

# Speciation: An Essential Tool for the Environmental Control of Inorganic Chemicals in Water\*

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The control of inorganic chemicals in water is presently entrusted to meaningless standards. Whereas organic compounds can often be directly identified and quantified in micro amounts by recognized laboratory methods,<sup>1</sup> procedures for the identification of inorganic contaminants are not as refined.<sup>2</sup> The result has been a "blindman's approach" to the setting of standards for maximum contaminant levels of inorganic chemicals. The Environmental Protection Agency ("EPA") has expressed such standards in terms of total elemental presence: *i.e.*, the maximum contaminant levels for an element are set solely by reference to the total amount of certain elements present at a water site. This approach does not identify the compounds in which the element is found and gives no consideration to whether or not the compounds formed by the element in a

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1. The molecular weights and fragmentation patterns of organic compounds can be measured by a mass spectrometer after separation of the components in the mixture by gas chromatography or high-performance liquid chromatography. Specific organic compounds may then be identified by reference to the molecular weights of the 109 organic compounds referred to in the 129 Priority Pollutants List, *see* Natural Resources Defense Council v. Train, 8 Env't Rep. Cas. (BNA) 2120, app. A (D.D.C. 1976) and EPA Effluent Guidelines and Standards for Steam Electric Power Generating, 40 C.F.R. §423, app. A (1982), or by reference to the National Bureau of Standards Library Search, Spectral Library, Full Length Cartridge, containing the molecular weights of 32,000 different organic compounds.

2. Rapid technological advances have nonetheless resulted in general laboratory protocols for the identification of small classes of inorganic compounds. Prack & Bastiaans, *Metal Speciation by Evolved Gas Inductively Coupled Plasma Atomic Emission Spectrometry*, 55 ANAL. CHEM. 1654-60 (1983).

particular body of water<sup>3</sup> are actually in the inorganic state, or even pose real danger to the environment. Often, EPA's inorganic chemical standards bear no relationship to the hazards of the compounds actually present at a water site. As a result, effective environmental protection has been seriously impeded.

Recently, a new procedure has been developed which makes it possible to identify "compound forms," the molecular species in which the element is found, and to quantify the different "compound forms" found in a water sample. This procedure, known as "speciation," makes possible the accurate determination of the hazards actually present in water bodies. The purpose of this article is to introduce the legal community to speciation and to urge that this new tool be incorporated into the regulatory system imposed by federal and state agencies for the control of inorganic chemicals in water.

## BACKGROUND

In 1962, the U.S. Department of Health, Education and Welfare issued revised maximum contaminant recommendations for inorganic chemicals in drinking water.<sup>4</sup> These standards were expressed, as they had been since 1925, in purely quantitative terms of total elemental presence.<sup>5</sup> EPA adopted the total elemental ap-

3. This article adopts the broad definition of "water" used in the Federal Water Pollution Control Act ("FWPCA") amendments of 1977: "any body of water, including ground water." 33 U.S.C. § 1314(a)(1)(A) (1976 & Supp. V 1981). It should be noted, however, that any reference in the text to the National Interim Primary Drinking Water Regulations, 40 C.F.R. § 141 (1982), concerns only those bodies of water and ancillary collection, storage and distribution facilities that are part of a system providing piped water to the public for human consumption.

4. PUBLIC HEALTH SERV., U.S. DEP'T OF HEALTH, EDUC. & WELFARE, PUB. NO. 956, PUBLIC HEALTH SERVICE DRINKING WATER STANDARDS (1962). Various organic chemicals such as "phenols" are also covered by the 1962 recommended drinking water standards. The focus of this paper, however, is upon the maximum contaminant recommendations for the inorganic chemicals.

