

## IMPORTANCE OF SMALL PARTICLES FOR THE BIOGEOCHEMISTRY OF ESTUARINE AND COASTAL ARCTIC SYSTEMS

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The Arctic Ocean is unique for its ice cover and limited water exchange with surrounding oceans. During a long time, the Arctic system was forgotten and the role of Arctic and adjacent marginal seas in the global budgets was neglected. The Siberian aquatorium is of interest because of considerable discharge of major world rivers such as the Lena, Ob, Yana and Yenissei. The joint French-Russian «SBASIBA» Research Programme, which was part of the international project «River-Ocean», had such as aim to understand the principal biogeochemical processes involving organic matter, trace elements, living biomass,... in the most greater Siberian rivers and their influence in the Arctic System. Here, we present the results concerning the role of the small particulate matter and their characterization and the principal processes involving dissolved reactive organic matter, obtained during the second SPASIBA cruise (September, 1991) in the Lena and Laptev system. The aim of this study was to understand the role that small particles (0.2-10  $\mu\text{m}$ ) can have on the biogeochemistry of estuarine and coastal waters of Arctic sea.

### Study area

The Lena River Delta (75N°, 130°E) is located on the coast of the Laptev Sea which is part of the East Siberian Basin (Russia). The mean river discharge is 16 650  $\text{m}^3 \text{s}^{-1}$ . The Lena River represents the second largest river discharging into the Arctic Ocean after the Yenissei (19 100  $\text{m}^3 \text{s}^{-1}$ ) and the eighth major river of the world. However, the monthly average discharge exhibits large variations ranging from 1 220  $\text{m}^3 \text{s}^{-1}$  in April to 73 700  $\text{m}^3 \text{s}^{-1}$  in June (Gordeev and Sidorov, 1993). Most of the Lena River water is supplied by the mountainous watersheds located in south-eastern Siberia; it reaches the Sea through four major delta branches (Letolle et al., 1993). The annual discharge of suspended sediments is estimated to be 17.6 \*10<sup>6</sup> t year<sup>-1</sup>, corresponding to an average suspended sediment load of 34 mg l<sup>-1</sup> (Gordeev and Sidorov, 1993). The Lena River is characterized by «black» waters, enriched in organic matter (Cauwet and Sidorov, 1996).

### Methodolgy of Analyses

We have used a flow cytometer (FCM) to characterize and to differentiate organic - inorganic (mineral) particles, and organic living – organic non living (which involve organic detritus, organic coatings) particles based on the scheme developed by Moreira-Turcq et al., 1998. At the same time we have carried out adsorption experiments, used to evaluate the nature and capability of natural dissolved organic matter to coat onto alumina particles ( $\text{Al}_2\text{O}_3$ ). The experiments were performed with natural water filtered on the GF/F pre-combusted filters and 25 mg l<sup>-1</sup> of  $\text{Al}_2\text{O}_3$ . The nature of this most reactive dissolved organic matter was determined using specific fluorescent dyes for proteins and different polysaccharides (Sigma reagents), and after analyzed by FCM.

## Results and Discussion

In the Lena-Laptev system total concentration of small suspended particles (0.2-10  $\mu\text{m}$ ) demonstrates a good correlation ( $r^2=0.8$ ) with salinity, which corresponds to an apparently conservative behavior during the mixing, but several processes seem to occur simultaneously. While mineral particles represent the majority in the Lena River (up to 90%), organic particles are dominant in Laptev Sea (up to 68%). We observe a simultaneous decrease on the concentration of mineral particles and an increase of organic particles in the coastal zone due to flocculation and adsorption processes and subsequent sedimentation. In Lena River organic non living particles (detritus) have basically a continental origin, while in Laptev Sea detritus material almost originate from degradation of marine organisms. Picoplankton biomass (organic living particles) varied between 6 and 56  $\mu\text{gC l}^{-1}$  in surface waters. The highest picoplankton biomass (56  $\mu\text{gC l}^{-1}$ ) was found at salinity 3.7 in the delta and represents ca 85% of the photosynthetic organisms and 15% of the POC (Figure 1). This high biomass is probably stimulated by the supply of nutrients and the lower turbidity in this region. In the coastal region of Laptev Sea, the picoplankton biomass reached 51  $\mu\text{gC l}^{-1}$  (Figure 1) at the surface (salinity 13.4 ‰). Picoplankton biomass decreased with depth, but picoeukaryotes were still observed in deep (20, 30 m) samples in the open Laptev Sea, showing a considerable autotrophic activity in spite of low temperatures. These data point out that these small organisms can play an important role in the transfer of organic carbon from rivers to seas.

