Anthropogenic very short-lived halocarbons from ballast water treatment

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Halocarbons as disinfection by-product (DBP)

Anthropogenic very short-lived halocarbons (VSHL) are formed as by-products during disinfection (DBP) of seawater in ships and power plants (Fig. 1). In the atmosphere, VSHL like bromoform are photolysed and thus involved in ozone depletion.[1] The environmental impact of anthropogenic VSHL is still unknown.

Bromoform (CHBr₃) as major DBP

Commercial ships discharge ~10⁹ m³ of ballast water (BW) in ports every day. Treatment of BW helps to prevent biofouling and the invasion of non-indigenous species.

But, chemical BW treatment produces high concentrations of VSHL as DBPs especially bromoform (CHBr₃).[2] We measured bromoform in BW with mean concentrations of 900 nmol/L ~ 230 g/L (Fig. 2).

Research area

VSHL require strong tropical convection to reach the upper troposphere and stratosphere. We focus on the highly industrialised area of tropical southeast Asia where 28% of the world’s 50 largest ports are located accounting for over 50% of commercial shipping worldwide (Fig. 3).

Ocean surface concentration

Over one year, BW can spread fast over large regions (Fig. 4). CTRL Bromoform concentrations are highest close to the discharge location.

Only 15% of bromoform stays in the surface ocean when outgassing is included (OUT). Air-sea flux prevents large-scale transport in the ocean.

Sea-to-air flux (OUT)

High wind variability leads to large fluctuations of sea-air flux (Fig. 5). Weak winds cause accumulation of particles near the source and less sea-to-air flux.

Regions of large harbours add substantially to the natural bromoform flux (Fig. 6). Fluxes from BW discharges add locally to background fluxes. 90% of bromoform from BW is instantly outgassed at discharge location.

Conclusions

- Bromoform is 900 ± 560 nmol/L in treated ballast water (BW).
- Peak values regionally reach up to 30-65 nmol/L in the ocean.
- Sea-to-air flux happens very fast: 85% of Br from Singapore BW is emitted at discharge location; 100% of Br from Hong Kong.
- Fluxes are highly variable and reach up to 2000 pmol/m²/hr near the discharge region.

Outlook

- Discharge of treated cooling water from industrial power plants is even larger than BW discharge.
- Economic growth and population rise lead to annual increase in water treatment.
- From regional to global: What are global anthropogenic VSHL emissions?

References


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