5. PUBLIC HEALTH SERV., U.S. DEP'T OF HEALTH, EDUC. & WELFARE, PUBLIC HEALTH SERVICE DRINKING WATER STANDARDS, 40 PUB. HEALTH REPS. NO. 15 (1925). Drinking water standards were first adopted in 1914 under interstate quarantine regulations, to protect the health of travelers on interstate common carriers that provided drinking water for passengers. These standards were revised in 1925, 1942, 1946, and 1962. 40 PUB. HEALTH REPS. NO. 15 (1925); 58 PUB. HEALTH REPS. NO. 3 (1943); 61 PUB. HEALTH REPS. NO. 11 (1946); PUB. HEALTH SERV. PUB. NO. 956 (1962). The 1925 revision was the first to establish specific maximum contamination limits for certain chemicals. Such limits were expressed in terms of total elemental presence. The 1946 edition was the first to recommend general application of the standards to all public water supplies in the United States.

proach in its first Water Quality Criteria Document, issued in 1972.<sup>6</sup> Other water quality documents which followed adopted the same approach.<sup>7</sup> Finally, in 1975, EPA issued the National Interim Primary Drinking Water Regulations,<sup>8</sup> as mandated by the Safe Drinking Water Act of 1974.<sup>9</sup> Section 141.11(b) of those regulations, which remains the controlling authority, once again sets maximum contaminant levels for inorganic chemicals on the basis of the total presence of certain designated toxic elements most commonly or predictably found in the inorganic state.<sup>10</sup>

A fatal shortcoming of EPA's drinking water standards for inorganic chemicals is that they rely upon the total elemental measurement, which fails to determine the actual compounds of the element present at a particular water site. Yet the hazards of the

6. COMM'N ON WATER QUALITY CRITERIA, ENVTL. STUDIES BD., NAT'L ACADEMY OF SCIENCES, NAT'L ACADEMY OF ENG'G, WATER QUALITY CRITERIA (1972).

7. OFFICE OF WATER & HAZARDOUS MATERIALS, U.S. ENVTL. PROTECTION AGENCY, PUB. NO. 263943, QUALITY CRITERIA FOR WATER (1976). Water Quality Criteria documents scheduled for issuance in 1980 were replaced by the Ambient Water Quality Criteria documents issued by EPA for 65 toxic pollutants and classes of pollutants listed at 40 C.F.R. § 401.15 (1982). Those 65 pollutants were selected in accordance with the Clean Water Act of 1977, 33 U.S.C. § 1317(a)(1) (1976 & Supp. V 1981), more fully stated and defined in the "Settlement Agreement" reached in *Natural Resources Defense Council v. Train*, 8 Env't Rep. Cas. (BNA) 2120 (D.D.C. 1976), *modified sub nom.* *Natural Resources Defense Council v. Costle*, 12 Env't Rep. Cas. (BNA) 1833 (D.D.C. 1979).

8. 40 C.F.R. § 141 (1982).

9. 42 U.S.C. § 300g-1(a)(1) (1976 & Supp. V 1981).

10. The maximum contaminant levels for inorganic chemicals set forth in § 141.11(b) of the National Interim Primary Drinking Water Regulations, 40 C.F.R. § 141.11(b) (1982), are as follows:

Contaminant	PPM (Parts per Million)
Arsenic	0.05
Barium	1.00
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.0
Selenium	0.01
Silver	0.05

This set of "contaminants" is merely a listing of some of the 105 elements now known to exist. Elements are broadly classified as metals, metalloids and non-metals. Metals are generally malleable, ductile solids conductive of heat and electricity and reactive to acids. Non-metals are generally solids, liquids or gases that are poor conductors of heat and electricity, nonmalleable and of poor ductility. Non-metals also react poorly with acids. Metalloids have some of the properties of both metals and non-metals. The elements listed as "contaminants" under § 141.11(b) of the National Interim Primary Drinking Water Regulations, 40 C.F.R. § 141.11(b) (1982), are either metals or metalloids.

element at any site may depend solely upon the exact combinations or groups, known as compound forms, formed at that site with other elements.<sup>11</sup> As a result of combinations with other elements, the actual hazards of the contaminants which are subject to the National Interim Primary Drinking Water Regulations may be greater or lesser than the hazards as regulated.

