

Engaging Citizen Scientists in Sediment Collection and Analysis behind Shoreline Breakwaters

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Abstract:

This paper outlines a framework for citizen scientists to collect and analyze sediment behind shoreline breakwaters, contributing to a better understanding of coastal dynamics and the effectiveness of these structures. For almost 30 years Reef Balls have been used as shoreline breakwaters. Numerous comparative material sites exist in various ecosystems. By starting with collecting the data from Reef Ball breakwaters we will for a standardized analysis. We should also in the same regions compare natural shorelines with the same characteristics, and breakwaters from other materials. We provide a step-by-step guide on sampling methods, laboratory procedures, and data analysis techniques, emphasizing the importance of community involvement in scientific research.

Introduction:

Shoreline breakwaters are coastal structures designed to protect against erosion and wave damage. However, their impact on sediment transport and deposition is not fully understood. Citizen scientists can play a crucial role in filling this knowledge gap by collecting and analyzing sediment samples behind breakwaters.

Methods:

Sampling Methods

- Site Selection: Identify breakwaters with accessible areas for sampling.
- Sampling Equipment: Use sediment corers or grab samplers to collect samples.
- Sampling Protocol: Collect samples at regular intervals along the breakwater, noting location and depth.

Laboratory Procedures

- Sample Preparation: Dry and sieve samples to separate grain sizes.
- Grain Size Analysis: Use sieves or laser diffraction to determine grain size distribution.
- Chemical Analysis: Measure parameters like pH, salinity, and nutrient levels.

Data Analysis

- Grain Size Interpretation: Relate grain size distribution to sediment transport patterns.
- Chemical Analysis Interpretation: Relate chemical parameters to water quality and sediment sources.
- Statistical Analysis: Compare results among sampling locations and with existing data.

Results:

Present findings in a clear and concise manner, including tables, figures, and graphs.

Discussion:

Interpret results in the context of coastal dynamics and breakwater effectiveness.

Conclusion:

Citizen scientists can contribute significantly to our understanding of sediment dynamics behind shoreline breakwaters. By following this framework, communities can engage in scientific research, promoting coastal stewardship and informed decision-making.

Acknowledgments:

Recognize the contributions of citizen scientists and collaborating organizations.

Appendix:

This paper provides a foundation for citizen scientists to participate in sediment collection and analysis behind shoreline breakwaters, fostering a collaborative approach to coastal research and management.

A. Laboratory procedure to identify the percent of calcium carbonate in the sample

Procedures

- Sample Preparation: Dry and sieve samples to separate grain sizes.
- Grain Size Analysis: Use sieves or laser diffraction to determine grain size distribution.
- Chemical Analysis: Measure parameters like pH, salinity, and nutrient levels.
- Calcium Carbonate (CaCO₃) Analysis:
 - Method: Titration with hydrochloric acid (HCl)
 - Procedure:
 1. Weigh 1-2 grams of dried sediment into a conical flask.
 2. Add 10-20 mL of 1M HCl and swirl to mix.
 3. Titrate with 1M sodium hydroxide (NaOH) until the endpoint is reached (pH 7).
 4. Record the volume of NaOH used.
 - Calculation:
 1. Calculate the percentage of CaCO₃ using the following formula:
$$\text{CaCO}_3 (\%) = (\text{Volume of NaOH} \times \text{Molarity of NaOH} \times 100) / (\text{Weight of sample} \times 1000)$$
 2. Express results as a percentage of CaCO₃ in the sample.

Note: This procedure assumes a 1:1 reaction between CaCO_3 and HCl . The molarity of the HCl and NaOH solutions should be accurately determined before the analysis.

Interpretation:

The percentage of CaCO_3 in the sample can indicate the presence of shell fragments, coral, or other biogenic materials. High CaCO_3 content may suggest a higher contribution from biogenic sources, while low CaCO_3 content may indicate a greater contribution from terrigenous sources.

