



Analysis of Hair Samples :

How do hair sampling results relate to environmental exposures?

In growing numbers, community members who are concerned about environmental exposures are having hair samples analyzed for chemical contamination and asking public health agencies to interpret the testing results. As a result, public health officials need to understand the science of hair sampling results. This fact sheet gives basic information on the strengths and limitations of human hair analysis. Overall, although hair analysis has some potential advantages over other biological sampling techniques, the Agency for Toxic Substances and Disease Registry (ATSDR) considers that the limitations associated with hair analysis currently far outweigh the strengths of this sampling tool.

This fact sheet applies only to the use of hair analysis for assessing environmental exposures, and does not address other applications of hair analysis techniques, such as use of hair analysis in forensics or in testing for illegal drug use.

What are the strengths and limitations of hair sampling and analytical methods?

A reported strength of hair sampling is that it is less invasive than other biological sampling methods, such as collecting blood samples. However, sampling and analysis of hair samples suffer from many limitations; most notably, standard procedures have not been published for collecting, washing, and analyzing hair samples. Consequently, many questions regarding appropriate sampling and analytical procedures remain unanswered.

For instance, no consensus has emerged among scientists about the extent to which different cutting tools introduce contaminants into hair samples, about the part of the scalp from which hair samples should be collected, and about the influence of washing techniques. Further, scientists have not developed approaches for using hair analysis to characterize exposures for most organic compounds, in part because questions remain on what metabolites to look for in the hair. Hair analysis has been performed for a limited number of substances of environmental concern, primarily metals and selected organo-metallic compounds (like methyl mercury). Overall, standard sampling and analytical methods need to be developed before hair analysis can become an accurate and precise technique.

How well do hair analysis results characterize exposure?

If a substance is detected in a hair sample, the one defensible conclusion that can be drawn is that the individual was exposed to the substance at some time when the hair strands were growing. Three key limitations prevent further interpretation of most hair analysis results:

- Hair analysis results cannot pinpoint the sources of chemical contaminants that were detected. For instance, hair analysis results typically cannot distinguish substances that have deposited onto hair (perhaps from hair care products or dusts) from substances that might have distributed into hair following an environmental exposure, such as ingestion of contaminated drinking water. In other words, hair analysis generally cannot differentiate *internal* from *external* exposure. Further, because many substances commonly detected in hair are also found in our diets and in occupational settings, it is often impossible to determine whether, or to what extent, environmental exposures contributed to a measured concentration. In short, a detection generally will not tell you how, when, or where the individual was exposed.

Summary

ATSDR believes many scientific issues need to be resolved before hair analysis can become a useful tool to understand environmental exposures. Although hair analysis may answer some questions about environmental exposure to a few substances, hair analysis often raises more questions than they answer. With very few exceptions, hair analysis results provide *no insights* as to whether an individual will develop health effects.

■ The scientific community currently does not know the range of contamination levels typically found in human hair. Without reliable data in the peer-reviewed literature on *baseline* or *background* hair contamination levels in the general population, health agencies cannot determine if hair analysis results from a given site are unusually high or low, unless hair samples were collected from comparison populations.

■ A critical input into public health assessments is an understanding of the *dose*, whether measured or estimated. Because we currently know too little about rates at which substances in our bodies distribute into hair, it is impossible to calculate internal doses from hair sampling results. Therefore, hair analysis would provide no added insight beyond the estimates of exposure dose calculated from the use of default exposure assumptions in conjunction with the detected concentrations of substances in air, soil, and water.

What can hair analysis tell me about exposure?

For most substances considered as contaminants, hair analysis offers virtually no quantitative insights into exposure doses. Qualitative insights might be gleaned from certain studies.

Can hair analysis results be used to predict adverse health effects?

With very few exceptions, hair analysis results provide *no insights* as to whether an individual will develop adverse health effects. Several limitations prevent health professionals from using hair analysis results to make scientifically defensible public health conclusions:

■ With one exception, ATSDR is unaware of any conclusive studies that link hair concentrations of contaminants to specific health outcomes. Health professionals therefore have no scientific basis for deciding whether a particular hair analysis result would be associated with adverse health effects. As the exception, scientists have studied how hair concentrations of methyl mercury in pregnant mothers relate to adverse developmental effects in their children.

■ Because little is known about the transfer kinetics of contaminants into hair, scientists have not been able to develop models that can use a hair analysis result to predict concentrations of contaminants in other biological media (e.g., blood). Thus, health professionals cannot use a hair analysis result to compute a body burden, an internal dose, or other parameter that would enable a meaningful toxicologic evaluation of a hair analysis result.

What can hair analysis tell me about health effects?

With the exception of methyl mercury, hair analysis results currently provide no meaningful insights on whether an individual will develop adverse health effects.

Under what circumstances should hair samples be collected?

Whether hair samples should be collected at a given site depends on the questions that you ultimately want to answer. ATSDR strongly encourages health professionals to develop clear study objectives and then critically evaluate whether hair analysis will help achieve those objectives. We recommend asking the following two questions before considering hair analysis:

- What conclusions will I be able to draw from a positive or negative test result?
- Can I collect more useful information by sampling other biological media (e.g., blood, urine)?

In general, hair analysis results can provide limited qualitative insights into environmental exposures and rarely can answer questions about potential health effects. The following table gives some examples of the utility of hair sampling:

Study Objective	Is Hair Sampling Useful?
To determine whether women of childbearing age have been recently exposed to methyl mercury at levels of concern by eating contaminated fish.	Yes. Data are available linking concentrations of methyl mercury in hair of expecting mothers to developmental effects in their children.
To demonstrate that chromium detected at trace levels in drinking water was resulting in birth defects.	No. ATSDR is unaware of any data in the peer-reviewed literature linking chromium levels in hair to any adverse health effects, including birth defects. In these cases, toxicologic evaluations of exposure point concentrations would likely be a better tool for commenting on public health implications of exposure.
To assess whether local residents were exposed to metals from a facility that closed 4 years ago.	No. Considering typical hair growth rates and how often most people cut their hair, hair analysis will not characterize exposures that occurred more than 1 year ago for most subjects.
To quantify environmental exposures to lead, chromium, and manganese among residents who live near a plating shop.	No. Exposure doses cannot be calculated from hair analysis results. Moreover, metals in hair can come from multiple sources (e.g., diet) other than contamination from the plating shop.
To determine whether residents near a smelter are exposed to elevated levels of metals.	Most likely not. Because reliable data are not available on “background” hair concentrations, hair sampling cannot detect elevated exposures. Use of a control (or not exposed) population in the study could assess the relative magnitude of exposures. However, quantitative conclusions could not be drawn on actual exposure doses, even if hair concentrations were lower in the control population.
To characterize any exposures to volatile organic compounds (VOCs).	No. Hair sampling methods currently focus on metals and organo-metallic compounds. Little information is available on whether hair sampling can characterize exposure to VOCs and their metabolites.

Where can I get more information on the state of the science for hair analysis?

ATSDR recently convened an expert panel to discuss the current state of the science for hair analysis. The meeting summary report documents the experts’ discussions and includes a long list of relevant references identified during a literature review. You can get a copy of this report by calling ATSDR: 1-888-42-ATSDR (or 1-888-422-8737). The report is available on ATSDR’s Web site at “www.atsdr.cdc.gov/HAC/hair_analysis.” We can also send you a fact sheet we prepared to explain the pros and cons of hair analysis to community members.

**For more information,
contact ATSDR's toll-free information line:**

(888) 42-ATSDR. . . that's (888) 422-8737

ATSDR's Internet address is <http://www.atsdr.cdc.gov>