Various factors are responsible for an element's widely differing behavior in its many different compound forms. For example, the mere presence of carbon and hydrogen changes the compound form to an organic state which may exhibit significantly less hazardous genicities<sup>12</sup> than the inorganic compound forms of the same element. Many elements that are of paramount concern in environmental protection can be found qualitatively as compound forms in the organic state, or in different valence forms in the inorganic state.<sup>13</sup> The precise valence<sup>14</sup> and oxidation state<sup>15</sup> of the element as found in each of its various inorganic compound forms is another factor that may result in many different genicity evaluations, depending upon the actual inorganic compound form present in the

11. Saddled with the limitations of the traditional total elemental measurement, the authors of an extensive study of water and fish samples from Chautauqua Lake, New York, could only conclude that "[p]ublic health consequences are difficult to assess because of differential toxicity of different arsenic forms, and because we do not presently know the form or forms of arsenic that are in the Chautauqua Lake waters." Foley, Spotila, Giesy & Wall, *Arsenic Concentrations in Water and Fish from Chautauqua Lake, New York*, 3 ENV. BIOL. FISH 361, 366 (1978).

12. An element's "genicities" are the toxicological or biological dangers and hazards posed by that element. The degrees of toxicological or biological dangers of chemicals, referred to in scientific terminology as "relative toxicities," are measured by certain scientifically-recognized animal testing procedures. Relative toxicities are established by toxicity testing of the poisonous properties of chemicals; teratogenicity is established by testing of the production of monstrous growths; oncogenicity, by testing of the production of cancerous tumors; and mutagenicity, by testing of the production of mutations. Toxicity, teratogenicity, oncogenicity and mutagenicity values of specific compound forms can be found in the scientific literature. In the New Jersey administrative proceedings more fully discussed *infra* at notes 36-39 and accompanying text, the term "genicities" was adopted to describe the scientific animal testing procedures and relative toxicity values of the tests.

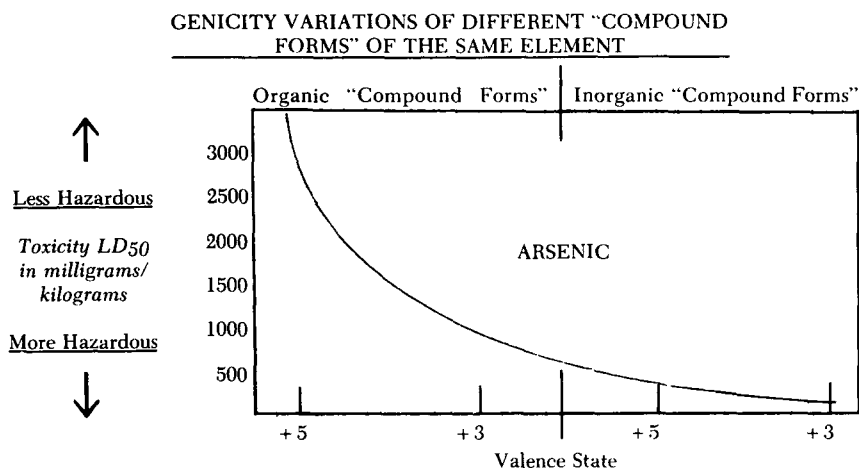
13. Such elements include antimony, arsenic, chromium, copper, lead, magnesium, manganese, mercury, molybdenum, phosphorus, selenium, sulphur, tellurium, tin, thallium and vanadium.