Example Table:

Sample ID	CaCO_3 (%)
S1	25.4
S2	12.1
S3	40.8

Example Figure:

- A bar graph showing the variation in CaCO_3 content among samples.

By including CaCO_3 analysis in the laboratory procedures, citizen scientists can gain a better understanding of the sediment composition and its potential sources, enriching their contribution to coastal research and management.

B. Identifying the percent of silicate rock in a sediment sample.

Laboratory Procedures

- Sample Preparation: Dry and sieve samples to separate grain sizes.
- Grain Size Analysis: Use sieves or laser diffraction to determine grain size distribution.
- Chemical Analysis: Measure parameters like pH, salinity, and nutrient levels.
- Calcium Carbonate (CaCO_3) Analysis: Titration with hydrochloric acid (HCl)
- Silicate Rock (SiO_2) Analysis:
 - Method: X-Ray Fluorescence (XRF) Spectrometry
 - Procedure:
 1. Prepare a homogeneous powder from the dried sediment sample.
 2. Load the powder into an XRF sample cup.
 3. Analyze the sample using an XRF spectrometer.
 4. Record the intensity of the SiO_2 peak.
 - Calculation:
 1. Calculate the percentage of SiO_2 using the following formula:
$$\text{SiO}_2 (\%) = (\text{Intensity of SiO}_2 \text{ peak} \times \text{Calibration Factor}) / (\text{Sample Weight} \times 1000)$$
 2. Express results as a percentage of SiO_2 in the sample.

Note: The XRF spectrometer should be calibrated with certified reference materials before analysis. The calibration factor should be determined using standards of known SiO₂ content.

Interpretation:

The percentage of SiO₂ in the sample can indicate the presence of silicate rocks, such as quartz, feldspar, or mica. High SiO₂ content may suggest a higher contribution from terrigenous sources, while low SiO₂ content may indicate a greater contribution from biogenic or anthropogenic sources.

Example Table:

Sample ID	CaCO ₃ (%)	SiO ₂ (%)
S1	25.4	40.2
S2	12.1	60.5
S3	40.8	20.1

Example Figure:

- A bar graph showing the variation in CaCO₃ and SiO₂ content among samples. By adding SiO₂ analysis to the laboratory procedures, citizen scientists can gain a more comprehensive understanding of the sediment composition, including the relative contributions from biogenic and terrigenous sources. This information can be used to better understand coastal processes and make informed decisions about coastal management.

C. Identifying the nutrient level in a sediment sample

Laboratory Procedures

- Sample Preparation: Dry and sieve samples to separate grain sizes.
- Grain Size Analysis: Use sieves or laser diffraction to determine grain size distribution.
- Chemical Analysis: Measure parameters like pH, salinity, and nutrient levels.
- Calcium Carbonate (CaCO₃) Analysis: Titration with hydrochloric acid (HCl)
- Silicate Rock (SiO₂) Analysis: X-Ray Fluorescence (XRF) Spectrometry
- Nutrient Analysis:
 - Method: Colorimetric Assay
 - Procedure:
 - Extract nutrients from the sediment sample using a suitable extractant (e.g., KCl or NH₄Ac).
 - Analyze the extract for nutrient levels using a spectrophotometer.

- Measure the absorbance of the sample at specific wavelengths for each nutrient (e.g., 450 nm for phosphorus, 630 nm for nitrogen).
- Compare the absorbance values to a calibration curve to determine the nutrient concentrations.
- Nutrients to be analyzed:
 - Nitrogen (N)
 - Phosphorus (P)
 - Potassium (K)
- Units: mg/kg (milligrams per kilogram) or ppm (parts per million)

Note: *The choice of extractant and analytical wavelengths may vary depending on the specific nutrient and sediment characteristics.*

Interpretation:

Nutrient levels in the sediment can indicate the potential for algal growth, microbial activity, and nutrient cycling. High nutrient levels may suggest a higher likelihood of eutrophication, while low nutrient levels may indicate nutrient limitation.

