ to 0.33 μg/m³ (Fig 1.).

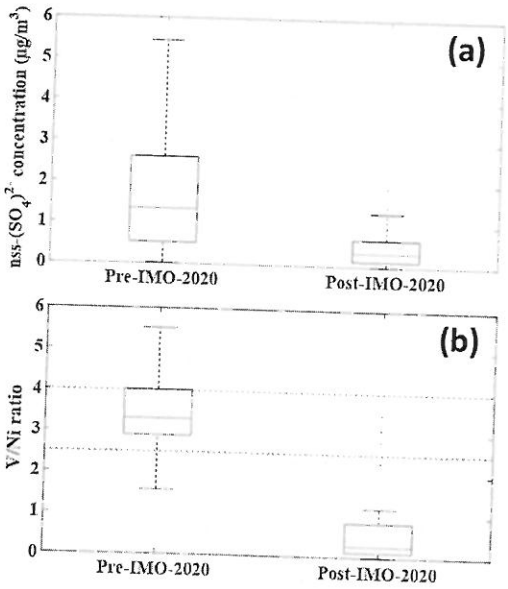

Figure 1. (a) Pre- and post-regulation nss-SO_4^{2-}, (b) Pre- and post-regulation V/Ni ratios. Horizontal lines represent previous ratio range for shipping emissions.

Results from the major ion analysis suggest great differences in marine atmospheric nss-SO_4^{2-} post-regulation, pointing towards a noticeable decrease in nss-SO_4^{2-} around PPAO, potentially influenced by the S regulation. Trace element results indicate a drastic change in V/Ni ratios, far different from the generally agreed-upon range of 2.5 to 4. The results have presented a need to further investigate the viability of the V/Ni ratio as a marker of shipping emissions, where the previous ratio must be re-evaluated.

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