Porosity Quantification in Flocs

A Multi-Scale Quantification of Pore Space in Flocculated Sediments

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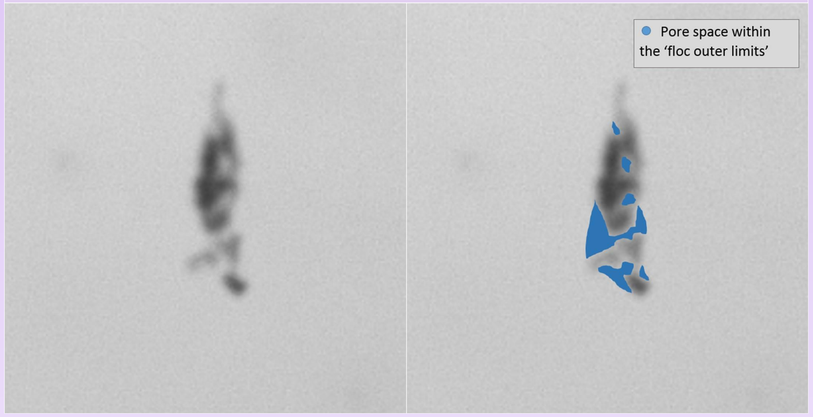
1 Introduction

- Flocculated sediments (flocs) play an important role in determining the fate of contaminants and pollutants in rivers and estuaries[1].
- Despite this, their internal structure is poorly understood, due partly to a lack of quantification of internal constituents.
- Pore space has a crucial influence on factors such as settling rate and stability of the floc in the water column[2].
- In order to fully understand the effects of porosity, it must be measured on multiple scales (gross scale (mm); micro scale (µm); and nano scale (nm)).

2 Method #1: LabSFLOC

- LabSFLOC is a settling column that facilitates video recording in order to collect settling data that can later be processed into settling velocity[3].
- In this instance, it was used to collect settling data in order to define the 'floc outer limits' of the pores present in the flocs.

3 LabSFLOC still image with pore limits (fig. 1)



4 Method #2: micro-CT scan & Fiji processing

- In order to analyse a floc on the micro scale, a µ-CT scan was performed.
- Before scanning, the sample underwent capture, staining, and was then set in a resin block.
- Fiji's '3D object counter' and 'Analyze Particles' were applied to the resulting image stack.
- This produced fig. 3, and the '3D viewer' allowed fig. 2 to be rendered from both the original stack and the '3D object counter' result.

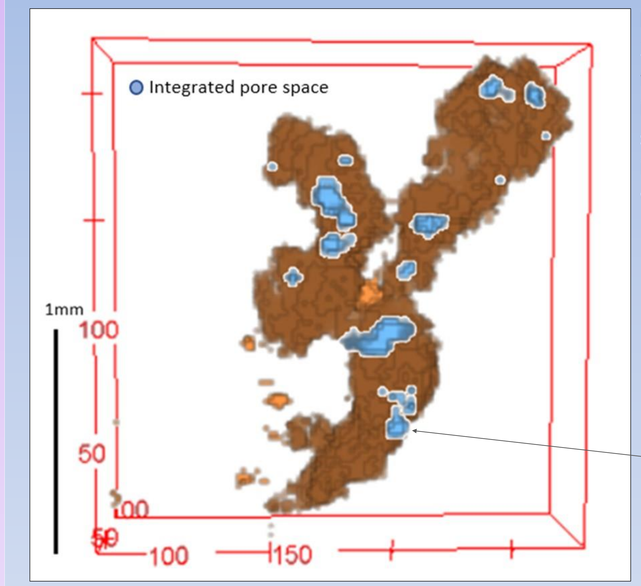


Fig. 2. 3D rendering of a floc with integrated pore space overlain to indicate location within the floc.

Fig. 3. Measurement statistics for 'pore 1', including total area and length

micro-CT slice number	*Pore pixel Area (pix²)*	***Pore Length (longest axis) (µm)***
68	29	**58**
69	48	**71**
70	62	**77**
71	59	**78**
72	45	**76**
73	29	**48**
74	13	**28**

5 Results

LabSFLOC:

- The blue highlighted areas are a preliminary indication of a definition of the 'floc outer limits', within which the empty space is considered pore space.
- This pore space can then be measured to provide porosity data on the gross scale (mm).

micro-CT:

- The 3D rendering with superimposed pore spaces shows the locations of the internal pores of the floc (fig.2).
- These pores are unlike those identified in the LabSFLOC data, as they are isolated within the structure, however open pores can also be measured.
- 'Pore 1' was identified in the image stack data and subsequently in the 'analyze particles' data which allowed size analysis to take place (fig.3).
- The data shows the pore length in each slice of the image stack, from which a 3D size and shape will be calculated.

6 Further work

- Once the pore space is measured from the LabSFLOC image, it can be compared statistically to other measurements from other flocs to determine statistical representativeness.
- Similarly, the size and shape of the open pores in the micro-CT data can be compared in this way.
- These statistical datasets can then be compared to determine whether there is a significant variation between porosity measured at different scales.
- Furthermore, nano-scale analysis using SEM imaging will be performed to add a further scale of comparison to the overall dataset.

References:

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[2]Manning, A.J; Baugh, J.V; Spearman, J.R; Whitehouse, R.J.S (2010) Flocculation Settling Characteristics of Mud: Sand Mixtures, *Ocean Dynamics* 60, 237-253

[3]Manning, A.J (2006) LabSFLOC – a laboratory system to determine the spectral characteristics of flocculating cohesive sediments, *HR Wallingford Technical Report* 156

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