Sediment quality assessment of lakes in the conterminous U.S.

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Lakebed deposits, or sediments, are an incredible archive and can provide insight into historic, ongoing, and potential stress to ecosystems and human health. One aspect of understanding the potential for ecosystem stress is to examine contaminants within sediment, which are chemicals including metals, metalloids, and organic compounds. There are multiple ways these chemicals can be transported to lakes such as through point sources, atmospheric deposition, and surface runoff from surrounding watersheds. Some may be natural processes such as bank erosion, mineral weathering, forest fires and some are due to human activity such as industrial, urban and agricultural runoff; oil and chemical spills; hazardous waste incineration and coal burning. These contaminants can then accumulate in sediment over time and pose a risk to aquatic life directly through toxicity as well through bioaccumulation and biomagnification in the food chain, potentially affecting wildlife and humans that consume them.

Typically, sediment contaminant measures are focused on lakes with known concerns. In contrast, this study samples a broad range of lakes where the contaminant status was initially unknown. In 2017, the USEPA in partnership with states and tribes conducted the first national scale survey of sediment quality of inland lakes as part of the National Lakes Assessment under the National Aquatic Resource Survey program.

What did we do?

Sediment samples were collected from 969 lakes and reservoirs from across the United States. In each sample, the top 5cm of surficial sediment was collected from a single spot near the deepest location of each lake using a corer as shown in Figure 1. These samples were analyzed at a single laboratory for 127 unique parameters including 16 metal(loids), 25 polycyclic aromatic hydrocarbons (PAHs), 53 polychlorinated biphenyl (PCBs) congeners, 27 legacy pesticides and metabolites, total organic carbon and grain size. Once the samples were analyzed, the results were interpreted using an effects-based approach that represents the likelihood of sediment toxicity to bottom-dwelling organisms. More specifically, we used consensus-based sediment quality guidelines and an integrative chemical index of mean probable effect concentration quotients. To align the sediment results with other NLA indicator categories, sediment quality was categorized into three condition categories based on mean probable effect concentration quotients. The "good" condition corresponds to a low incidence of toxicity to benthic dwellers, the "fair" condition is associated with less known incidence of toxicity and a "poor" condition with a high incidence of sediment toxicity.

A subset of the data was further analyzed to calculate ambient background values that include natural and or diffuse anthropogenic sources. By utilizing USEPA software, proUCL an upper tolerance limit UTL95-95 was calculated for Minnesota and several ecoregions. This helps explore the possibility of developing another approach for environmental

Figure 1. NLA field team measuring to ensure collection of the top 5 cm from the sediment core.

practitioners to explore when evaluating sediment data and clean up goals. Results were also compared against lake, watershed and land use parameters.

What we learned

Sediment quality in U.S. lakes was mostly in good or fair condition. Our analysis suggests that approximately 26 percent of lakes were in good condition, 69 percent were in fair condition, and 2 percent of lakes were in poor condition (Figure 2). Deeper lakes tended to have higher concentrations of metals and PAHs than shallow lakes. While the pattern is clear, this study could not determine whether these higher contaminant levels were the result of natural enrichment or human activity around lakes. On a landscape scale, lower elevation lakes were also associated with more contamination than higher elevation lakes. We also found that there was greater contamination associated with watersheds that had a higher percentage of areas that were developed such as urban, residential neighborhoods and recreational parks.

Even with discontinued use, some legacy contaminants and their degradants were still observed in lakes across the U.S. For instance, DDT has been banned in the U.S. since 1972, however metabolites such as 4,4'-DDD was detected at 16.4 percent, and 4,4'-DDE was detected 33 percent of lakes. These lakes with legacy contaminants are spread across the U.S.

There was a wide range of lake and reservoir sizes and types included in the survey which can be analyzed to further inform how other indicators may be influenced by physical, chemical, and other lake characteristics.

Typically, lake sediment monitoring is targeted to known contaminated sites whereas this was a robust first assessment and step toward exploring sediment as an indicator to help better understand the health of our water bodies and in managing them. For example, a companion study examined a subset of these samples to better understand background levels of contaminants in sediment among lakes. Inclusion of sediment quality monitoring in a wide range of lakes can help determine if pollution prevention efforts, environmental laws and policies, and improvement in land use practices are making a difference.

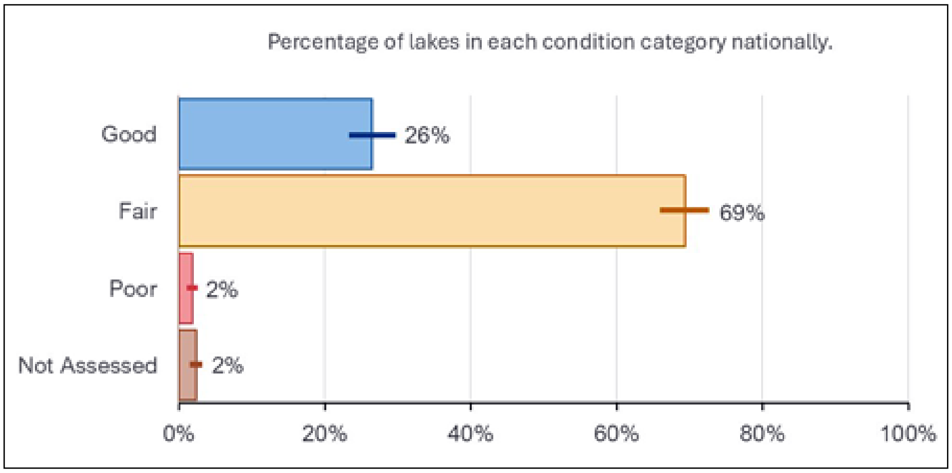

Figure 2. Percent of condition category for sediment quality. Good condition has a confidence interval of 20-33 percent, Fair condition has a CI of 63-76 percent, and poor has a CI of 0.3-3 percent. Each bar represents the percentage of the population of lakes in each condition category, where the numeric percent is shown and 95 percent confidence intervals are identified as bars around the percentage.

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