PROPERTIES OF SEDIMENTS FROM THE NEW YORK/NEW JERSEY HARBOR*

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Sediments in the rivers, lakes and estuaries of the United States are widely contaminated by organic and inorganic compounds of anthropogenic origin. In many instances there is need for remedial action to ameliorate their environmental impact and potential risks to human health. In other cases, dredging is required to maintain and improve navigation channels used for commercial purposes. The New York/New Jersey Harbor is a specific example of a location where actions need to be taken to reduce the effects of contaminants for both environmental and practical reasons. For example, navigational dredging is required to maintain channel depths and for channel deepening to accommodate larger container ships. Approximately 1,500,000 m^3 of dredged material must be disposed of on upland locations each year. The Passaic River in New Jersey may require remediation for environmental reasons and indirectly, since it is a source of pollutants that can degrade sediment quality in other sections of the Harbor. Thus, there is a practical need to understand the properties of Harbor sediments and the behavior of associated contaminants in the environment in a way that integrates scientific investigations with the other features involved in creating a Harbor that meets environmental, recreational, and commercial needs.

We, and our collaborators, have carried out a number of investigations of the Harbor sediments using several different synchrotron-based analytical methods that are relevant to different aspects of the contaminated sediment problem. Our work has included use of four beam lines at the National Synchrotron Light Source and one beam line at the European Synchrotron Radiation Facility (ESRF). The experiments are discussed briefly below.

Knowledge of the microstructure of sediments can be useful in understanding sedimentation processes and the transport of contaminants by advection. Computed microtomography at NSLS beam line X27A was used to investigate the three-dimensional structure of a sandy sediment. The data are used to obtain values for the porosity as a function of depth through the sample and on the connectivity of the pore space. The results can be compared to theoretical models for the sedimentation process and used as the basis for modeling pore-scale contaminant advective-diffusive transport.

The distribution of metals on individual whole-sediment grains (diameters > 30 μm) was investigated with micro x-ray fluorescence at NSLS beam line X26A. The measurements showed that most of the grains contained contaminants. Our results did not allow us to

determine whether the contaminants were associated with the particle surface or with an organic film on the particle surface.

Further information on the metal distributions was obtained by study of single particle using fluorescent computed microtomography at the ID-13 beam line at the ESRF. Measurements were made on sediments from the Harbor and from the North Sea. Some elements were distributed through the particles while others were found on the surface and could be associated with smaller particles on the surface.

The relation of carbonaceous materials with respect to clay particles was investigated using scanning transmission x-ray microscopy at the NSLS X1A beam line. The measurements were made around the carbon K-x ray absorption edge. The results helped to give information on the morphology of the organic materials and sediments associated with them. The results may be useful in developing a better understanding of sediment-washing procedures designed to separate the organic materials from the sediment particles as part of a cleaning process. The functional groups of the organic compounds were investigated through x-ray near-edge spectroscopy measurements for carbon. Results indicate that Harbor organic materials give spectra substantially different from those obtained for humic substance standards.

We made further investigations of the functional groups occurring in the sediments using Fourier Transform Infrared Spectroscopy (FTIR) at the NSLS beam line U2B. Measurements were made on the raw sediments, on the liquids obtained from extraction with water, alcohol, and hexane, and on size fractions obtained after filtration to obtain size fractions <1.5 μm and <0.45 μm. The investigations demonstrated the heterogeneity of the sediments and for the materials extracted from them. Preliminary assignments of functional groups have been made to some spectral features. The results also show that application of FTIR could be useful for rapid assessment of the effectiveness of sediment washing decontamination technologies.

Finally, we used micro x-ray fluorescence at the NSLS beam line X26A to investigate mercury distributions in the hair of subjects from two epidemiological studies. Mercury concentrations in the hair have been used to determine mercury intake from fish consumption in efforts to understand the magnitude of possible health effects on childhood development. The results will be useful in giving better spatial (time) resolution than possible with non-synchrotron x-ray sources and in understanding where the mercury resides in the hair structure. The results will help improve the data used in the epidemiological studies that are used to set limits on fish consumption. This is important for the Harbor since mercury levels there are affected by anthropogenic mercury sources.

We believe that the experiments discussed show that there are a number of synchrotron x-ray techniques that are useful for investigations of the complex sediment systems found in the New York/New Jersey Harbor. The experiments give information that is useful for understanding the characteristics of the sediments and associated organic and inorganic

contaminants. The results have use in application of decontamination technologies, creation of beneficial use products, and setting of environmental regulations.

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