14. The "valence" of an element is the number of monovalent ligands attached to the central atom.

15. The addition of oxygen and/or any other non-metallic element to a compound form may vary the formal charge on the metal or metalloid element, and hence the "oxidation state."

sample.<sup>16</sup> The effect of different valence states, and the presence of carbon and hydrogen in a compound form, upon the toxicity of one element (arsenic) is illustrated in the accompanying graph.<sup>17</sup>

It is the identification and measurement of the compound forms of an element, then, that is essential to the evaluation of the hazards posed by inorganic chemicals in water. The traditional total elemental approach lacks the capacity to isolate the truly hazardous inorganic compound forms of an element from its significantly less hazardous organic or inorganic compound forms. Under the total elemental approach, less hazardous organic compound forms<sup>18</sup> and inorganic compound forms containing the element in less hazardous valence states (albeit potentially variable) are included as part of a total measurement for inorganic chemicals,<sup>19</sup> which is then evalu-



16. For example, the oxidized form of inorganic arsenic, known as arsenate (valence +5), is reported to be 60 times less hazardous than the reduced inorganic compound form of arsenic known as arsenite (valence +3). Hounslow, *Ground Water Geochemistry: Arsenic in Landfills*, 18 GROUNDWATER 331 (1980).

17. The graph notes toxicity LD<sub>50</sub> in milligrams/kilograms for arsenite (inorganic compound form at +3), arsenate (inorganic compound form at +5) and cacodylic acid and sodium methanearsonate (organic compound form at +5). As to other compound forms of arsenic, the graph only represents a general trend, dependent upon the type of animals tested and the actual compound forms present.

18. This is not to say that all of the elements listed at note 10, *supra*, are less hazardous in their organic compound forms. Certain elements, such as mercury, are *more* hazardous in their organic compound forms. It is essential that a specific evaluation be made of the genicities of all of the compound forms of an element determined to be present at a water site.

19. The title of § 141.11 is Maximum Contaminant Levels for Inorganic Chemicals, 40 C.F.R. § 141.11 (1982). The term "inorganic chemicals" is substituted here for what really

ated by reference to a standard based upon the presence of only the most hazardous compound forms of the element.<sup>20</sup>

The element arsenic may be taken as an example. The most toxic form of environmentally-occurring arsenic is the inorganic compound form known as arsenite.<sup>21</sup> A sample of water containing only the arsenite contaminant at amounts measured by total elemental presence at or below .05 ppm would meet EPA's drinking water standard for arsenic. Yet a sample of water containing only the far less toxic organic compound forms of arsenic at .15 ppm would exceed the standard. In the example given, environmental agencies would direct their concern and control programs only to the source of the latter sample, which would be less toxic and less dangerous than the waters contained in the former sample. Clearly, the continued use of the simple elemental measurement by environmental regulatory authorities has resulted in maximum contaminant levels that are inherently misleading and that may result in the waste of precious dollars allocated for the control of chemical hazards.<sup>22</sup>

should be measured if it were technologically feasible: inorganic compounds. The permissible levels of these inorganic chemicals, which actually exist as compounds of some sort in the natural environment, are measured by and expressed in terms of the total presence of an element. It is difficult, if not impossible, to comprehend how an inorganic compound as it exists in the environment can be meaningfully evaluated and measured solely on the basis of the total presence of one of its parts, or how a "compound" can be evaluated, measured and expressed as an "element." The word "element" is conspicuously absent from the columnar description of the inorganic chemicals for which standards are set forth in § 141.11(b). The word "contaminant" is used in its place and can only be characterized as a fudge word.

20. For example, the drinking water standard for arsenic set by EPA assumes the presence of the most hazardous environmentally-occurring compound form of arsenic, an inorganic compound form known as arsenite. U.S. ENVTL. PROTECTION AGENCY, PUB. NO. 570/9-76-003, NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS 51-57 (1977). Similarly, in setting the drinking water standards for mercury, EPA assumed the presence of the most toxic and dangerous compound forms of mercury, the organic compound forms. *Id.* at 76-80. In either instance, the standard becomes meaningless if the compound forms of the element actually found at a given water site are not the most hazardous compound forms upon which the standard is predicated. The standard also becomes meaningless if the most hazardous compound forms are found in amounts far in excess of quantities only assumed to be present in setting the standard.

