Insights to the short-term atmospheric deposition impacts on the biology and chemistry of the sea surface microlayer in the Adriatic Sea coastal region

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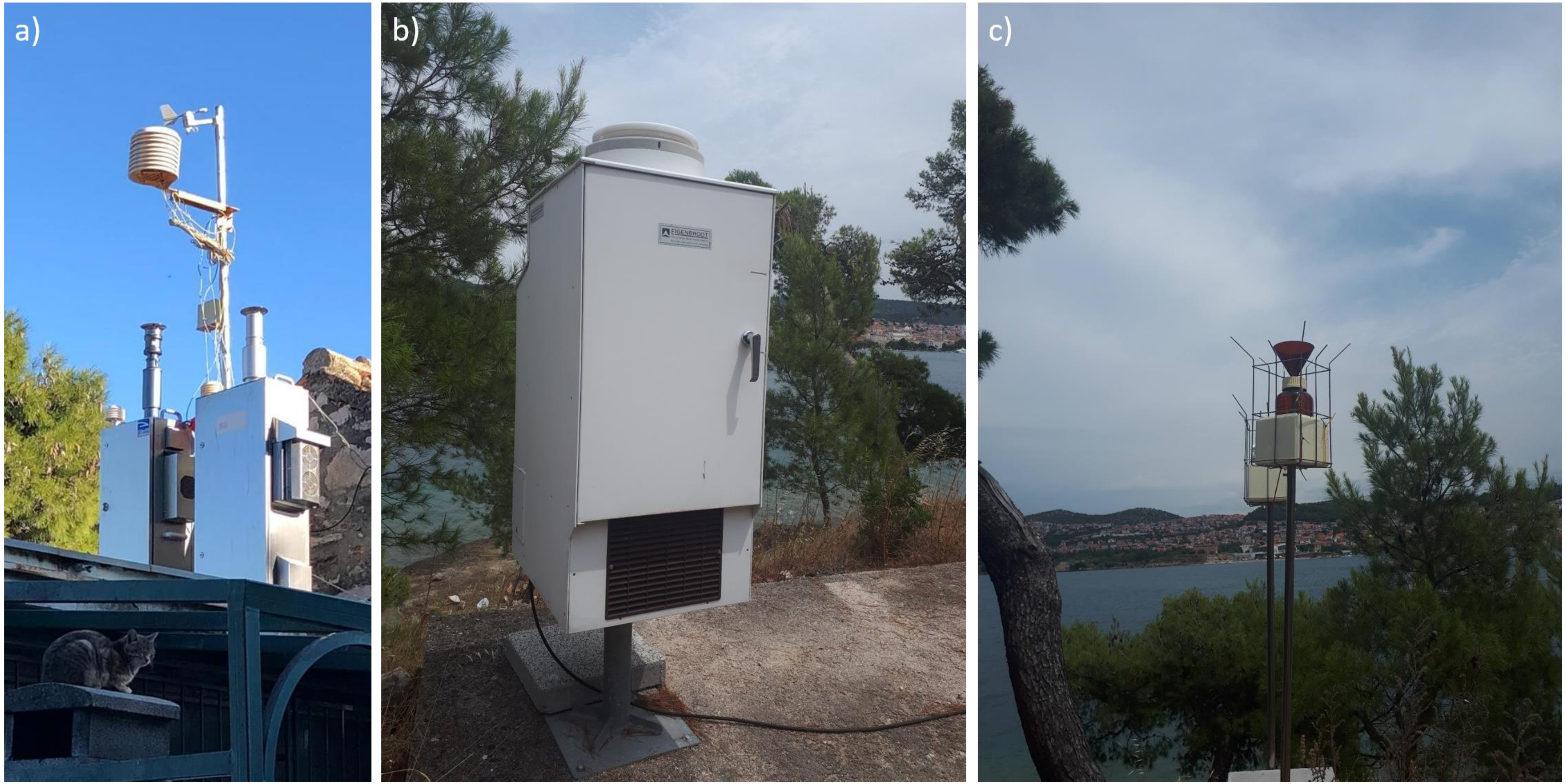
EGU General Assembly 2023, 23 - 28 April 2023, Vienna


a)
b)
c)

models:

