Supporting Information for

CO_2 emissions from dredged sediment as a function of moisture, temperature, and oxygen

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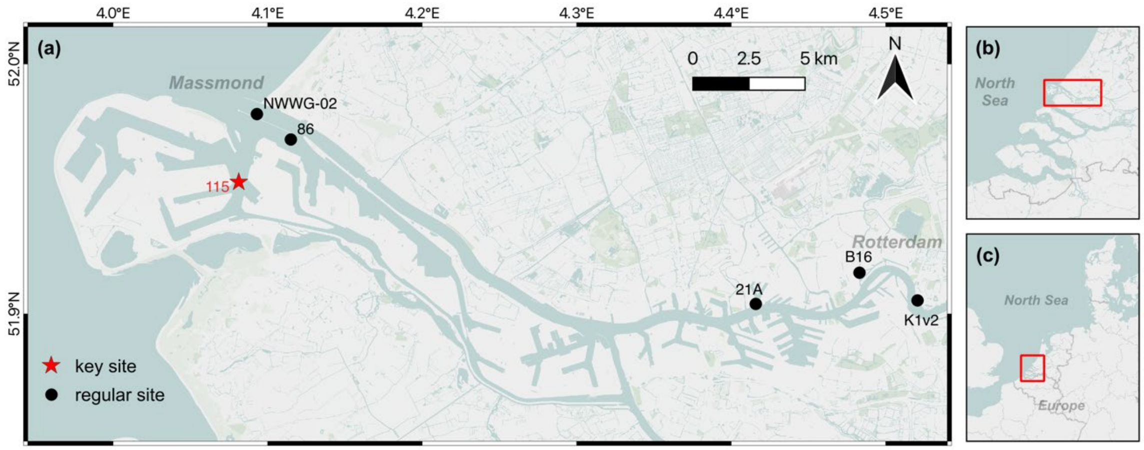

Figure S1. (a) The investigated study area and sampling sites. (b) The location of study area in the Rhine-Meuse estuary. (c) The location of Rhine-Meuse estuary in Western Europe. Map created using QGIS software. Basemap courtesy of Mapbox.

Sediment solid phase analysis

Grain size analysis: One portion of wet sediment residue (~1 g) was mixed with 50 mL of 3 g L^{-1} sodium pyrophosphate solution and gently shaken to disaggregate particles. Particle size distribution was determined using a Coulter laser particle sizer (Beckman Coulter), from which percentages of clay (0–2 μm), silt (2–63 μm), sand (63–2000 μm) and the median particle size (D50) were calculated.

TOC and TN: Approximately 10 g wet sediment residue was freeze-dried (Hetosicc freeze dryer) for 72 h and manually ground with an agate pestle and mortar, and further subsampled for carbon and nitrogen (CN) analysis. One subsample of the freeze-dried sediment (~10 mg) was directly used for measuring total nitrogen (TN) by a CN elementary analyzer (Thermo Scientific, FLASH 2000). Another freeze-dried subsample (~0.5 g), firstly treated with 1 M HCl to remove carbonates, was used for measuring total organic carbon (TOC). Certified laboratory standards (acetanilide, urea, and casein) were used for calibration with each sample. The relative standard deviation (RSD; standard deviation/mean) was <10% for TOC and TN.

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Table S1. Composition of artificial rainwater used in aerobic incubation experiments for moisture adjustment. The composition was based on the Dutch rainwater.(Harpenslager et al., 2015) Chemicals were analytical grade dissolved in milli-Q water.

Salt	Concentration (mg/L)
NaCl	3.13
$MgSO_4 \cdot 7H_2O$	1.91
$MgCl_2 \cdot 6H_2O$	1.22
$CaCl_2 \cdot H_2O$	2.58
KCl	1.61

Gas flux calculation

Gas analysis was based on a volume of 150 µL headspace gas withdrawn by a 250 µL glass, gas-tight syringe (Hamilton) with a side port needle (Hamilton, port-style 5). The headspace sample was immediately analyzed by a gas chromatograph (GC, Agilent, 8890 GC system) equipped with a Jetanizer (for CO_2 and CH_4) and a flame ionization detector (FID). Gases were carried by helium and separated by a Carboxen-1010 PLOT column (Sigma-Aldrich). The detected gas concentrations were further calibrated by certified reference gases (Scott specialty gases, Air Liquide, Eindhoven, the Netherlands). The gas fluxes were obtained from the observed changes in gas concentrations as follows:

$$\frac{dC}{dt} = \frac{\Delta C_{gas} \cdot V}{R \cdot T \cdot m_{sed} \cdot \Delta t} \quad (1)$$

where ΔC_{gas} is the change in gas concentration over the closed incubation period (µmol L^{-1}), V is the volume of the headspace (L), R is the gas constant (8.314472 L kPa K^{-1} mol^{-1}), T is the temperature (K), Δt is the time the headspace was closed off (hr), and m_{sed} is the mass of the incubated sediment sample (g dry weight).