21. U.S. ENVTL. PROTECTION AGENCY PUB. NO. 570/9-76-003, NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS 51-57 (1977) and I. Felkner, *Oncogenicity and Metabolism of Methylarsonates* (Aug. 31, 1980) (unpublished report accompanying letter from I. Cecil Felkner, Texas Tech Univ. Health Sciences Centers, to Christine Chaisson, Deputy Chief, Toxicology Branch, Human Env't Dep't, U.S. Env'tl. Protection Agency (Oct. 1, 1980)).

22. This article concentrates upon the National Interim Primary Drinking Water Regulations, 40 C.F.R. § 141 (1982), merely for illustrative purposes: these regulations are ideal for comment, as they present concise statements of standards and an antiquated vehicle for "contaminant" measurement. The concepts set forth in this paper are more broadly applica-

## SPECIATION

In 1977, more than a year and a half after EPA issued its National Interim Primary Drinking Water Regulations, a speciation procedure generally applicable for the identification of compound forms of the metal and metalloid elements was reported in the scientific literature.<sup>23</sup> The procedure utilized cation (metals) exchange. Subsequent reports dealt with speciation of the compound forms of arsenic, mercury, lead, tin, silicon and selenium.<sup>24</sup> A

ble, however. The ambient water criteria documents for antimony, arsenic, cadmium, chromium, copper, lead, mercury, selenium, silver and thallium that have been issued pursuant to the FWPCA amendments of 1977, 33 U.S.C. § 1314(a)(1) (1976 & Supp. V. 1981), adopt the total elemental approach, although in some instances they discuss the genicities of different compound forms. For example, the Ambient Water Quality Criteria for Mercury, while recognizing the far more toxic genicities of the organic compounds of mercury, nonetheless establishes both the criteria and concentration limits only in terms of total elemental mercury. U.S. ENVTL. PROTECTION AGENCY, PUB. NO. 440/5-80-058, AMBIENT WATER QUALITY CRITERIA FOR MERCURY, C-93 (1980). Additionally, many of the effluent guidelines issued pursuant to the FWPCA amendments of 1977, 33 U.S.C. §§ 1311, 1314(b), (e), (g), 1316(b), 1317 (1976 & Supp. V 1981), rely upon the total presence of elements listed in § 141.11(b), instead of on a recognition of the different compound forms of those elements that may be present in the waste streams at a given site. See, e.g., EPA Effluent Limitations Guidelines for Standards of Performance and Pretreatment Standards for New Sources for the Nonferrous Metals Manufacturing Point Source Category, 40 C.F.R. § 421 (1982). The comments set forth in this paper also apply to the Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, issued pursuant to § 265.92(b)(1) of the Resource Conservation and Recovery Act of 1976, 42 U.S.C. §§ 6905, 6912(a), 6924 (1976 & Supp. V 1981), for groundwater monitoring systems designed to determine the exact impact of leaks from surface impoundments of hazardous wastes. 40 C.F.R. § 265 Subpart F (1982). Applications may also include compound form identification refinements and evaluations essential for more meaningful toxicity evaluation under the Hazardous Ranking System of the National Oil and Hazardous Substances Contingency Plan, § 3.4, app. A, table 6—SAX Toxicity Ratings, table 7—NEPA Toxicity Ratings, 40 C.F.R. § 300, app. A (1982), and ultimately upon the issue, usually negotiated, of "How clean is clean?"