- Aethalometer model
- HYSPLIT model
- LOTOS-EUROS model

Particulate matter

- total **PM_{10} mass** by gravimetric weighing
- **anions and cations** in aqueous extracts by ion chromatography (IC)
- **trace metals** (TMs) by inductively coupled plasma mass spectrometry (ICP-MS)

Deposition

- **anions and cations** by ion chromatography (IC) and UV-Vis spectrophotometry
- **trace metals** (TMs) by inductively coupled plasma mass spectrometry (ICP-MS)

Sea water (SML and ULW)

dissolved (< 0.7 µm)

- **dissolved organic carbon** (DOC) by the HTCO method
- **nutrients** by UV-Vis spectrophotometry
- **dissolved lipids** (DL) after liquid-liquid filtrate extraction
- **dissolved and total surface active substances** (SAS) by anode dissolution voltammetry
- **total dissolved carbohydrates** (DCHO) spectrophotometrically

- **trace metals** (TMs) by voltammetry
- **phytoplankton communities** sedimentation by Utermöhl
- **phytoplankton abundance** by inverted microscope
- **abundance of heterotrophic bacteria** (HB) by flow cytometer

particulate (> 0.7 µm)

- **particulate organic carbon** (POC) from the filter by the HTCO method
- classes of **particular lipids** (PL) by thin layer chromatography with flame ionization detector (TLC-FID) after extraction of the filter with organic solvents
- **transparent exopolymer particles** (TEP) and **Coomassie stainable particles** (CSP) spectrophotometrically after filter staining
- **total particular carbohydrates** (PCHO) spectrophotometrically
- **chlorophyll *a*** (Chl *a*) spectrophotometrically

Calculation of nutrient fluxes:

Wet depostition flux (F_w):

$$F_w = \frac{C_w \times V(rainwater)}{A}$$

C_w – measured conentraions in rainwater
V – volume of rainwater collected
A – opening area of the collection device

Dry deposition flux (F_d):

$$F_d = C_d \times V_d$$

C_d – measured concentration of water soluble ions in the aerosol samples
V_d – deposition velocity

$V_d(NO_3^-) = 1.2\ cm\ s^{-1}$
$V_d(NH_4^+) = 0.6\ cm\ s^{-1}$
$V_d(PO_4^{3-}) = 2.0\ cm\ s^{-1}$

Enrichment factor:

$$EF(X) = [X]_{SML}/[X]_{ULW}$$

Suppression effect:

$$k_w[\%] = 32.44[SAS_{SML}] + 2.51$$

Pereira et al., Nat. Geosci., 2018

Aethalometer source apportionment of BC:

Mean ± 1σ variation and median, 1st quartile – 3rd quartile of BC_{ff} and BC_{bb} concentrations (μg m^{-3}) as well as the BC_{bb} contribution to total BC (% BC_{bb}) determined at the Central Adriatic coastal site during the period from February to June 2019, denoting different seasons: winter (February to March), spring (April to May) and summer (June).

