

Optical Properties of Natural Organic Matter in the Yukon River Basin (Extended Abstract)

CÉLINE GUÉGUEN, DELI WANG and LAODONG GUO

International Arctic Research Center, University of Alaska Fairbanks,
Fairbanks, AK 99775, USA

(Received November 21, 2002)

Introduction

The Yukon River is one of the largest rivers draining into the Arctic with an annual discharge of more than 200 billion m³ of freshwater and contributes ~8% of the total freshwater to the Arctic Ocean. Colored dissolved organic matter (CDOM) derived from riverine waters can be used as a potential water masses tracer (Coble, 1996; de Souza Sierra *et al.*, 1994) and may play a critical role in radiative transfer of light in the ocean and remote sensing of primary production (e.g. Mobley, 1994). However, the amount and nature of terrestrial CDOM entering the Arctic Ocean via the Yukon River basin remain largely unknown. This study aimed to fractionate the dissolved organic matter (DOM) into two sized fractions added during snow melting and soil leaching, and to systemically characterize their optical properties and their seasonal variations.

Experimental

Monthly water samples were collected from the Yukon River at the Yukon River Bridge station, Alaska (Lat. 65°52'N, Long. 149°43'W) from May to September 2002 (Table 1). The first samples were collected under partially ice cover (YR-01) and during snow melting (YR-02 and YR-03). Surface water samples were obtained with a Teflon pumping system at 1 m-depth. Water samples were collected in acid cleaned plastic containers and filtered either in situ or within 4 hours through a 0.45 µm regenerated cellulose cartridge (Osmonics) (Figure 1). Immediately after filtration, the tangential flow ultrafiltration (UF) equipped with a 1 kDa regenerated cellulose cartridge (Amicon, S10Y1) was used to fractionate the bulk DOM into high molecular weight (HMW, 0.45 µm-1 kDa) and low molecular weight (LMW, <1 kDa) fractions in the laboratory (Guéguen *et al.*, 2001; Guo *et al.*, 2000). The concentration factors (Cf) applied for ultrafiltration were between 7 and 13 (Table 1).

Aliquots of dissolved (<0.45 µm), HMW (0.45 µm-1 kDa) and LMW (<1 kDa) fractions were collected and kept in amber glass flasks, previously combusted at 550°C for 6 hours. Sub-samples for dissolved organic carbon (DOC) analysis were acidified with HCl to pH=2 immediately upon collection and stored at 4°C in the dark until analysis. The measurements were performed with a Shimadzu Total Organic Carbon Analyzer

Table 1. Yukon River sampling and dissolved organic matter contents.

Station	Date	Discharge (m ³ /s)	Cf	DOC (mg/L)	HMW %	S (nm ⁻¹)
YR-01	May 15	991	9.0	33.9±0.6	84	0.015
YR-02	May 31	10,337	9.4	13.9±0.2	73	0.015
YR-03	June 14	7,080	6.7	8.7±0.1	74	0.016
YR-04	July 12	5,721	9.3	6.7±0.1	67	0.016
YR-05	Aug. 9	4,984	9.9	6.1±0.0	72	0.017
YR-06	Sept. 12	5,098	13.0	6.4±0.1	68	0.017

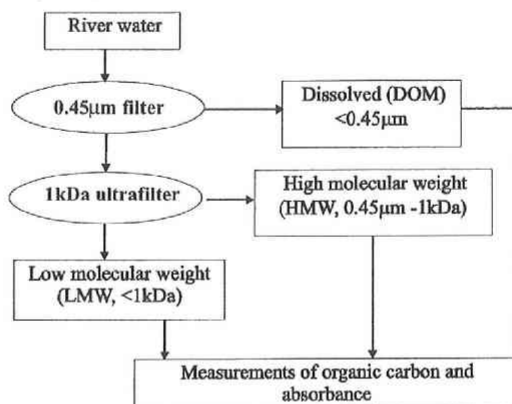


Figure 1. Schematic of organic matter size fractionation using filtration and ultrafiltration.

(Shimadzu TOC-V). DOC was measured as non-purgeable organic carbon (Guo *et al.*, 1995). The acidified sample was sparged with high purity air for 5 min to remove the inorganic carbon, then injected into a combustion tube which is packed with catalyst and kept at 680°C. The CO₂ formed was thus measured by nondispersive infrared detection.

The absorbance was measured by a UV-Vis spectroscopy (Agilent 8453) using a 1 cm pathlength quartz cell, and the full spectra from 200 to 900 nm was recorded. Absorption coefficients were derived from :

$$a(\lambda) = 2.303 A(\lambda)/L$$

where $A(\lambda)$ is the absorbance and L the pathlength of the absorbance cell in meters. Absorbance data were corrected for baseline offsets by subtracting the absorbance value at 550 nm. The spectral slopes, $S(\text{nm}^{-1})$, were determined using least squares linear regression of log-linearized adsorption data. The spectral range used to calculate S was 270–450 nm.

Results and discussion

Dissolved organic carbon—DOC concentration decreased from 34 mg-C/L in mid-May to <7 mg-C/L during ice open season (Table 1). As shown in Table 1, the most significant change in DOC concentration occurred in spring during snow melting and soil leaching. After river opening, DOC concentrations were almost constant at 6.4 ± 0.3 mg/L from July to September. Within the total DOM pool, up to 84% of the total DOC was observed in the HMW (or colloidal) fraction in mid-May. This colloidal portion also decreased slightly from May (84 %) to September (69%).

Absorbance—There is a significant correlation between the UV absorbance and concentrations of DOC for all fractions taken in the Yukon River (Figure 2). Measurements of UV absorbance at 254 nm can be considered to be informative and useful as indicators of the abundance of DOM in river waters.