Example Table:

Sam ple ID	CaC O ₃ (%)	SiO ₂ (%)	N (mg/ kg)	P (mg/ kg)	K (mg/ kg)
S1	25.4	40.2	100	20	500
S2	12.1	60.5	50	15	300
S3	40.8	20.1	200	30	700

Example Figure:

- A bar graph showing the variation in nutrient levels among samples.

By including nutrient analysis in the laboratory procedures, citizen scientists can gain a better understanding of the sediment's potential to support algal growth and microbial activity, and how these processes may impact coastal ecosystems.

D. Determining Salinity of Sediment Samples

Method: Conductivity Measurement

Equipment:

- Conductivity meter or probe
- Sediment sample
- Distilled water (for calibration)

Procedure:

1. Calibrate the conductivity meter: Measure the conductivity of distilled water (0 ppt salinity) and a standard salt solution (e.g., 35 ppt salinity) to ensure accurate readings.
2. Prepare the sediment sample: Mix 1-2 grams of dried sediment with 10-20 mL of distilled water to create a sediment slurry.
3. Measure conductivity: Insert the conductivity probe into the sediment slurry and record the conductivity value (usually in microsiemens per centimeter, $\mu\text{S}/\text{cm}$).
4. Convert conductivity to salinity: Use a conductivity-salinity conversion chart or equation to determine the salinity of the sediment sample (usually in parts per thousand, ppt).

Example Conversion Equation:

$$\text{Salinity (ppt)} = (\text{Conductivity } (\mu\text{S}/\text{cm}) \times 0.013) + 0.25$$

Interpretation:

- Low salinity values (<10 ppt) indicate freshwater or low-salinity sediment sources.
- Moderate salinity values (10-30 ppt) suggest a mix of freshwater and marine influences.
- High salinity values (>30 ppt) indicate marine or hypersaline sediment sources.

Example Table:

Sample ID	Conductivity ($\mu\text{S}/\text{cm}$)	Salinity (ppt)
S1	250	3.25
S2	500	6.50
S3	1000	13.00

By measuring the conductivity of sediment samples, citizen scientists can determine the salinity of the sediment and gain insights into the sediment's origin, transport mechanisms, and potential impacts on coastal ecosystems.

E. Determining pH of Sediment Samples

Method: pH Measurement using pH Paper or pH Meter

Equipment:

- pH paper (pH 3-10 or pH 4-9)
- pH meter (optional)
- Sediment sample
- Distilled water (for calibration)

Procedure:

Using pH Paper:

1. Prepare the sediment sample: Mix 1-2 grams of dried sediment with 10-20 mL of distilled water to create a sediment slurry.
2. Dip the pH paper: Submerge the pH paper into the sediment slurry for 1-2 seconds.
3. Compare the color: Match the resulting color on the pH paper to the corresponding pH value on the reference chart.

Using a pH Meter:

1. Calibrate the pH meter: Measure the pH of a buffer solution (e.g., pH 4, 7, or 10) to ensure accurate readings.
2. Prepare the sediment sample: Mix 1-2 grams of dried sediment with 10-20 mL of distilled water to create a sediment slurry.
3. Measure the pH: Insert the pH probe into the sediment slurry and record the pH value.

Interpretation:

- Acidic pH values (<7) indicate high concentrations of acidic compounds or organic matter.
- Neutral pH values (7) suggest a balanced sediment composition.
- Basic pH values (>7) indicate high concentrations of basic compounds or calcium carbonate.

Example Table:

Sample ID	pH (pH Paper)	pH (pH Meter)
S1	6.5	6.4 ± 0.1
S2	7.5	7.6 ± 0.1
S3	5.5	5.4 ± 0.1

By measuring the pH of sediment samples, citizen scientists can determine the acidity or basicity of the sediment and gain insights into the sediment's composition, potential sources, and environmental implications.

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