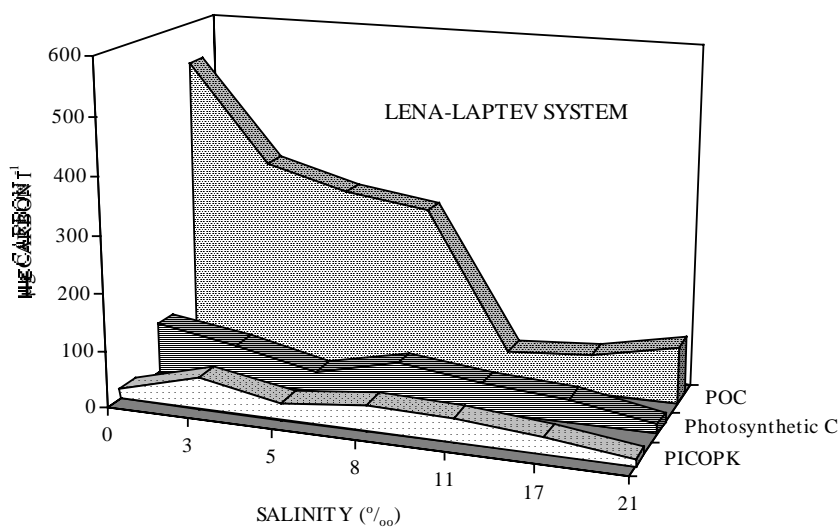


Figure 1: Picoplankton biomass (PICOPK), total autotrophic phytoplankton biomass (CHLa), and particulate organic carbon (POC) in a horizontal salinity gradient. Picoplankton biomass (PICOPK), total autotrophic phytoplankton biomass (CHLa), and particulate organic carbon (POC) in a horizontal salinity gradient in Lena-Laptev System.

Adsorption experiments permitted to point out the occurrence and importance of sorptive processes in the system. In the coastal region of Lena Delta and in Laptev Sea, we observed a

high percentage of fluorescent organic matter (proteins and carbohydrates) adsorbed onto alumina particles and characterized by a low fluorescence intensity. Conversely, the Lena River presents a low percentage of fluorescent particles adsorbed onto alumina particles and a high fluorescence intensity. These differences are related (1) to different concentrations of natural suspended matter loads and (2) principally, to different compositions of natural organic matter: products of degradation and excretion of phytoplankton and bacteria membranes, in Laptev sea, humic substances in Lena river.

This process associated to others such as flocculation, coagulation and sedimentation involving organic matter and mineral particles are the main responsible for composition, form and concentration of the matter exported to Arctic waters from Lena-Laptev system.

### **Conclusions and Perspectives**

Small particles carried by estuarine waters and produced on coastal waters can be of primordial importance for biogeochemical processes occurring in the Arctic system, mainly as part of picoautotrophic activity and for the transport of dissolved material. These small particles represent numerous free sites for adsorption of ions and organic dissolved material and are important contributors to plant biomass and to total particulate carbon transported in arctic estuaries and coastal zones.

A great part of matter present in Arctic waters is supplied by river inputs, which are of great importance in this area. Future researches, coupling hydrological and biogeochemical studies, during different seasons in the coastal zones of Arctic seas, are of fundamental importance to know the origin and nature of the organic matter that can be coexisting in the Arctic waters and can be exported to surrounding areas. Their role in the global carbon budget must also be evaluated.

### **References**

- Cauwet, G., Sidorov, I., 1996. The biogeochemistry of Lena river: organic carbon and nutrients distribution. *Marine Chemistry*, **53**: 211-227.
- Gordeev, V.V. and Sidorov, I., 1993. Concentrations of majors elements and their outflow into the Laptev Sea by the Lena River. *Marine Chemistry*, **43**: 33-45.
- Letolle, R., Martin, J.M., Thomas, A.J., Gordeev, V.V.,Gusarova, S. and Sidorov, I.S., 1993. <sup>18</sup>O abundance and dissolved silicate in the Lena Delta and Laptev Sea (Russia). *Marine Chemistry*, **43**: 47-64.
- Moreira-Turcq, P.F., Martin, J.M., 1998. Characterisation of fine particles by flow cytometry in estuarine and coastal arctic waters. *Journal of Sea Research*, **39**: 217-226.