The parameter, *S*, defines the spectral dependence of the CDOM absorption coefficient and thus provides information about the nature of CDOM (Bricaud *et al.*, 1981; Blough and del Vecchio, 2002 and references therein). *S* values of the dissolved fraction were slightly lower during the snow melting than in summer (from July to September) (Table 1). Larger fluctuations were observed in the size fractionated DOM samples (Figure 3).

It can be noted that higher *S* value was measured in the LMW DOM, which is in agreement with increased *S* with decreasing molecular weight (Blough and Green, 1995). During the ice-melting period, *S* values decreased, indicating an increase in MW for CDOM. This may be due to the presence of pedogenic organic matter exported into the river from leaching of drainage basin during the snow melting. From July to September, *S* values were higher and CDOM contained lower MW compounds. Based on the properties of humic substances, this increase of *S* value suggests a loss of aromaticity of the CDOM pool.

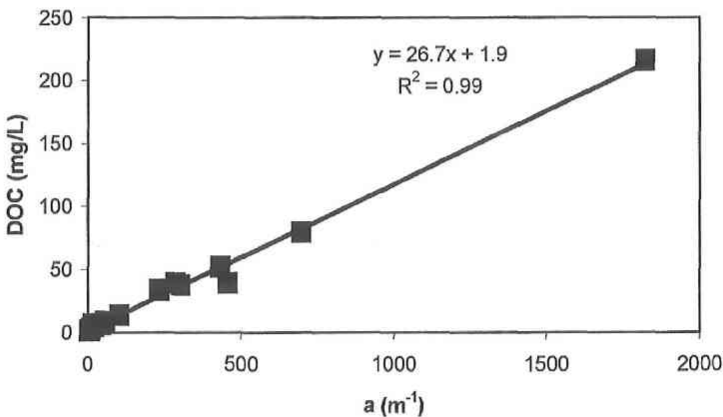


Figure 2. Dissolved organic carbon vs absorption coefficient (254 nm) for Yukon River waters, including dissolved, HMW and LMW fractions.

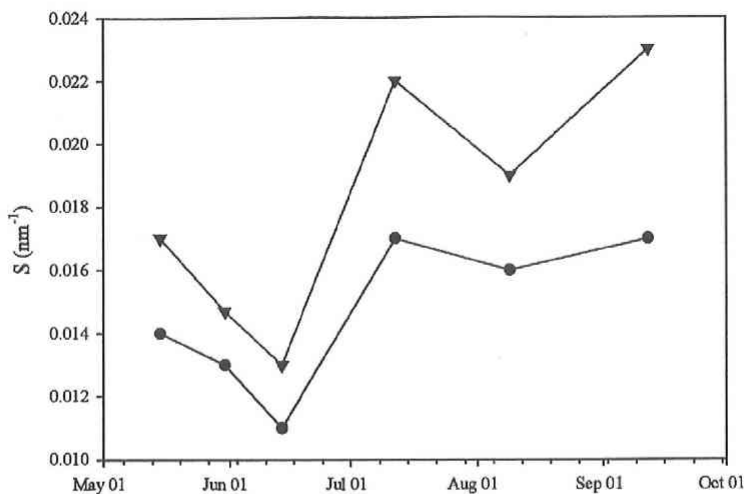


Figure 3. Values of S obtained for CDOM absorption spectra for size-fractionated fractions (● HMW and ▼ LMW)

Conclusions

The optical properties and abundance of DOM in Yukon River waters were determined from May to September. While the characteristics of dissolved fraction were relatively constant, the size fractionated fractions, HMW and LMW, showed meaningful variations in term of origin and molecular weight. The snow melting was accompanied by important terrestrial inputs and diverse DOM components entering into the Yukon River. On the other hand, the open season was characterised by lower DOM concentration and smaller MW in the CDOM pool.

Acknowledgements: This work was supported by Frontier Observational Research System for Global Change/IARC and a Swiss NSF fellowship.

References

- Blough N.V., Del Vecchio R., 2002: Chromophoric DOM in the coastal environment. In D.A. Hansell & C.A. Carlson (Eds) *Biogeochemistry of marine dissolved organic matter*. Elsevier, San Diego, 509-546.
- Blough N.V., Green S.A., 1995: Spectroscopy characterization and remote sensing of non-living organic matter. In R.G. Zepp and C. Sonntag (Eds) *The role of non-living organic matter in the Earth's carbon cycle*. Wiley, Chichester, 23-45.
- Bricaud A., Morel A., Prieur L., 1981: Absorption by dissolved organic matter in the sea (yellow substance) in the UV and visible domains. *Limnol. Oceanogr.*, **26**, 43-53.
- Coble P.G. 1996: Characterization of marine and terrestrial DOM in seawater using excitation-emission matrix spectroscopy. *Mar. Chem.*, **51**, 325-346.
- De Souza Sierra M.M., Donard O.F.X., Lamotte M., Belin C., Ewald M., 1994: Fluorescence spectroscopy of coastal and marine waters. *Mar. Chem.*, **47**, 127-144.
- Guéguen C., Belin C., Dominik J., 2002: Organic colloid separation in contrasting aquatic environ-

- ments with tangential flow filtration. *Wat. Res.*, **36**, 1677-1684.
- Guo, L., Santschi, P.H. and Warnken, K.W., 1995 : Dynamics of dissolved organic carbon in oceanic environments. *Limnol. Oceanogr.*, **40**, 1392-1403.
- Guo L., Wen L., Tang D., Santschi P.H., 2000 : Re-examination of cross flow ultrafiltration for sampling aquatic colloids : evidence from molecular probes. *Mar. Chem.*, **69**, 75-90.
- Mobley C.D. 1994 : Light and water : radiative transfer in natural waters. Academic press, New York. 592 p.