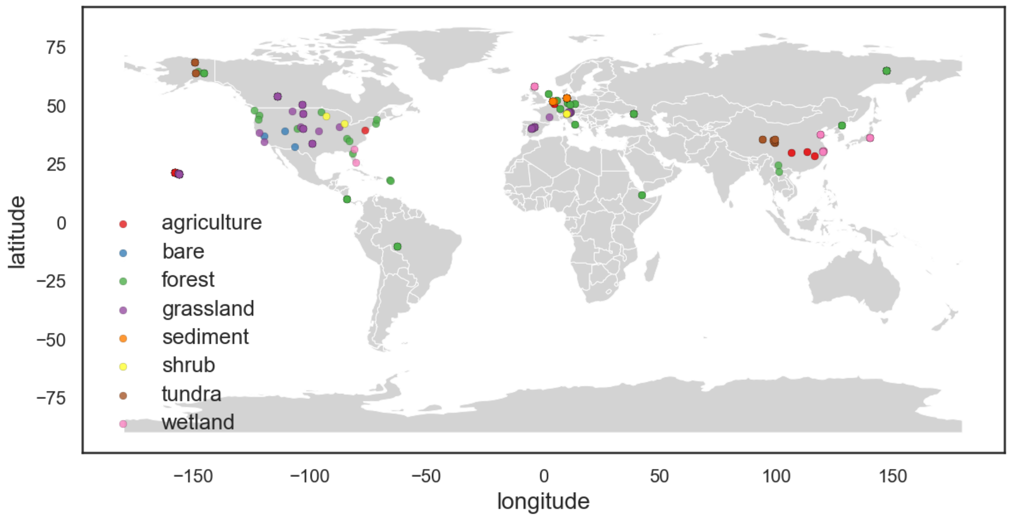

Figure S2. Geographical distribution of soil and sediment sampling locations. Colors indicate different sample types as categorized in each study.

Conversion from water holding capacity (WHC) to water-filled pore space (WFPS)

Conversion was made based on the following equations:

$$GWC = WHC \times fraction\ of\ WHC \quad (2)$$

$$VWC = \frac{GWC}{BD} \quad (3)$$

$$porosity = \frac{BD}{PD} \quad (3)$$

$$WFPS = \frac{VWC}{porosity} \quad (4)$$

Fraction of WHC (%)

WHC: water holding capacity (g H_2O g dry soil^{-1})

WFPS: water-filled pore space (ml H_2O ml bulk soil^{-1})

GWC: gravimetric soil water content (g H_2O g dry soil^{-1})

VWC: volumetric water content (ml H_2O ml bulk soil^{-1})

BD: bulk density of soil (g dry soil ml bulk soil^{-1})

PD: particle density (g dry soil ml dry soil^{-1}), here assuming 2.65 g ml^{-1}

Porosity (ml pore ml bulk soil^{-1})

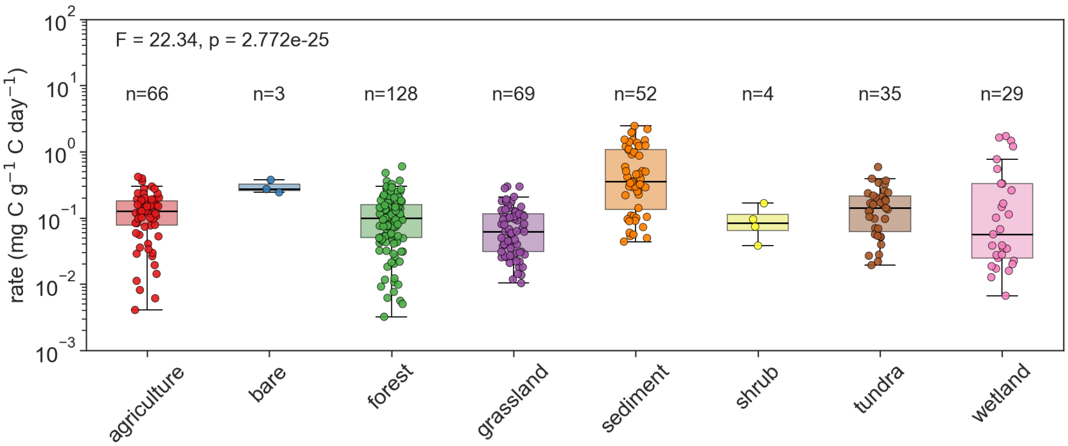

Figure S3. Carbon emission rates across different soil and sediment types during incubation experiments. Boxplots represent the distribution of rates for each habitat type, with sample sizes (n) indicated above each category.

