

DEFINING THE GREENNESS OF MONITORING METHODS

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ABSTRACT

The greenness of environmental monitoring methods can now be compared in the National Environmental Methods Index (NEMI, www.nemi.gov). The NEMI database, with over 1000 methods for environmental monitoring and averages 6000 visitors per month, can be used for finding and downloading a method, comparing methods based on performance criteria, and comparing based on greenness profiles.

The analytical methods used for environmental monitoring can be hazardous to the environment and to human health. Greener analytical methods use fewer hazardous solvents, use safer chemicals, prevent waste, and conserve energy during the sample preparation and analysis. A more detailed review of the topic can be found in the recent publication, Keith, L. H.; Gron, L. U.; Young, J. L. *Chemical Reviews*, **2007**, 107, 2695-2708.

The four criteria used for defining the greenness profiles are Persistent/Bioaccumulative/Toxic (PBT), Hazardous, Corrosive, and Waste. A method is defined as less green if:

1. PBT – A chemical used in the method is listed as persistent, bioaccumulative, and toxic (PBT), as defined by the EPA's Toxic Release Inventory (TRI).
2. Hazardous – A chemical used in the method is listed on the TRI or on one of the RCRA's D, F, P or U hazardous waste lists.
3. Corrosive – pH during the analysis is less than 2 or greater than 12.
4. Waste – Waste amount generated is greater than 50 g.

Of the methods in NEMI for which greenness profiles were generated, 2/3 of methods failed waste criterion. Generally, organic analyses fail due to extractions with solvents and inorganic analyses fail due to mineral acids for preservation or digestion. The greener examples use small sample sizes and generate less than 50g of waste. For the hazardous chemical criterion, 1/2 of methods failed, with greener examples using safer chemicals or eliminating chemicals. About 1/5 of methods failed the pH criterion, with greener examples using neutral pH, buffers, or refrigeration instead of acidification for preservation. Only 1/20 of methods failed the PBT criterion, mostly due to using lead in digestion or mercury in preservation. Learning from the greenness profiles in NEMI, suggestions for developing greener methods will be given.

Keywords

environmental monitoring, analytical methods, greenness profiles, NEMI, green methods, safer chemicals, minimize waste, chemical analysis