

EVALUATION OF BACKGROUND METALS CONCENTRATIONS

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The main focus of environmental investigations and remedial activities on Long Island and across the country is to evaluate the nature, extent, and remedial clean-up alternatives of anthropogenic compounds which are deemed to be hazardous to human health or the environment. Metals are one of the significant classes of contaminants often evaluated at sites during the environmental investigations. Unfortunately, it can be very difficult to distinguish between naturally occurring concentrations of metals and those with anthropogenic origins. The New York State Department of Environmental Conservation (NYSDEC) has promulgated cleanup criteria for metals; however, these criteria are often cited as "site background". Due to the natural variation in the metals contents of sediment, an investigator needs to collect and analyze several sediment samples from across a site to determine accurate and meaningful site backgrounds; however, due to budgetary restrictions, this is not often possible. The NYSDEC also allows for the comparison of site-specific data with Eastern United States (EUS) background concentrations. However, it seems inappropriate to compare metals concentrations in Long Island sands to Florida carbonates or New England granites. We recommend a simple statistical approach whereby site data are used to determine site-specific action levels or clean-up objectives.

As part of environmental investigations, it is usually necessary to evaluate the nature and extent of contamination related to an anthropogenic release such as a spill or improper disposal practices. The typical anthropogenic materials of concern, especially on Long Island, include several classes of compounds/elements including:

1. Volatile Organic Compound (VOCs) - VOCs are commonly components of gasoline and industrial/dry cleaning solvents.
2. Semi-Volatile Organic Compounds (SVOCs) - SVOCs are common constituents found in fuel oil, wood treatment/preservative fluids, coal, and coal byproducts (i.e., slag).
3. Pesticides/PCBs - Pesticide compounds are found in nearly all agricultural areas. PCBs are typically found in industrialized areas.
4. Metals - Metals are found in many industrial areas especially associated with printing facilities, plating operations, wood preservative facilities, and sewage treatment facilities.

Of the four above-referenced classes of contaminants, nearly all VOCs, SVOCs, and Pesticides/PCBs are not naturally occurring and only have anthropogenic origins. Their presence or absence are easily determined through various analytical tests which are compound specific. If any of the compounds are present, then some sort of release/discharge from an anthropogenic source has occurred. Typically, concentrations of these compounds which require attention (i.e., action levels) are well defined for solid (soil/sediment), liquid (surface water and groundwater), and air matrices by local, state and federal regulatory agencies.

The presence of metals in environmental samples presents a difficult problem. Metals are naturally occurring elements and their presence does not necessarily indicate the release of anthropogenic materials into the environment. Additionally, different geologic materials can contain differing concentrations of

metals. As a result, the natural (i.e., background) concentrations of metals can vary greatly with geographic location due to differing parent material and can vary greatly within a small geographic area due to differing lithologies. United States Geological Survey (USGS) personnel collected and analyzed soil and other surficial material samples from across the country for metals (Shacklette and Boerngen, 1984). The average concentrations and ranges in concentrations of metals for the Conterminous United States are presented in Table 1. The ranges of concentrations of metals vary greatly across the Conterminous United States again indicating that differing lithologies result in differing metals concentrations.

When conducting an environmental investigation on Long Island, the NYSDEC often requires the investigator to analyze soil/sediment and groundwater samples for the presence of metals. In order to allow an investigator to determine if metals are present above concentrations of concern in a soil matrix, the NYSDEC has promulgated clean up guidelines in the form of recommended soil cleanup objectives (RSCO) for inactive hazardous waste sites (NYSDEC, 1992 and 1994). According to the 1994 Technical and Administrative Guidance Memo (TAGM), the RSCOs were based on "average background concentrations as reported in a 1984 survey". As shown on Table 1, most of the metals had a promulgated RSCO, or a site background concentration. Three metals (calcium, magnesium, and manganese) have RSCOs of site background only. In the 1994 TAGM, a total of 10 metals (aluminum, antimony, calcium, lead, magnesium, manganese, potassium, silver, sodium, and thallium) have RSCOs of site background only. These site background RSCOs present a worker in the environmental business with a great problem: how does one determine metals background conditions at a site?