Month	February	March	April	May	June
BC_{ff}	0.63 ± 0.58 0.42, 0.22–0.92	0.47 ± 0.37 0.39, 0.20–0.61	0.34 ± 0.28 0.28, 0.19–0.40	0.24 ± 0.22 0.19, 0.11–0.30	0.46 ± 0.23 0.43, 0.32–0.55
BC_{bb}	0.26 ± 0.20 0.21, 0.10–0.38	0.15 ± 0.15 0.10, 0.05–0.20	0.10 ± 0.10 0.07, 0.04–0.13	0.04 ± 0.04 0.03, 0.01–0.06	0.05 ± 0.04 0.05, 0.02–0.07
% BC_{bb}	32 ± 7 31, 28–35	24 ± 5 26, 21–28	22 ± 5 22, 18–26	16 ± 5 14, 12–18	10 ± 1 10, 9–11
Season	**Winter**		**Spring**		**Summer**
BC_{ff}	0.53 ± 0.47 0.39, 0.21–0.68		0.29 ± 0.26 0.23, 0.14–0.35		0.46 ± 0.23 0.43, 0.32–0.55
BC_{bb}	0.20 ± 0.18 0.13, 0.06–0.28		0.07 ± 0.08 0.05, 0.02–0.09		0.05 ± 0.04 0.05, 0.02–0.07
% BC_{bb}	28 ± 7 28, 22–31		26 ± 6 18, 14–24		10 ± 1 10, 9–11
Overall			**February – June 2019**		
BC_{ff}			0.41 ± 0.37 0.31, 0.18–0.51		
BC_{bb}			0.12 ± 0.14 0.07, 0.03–0.14		
% BC_{bb}			21 ± 8 21, 14–27		

Deposition fluxes of PO_4^{3-}, NO_3^- and NH_4^+:

Mean ± standard deviation of dry, wet and total (dry + wet) inorganic N and P deposition fluxes (µmol m^{-2} d^{-1}) and the contribution of each species to the respective total inorganic N and P deposition (in brackets) at the central Adriatic coastal site calculated when both wet and dry deposition occurred.

	Dry deposition	Wet deposition	Total deposition
NH_4^+	17.1 ± 15.1 (13 %)	59.0 ± 33.4 (41 %)	65.3 ± 33.4
NO_3^-	25.4 ± 18.9 (19 %)	39.7 ± 23.4 (27 %)	57.9 ± 21.7
PO_4^{3-}	1.4 ± 0.3 (88 %)	0.2 ± 0.1 (12 %)	1.6 ± 0.3
DIN[a]	42.5 ± 32.5 (32 %)	98.7 ± 56.2 (68 %)	123.2 ± 53.2
DIN/PO_4^{3-}	30 ± 21	648 ± 213	79 ± 30

DIN dominating in total deposition (68% wet)

PO_4^{3-} : 88% in dry deposition

2-week post-fire period:

DIN/PO_4^{3-} = 648 in wet deposition

DIN/PO_4^{3-} = 103 in total deposition (70)

Environmental implications:

Assumptions:

$C/N \sim 6.6$

i) all atmospherically deposited soluble NO_3^- and NH_4^+ are bioavailable to primary producers
ii) there is no co-limitation by other nutrients

$F_{tot}(DIN)$ = 123.2 µmol m^{-2} d^{-1} or 1.96 mg N m^{-2} d^{-1}

↓

~ 800 µmol C m^{-2} d^{-1} or **10 mg C m^{-2} d^{-1}**

Adriatic Sea (2013 – present) = 154 mg C m^{-2} d^{-1}

↓

up to **6 % of new production** in the central Adriatic coastal area

11 % considering the **highest values of DIN** deposition

BB event: k_w = 24.1 %
non BB: k_w = 7.8 %

BB k_w= **3 x** non BB k_w

↓

suppression of CO_2 exchange

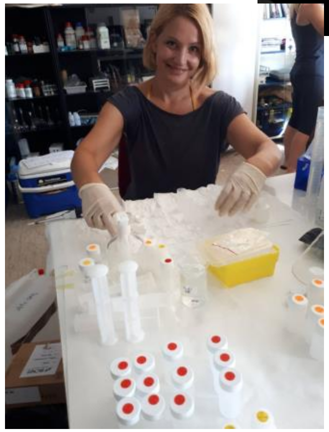













Thank you for the attention!

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Publications:

Project:

This research was financed by the Croatian Science Foundation BiREADI project (IP-2018-01-3105).