23. Brinckman, Parris, Blair, Jewett, Iverson & Bellama, *Questions Concerning Environmental Mobility of Arsenic: Needs for a Chemical Data Base and Means for Speciation of Trace Organoarsenicals*, 19 ENVTL. HEALTH PERSPS. 11-24 (1977). The need for such an analytical technique had been discussed in Brinckman & Iverson, *Marine Chemistry in the Coastal Environment*, 18 AMERICAN CHEMICAL SOCIETY SYMPOSIUM 319-42 (T. Church, ed., 1975); in Brinckman, Iverson & Blair, *Approaches to the Study of Microbial Transformations of Metals*, in PROCEEDINGS OF THE THIRD INTERNATIONAL BIODEGRADATION SYMPOSIUM 919-36 (N. Sharpley & A. Kaplan, eds. 1976); and in Blair, Iverson & Brinckman, 3 CHEMOSPHERE 167 (1974).

24. J. JACKSON, W. BLAIR, F. BRINCKMAN & W. IVERSON, GAS CHROMATOGRAPHIC SPECIATION OF METHYLSTANNANES IN THE CHESAPEAKE BAY USING PURGE AND TRAP SAMPLING WITH A TIN-SELECTIVE DETECTOR (Chem. & Biodegradation Processes Group, Nat'l Bureau of Standards, Interim Tech. Rep. No. 5610406, 1981); F. BRINCKMAN, J. JACKSON, W. BLAIR, G. OLSON & W. IVERSON, ULTRATRACE SPECIES IN ESTUARINE WATERS (Chem. & Biodegradation

different speciation procedure using anion (metalloids) exchange was reported in 1980.<sup>25</sup>

The speciation procedures described in these reports make it possible to qualitatively analyze compound forms and to quantify each different compound form. As such, the procedures are far more accurate in measuring the hazards posed by inorganic chemicals in water. To return to the example of arsenic, a water sample purportedly containing 1 ppm of total elemental arsenic may, upon speciation, be found to contain inorganic compounds of arsenic which fall below the drinking water standard of .05 ppm<sup>26</sup> for all such inorganic compounds. The remainder of the sample may be found to contain one or more organic arsonates that, for each genericity, pose significantly lesser hazards than the inorganic arsenate chemicals that meet the drinking water standard. EPA has not set maximum contaminant levels for the less hazardous organic arsonates in drinking water;<sup>27</sup> speciation could therefore be useful

Processes Group, Nat'l Bureau of Standards, Interim Tech. Rep. No. 5610406, 1981); E. PARKS & F. BRINCKMAN, CHARACTERIZATION OF BIOACTIVE ORGANOTIN IN POLYMERS: FRACTIONATION AND DETERMINATION OF MW BY SEC-GFAA, (Chem. & Biodegradation Processes Group, Nat'l Bureau of Standards, Interim Tech. Rep. No. 5610406, 1980); F. Brinckman, Environmental Organotin Chemistry Today: Experiences in the Field and Laboratory (Oct. 1980) (unpublished report); Brinckman, Parris, Blair, Jewett, Iverson & Bellama, *Questions Concerning Environmental Mobility of Arsenic: Needs for a Chemical Data Base and Means for Speciation of Trace Organoarsenicals*, 19 ENVTL. HEALTH PERSPS. 11-24 (1977); F. BRINCKMAN & W. BLAIR, SPECIATION OF METALS IN USED OILS: RECENT PROGRESS AND ENVIRONMENTAL IMPLICATIONS OF MOLECULAR LEAD COMPOUNDS IN USED CRANKCASE OILS (Nat'l Bureau of Standards, Spec. Pub. No. 556, 1979).

25. Woolson & Aharonson, *Separation and Detection of Arsenical Pesticide Residues and Some of their Metabolites by High Pressure Liquid Chromatograph—Graphite Furnace Atomic Absorption Spectrophotometer*, 63 J.A. OFFICIAL ANALYTICAL CHEMISTS 523-28 (1980). The cation and anion procedures use the same equipment: high pressure liquid chromatograph and radial compression module, atomic absorption spectrophotometer and automatic sampling unit. The high pressure liquid chromatograph and the radial compression module separate the various compound forms, which are then detected and measured by the atomic absorption spectrophotometer. The actual amounts in parts per million or parts per billion of each of the compound forms speciated can be calculated from those measurements. The automatic sampler allows for a completely automatic analytical procedure. The speciation procedure is fully described in Woolson & Aharonson, *supra*, and in Woolson, Aharonson & Iadevaia, *Application of the High Pressure Liquid Chromatography—Flameless Atomic Absorption Method to the Study of Alkyl Arsenical Herbicide Metabolism in Soil*, 30 J. AGRIC. & FOOD CHEM., 580-84 (1982).