One method that the NYSDEC has approved for determining soil background conditions at some sites is the collection of a single soil sample, which supposedly represents site background conditions. According to the 1994 TAGM "Background samples should be free from the influences of this site and any other source of contaminants. Ideal background samples may be obtained from uncontaminated upgradient and upwind sources" (NYSDEC, 1994). Unfortunately, metals are not typically evenly distributed through the sediment column and one expects variations in metals concentrations. In addition, sites located in industrial areas may have elevated background conditions unrelated to site-specific activities. It should be noted that both the U.S. Environmental Protection Agency (USEPA) and the NYSDEC are currently revising the regulations to reflect the need for elevated action levels for sites located in industrial areas.

Another approach is to compare the ranges of metals concentrations from a site with those of the published EUS background. However, Long Island sands are not related to materials such as Florida carbonates, Maine granites, or Tennessee metamorphics. As an alternative, a relatively simple statistical approach has been developed where site data are used to determine site-specific action levels or clean-up goals. The data set should only include those soil samples collected from non-metals source areas. This is a valid data-screening tool in that during most environmental investigations, many samples are collected and analyzed for metals as part of a VOC or SVOC investigation. The mean (X) and standard deviation (SD) are calculated for each metal of concern. The values for the mean plus two SDs ($X+2SD$) and the mean plus three SDs ($X+3SD$) are calculated. The $X+2SD$ value represent concentrations falling within 95 percent of the mean while the values above $X+3SD$ reflect data over 99 percent from the mean (Freedman, et. al, 1978). We have found that any concentrations below $X+2SD$ seem to reflect the normal distribution of metals in typical sediment. Concentrations falling between $X+2SD$ and $X+3SD$ may indicate elevated concentrations due to anthropogenic sources and need to be further investigated while concentrations above $X+3SD$ indicate metals present due to anthropogenic sources. The advantage of this method is that site-specific data are used and takes into account if background concentrations were elevated due to area-wide industrial activities. The disadvantage of this method is that for sites where metals are the major chemical

class of concern, many extra samples outside of the site must be collected and analyzed to make the statistics valid. Unfortunately, budgets do not often allow for this luxury.

To illustrate this point, 23 soil samples were collected at depths ranging from the surface to 32-feet below ground surface (bgs) at a site located in Suffolk County, New York. The chemicals of concern at this site were not metals; therefore, the metals present probably represent those typically found at Long Island industrial areas. A summary of the analytical results are presented in Table 2. Additionally, a single soil sample was collected from a visually unimpacted portion of the site to represent background metals conditions.

As shown on Table 2, the values for $X+2SD$ and $X+3SD$ do not correlate well with the EUS background concentrations cited in the NYSDEC TAGM (NYSDEC, 1994). This indicates that the EUS background concentration is probably not applicable to Long Island sites. Additionally, by using this approach, we were able to create acceptable metals concentration ranges in the sediment at the site. This approach is more realistic than collecting a single soil sample which is supposed to represent site-wide background conditions.

In summary, we have found that to evaluate the presence of metals above levels of concern, the best approach is to use site data to determine a site-specific range using simple statistical functions. The collection and analysis of a single soil sample to reflect site-wide sediment conditions with regards to metals is inappropriate and can easily lead to high- or low-biased data.

List of References

- NYSDEC, 1992, NYSDEC Division Technical and Administrative Guidance Memo (TAGM): Determination of Soil Cleanup Objectives and Cleanup Levels, HWR-94-4046, November, 16, 1992
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- Freedman, D., Pisani, R., and Purves, R., 1978, Statistics, W.W. Norton & Company, Inc., New York.