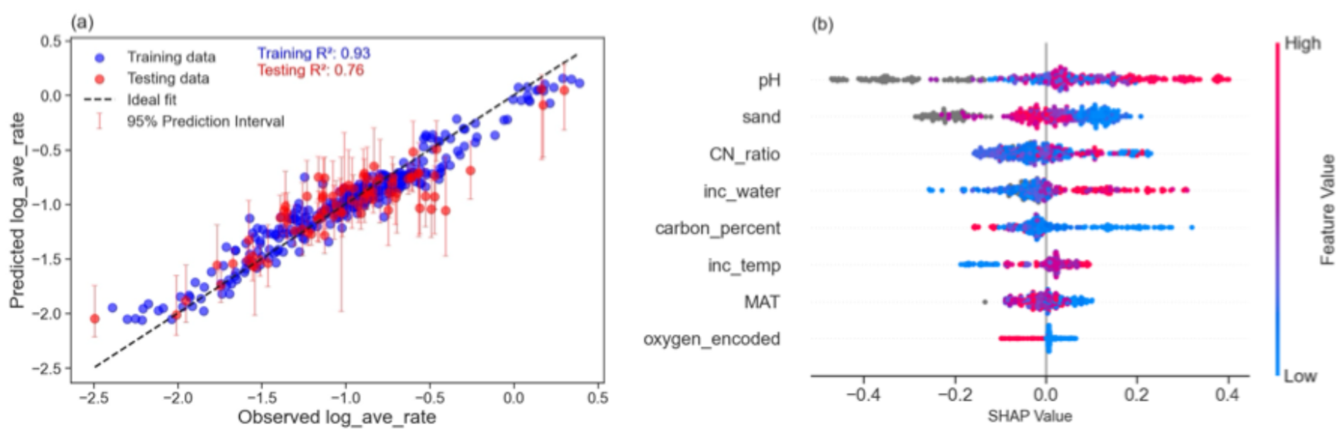

Figure S4. (a) XGBoost model performance for predicting the average carbon emission rate. (b) Beeswarm plot with SHAP values indicating feature impact on the model output.

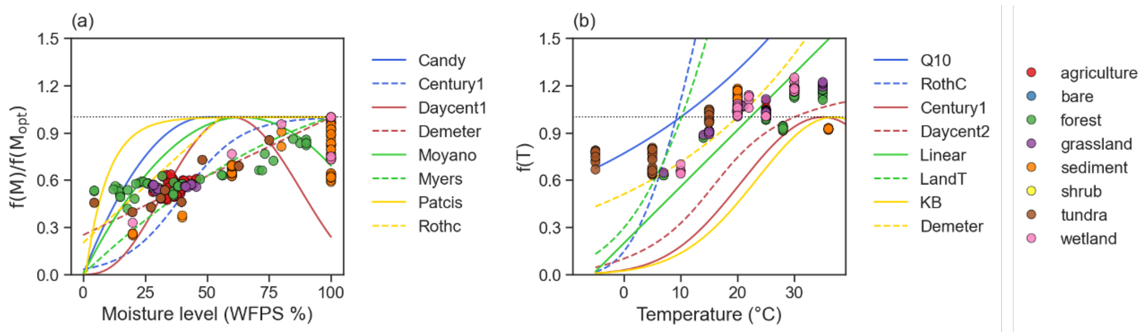

Figure S5. (a) Moisture effect normalized to the optimal moisture condition effect, also known as heterotrophic respiration (HR)-moisture relationship. (b) Temperature coefficient (f(T))-temperature relationship. Data points were derived from a global dataset. Colors indicate sample types. Horizontal dashed lines indicate the HR and f(T) equal ‘1’. Other lines represent empirical moisture functions or temperature functions commonly used in Earth system models.(Burke et al., 2003; Sierra et al., 2015; Yan et al., 2018)

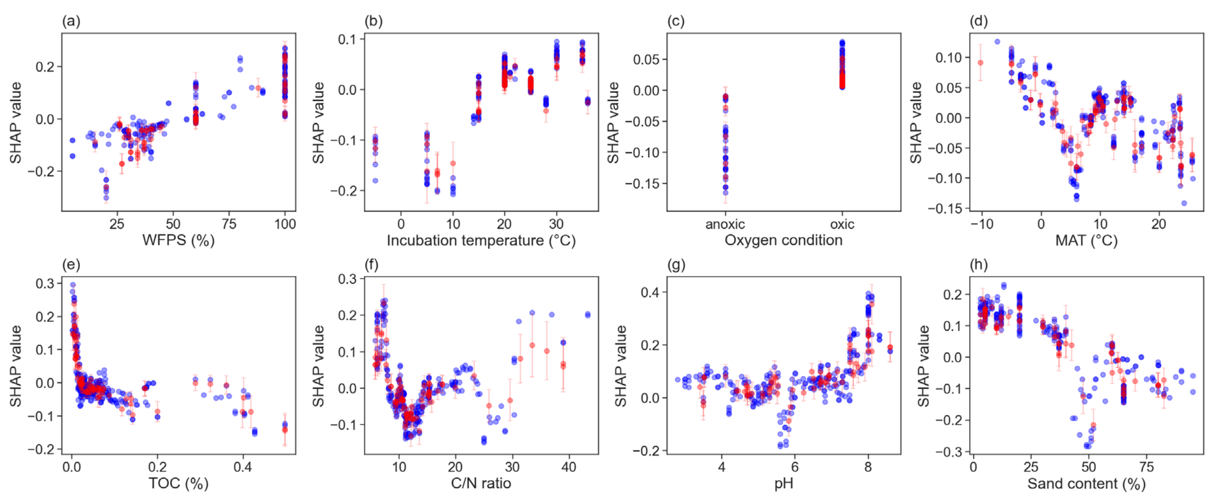

Figure S6. SHAP dependence plots for eight features contribute to the predicted average carbon emission rates by the XGBoost model. Blue dots represent training data. Red dots represent testing data with error bars representing 95% prediction interval.

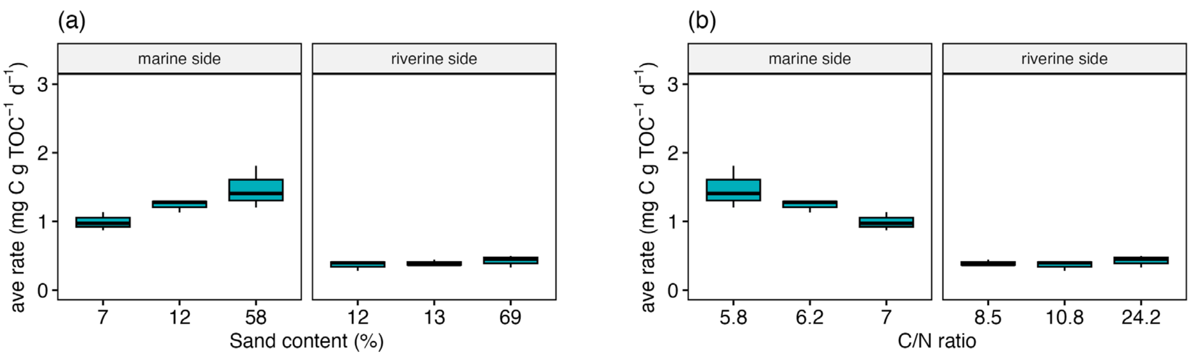

Figure S7. Carbon emission rates from dredged sediments plotted against (a) sand content and (b) C/N ratio. Sediments in the marine side include site 115, 86, and NWWG-02, while riverine sites include site 21A, B16, and K1v2 (Figure S1).

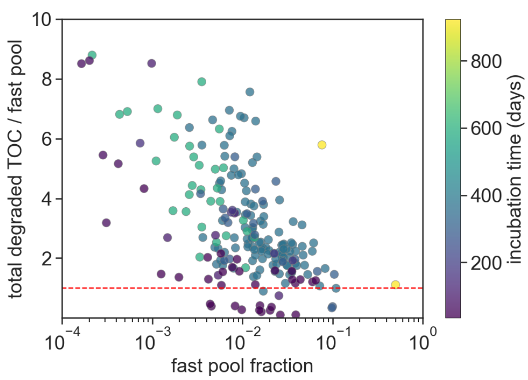

Figure S8. The ratio of total degraded carbon to fast pool size plotted against fast pool fraction. The red dashed line indicates a ratio of 1. The color gradient represents the duration of incubation experiments.

References

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