26. See *supra* note 10.

27. EPA might take the position that arsonates are included in the term "contaminant" in § 141.11(b) and that the .05 ppm standard for the inorganic chemicals of arsenic therefore takes into account the presence of organic arsonates. However, this position does not explain why there is no standard in the National Interim Primary Drinking Water Regulations that



in setting such levels based upon the reported genicities of the organic arsonates actually present in the waters.<sup>28</sup>

By accurately determining the water sites actually contaminated by the most hazardous inorganic or organic compound forms of an element, speciation could lead to a more effective allocation of funds for environmental control programs. Significant improvement of the environment by the use of speciation could also take place in other ways. Treatment methods implemented at existing water treatment plants are generally formulated on the basis of traditional bench scale analyses. Speciation could make possible the identification of certain compound forms which may not be responding optimally to such treatment methods. Introduction of a pretreatment or final polishing stage specifically addressed to the isolated "problem compound form" could increase significantly the efficiency of water treatment plants.<sup>29</sup>

Speciation could also provide a useful tool for the identification of the processors of certain chemicals found in surface waters, abandoned repositories and "midnight" dump sites. Each manufacturer of a compound such as cyanide has a unique set of metal and metalloid impurities in its final product. The set of impurities in any particular product is the result of the exact composition of raw materials used by that manufacturer, and is also affected by leaks in processing operations, entrainments and many other factors. Analysis of these impurities can serve as a "fingerprint" to identify the most likely source of the compound found at an illegal dump site.<sup>30</sup> A computer data base could be developed of speciated metal and

refers to arsonates, or the fact that the .05 ppm standard set for the "contaminant" arsenic is based upon the presence of the most toxic compound form of that element (arsenite), and does not reflect an evaluation of the hazards of arsonates.

28. Various approaches are possible. The standards set forth in § 141.11(b) are only for the maximum contaminant levels for inorganic chemicals; some multiple of the existing standard for inorganic chemicals could be applied to the total elemental amount of the less hazardous compound forms of § 141.11(b) elements found at a specified location. Alternatively, each of the compound forms determined as being present at a particular site could be measured by standards expressed in terms of and applicable to each of the compound forms. The ultimate approach to be taken will depend upon the chemical stability of the compound forms of the § 141.11(b) elements.

29. The use of speciation in this manner has resulted in a 100% increase in the efficiency of the water treatment plan further discussed *infra* at note 39 and accompanying text. In that situation, samples of water were speciated, both prior to and subsequent to treatment. Comparison of the results clearly indicated that one of the compound forms was not responding at all to the treatment protocol. Experimental testing, again using speciation, was specifically directed at, and succeeded in reducing, the problem compound form.

30. Speciation of inorganic compounds is discussed in Prack & Bastiaans, *supra* note 2.

metalloid impurities found in the commercial products and the waste materials generated by major chemical manufacturers and processors. Such a "fingerprint" system would have enormous potential value in helping to identify those actually responsible for creating certain environmental hazards.

### LEGAL STATUS

Federal agencies have already accorded some recognition to speciation and the compound form approach to the control of inorganic chemicals in water. The Occupational Safety and Health Administration ("OSHA")'s Occupational Safety & Health Standards evaluate some chemical hazards based upon the compound forms actually present at the job site.<sup>31</sup> OSHA has also specified, in a research paper, the procedure for collection and identification by speciation of certain particulates in air samples.<sup>32</sup> The World Health Organization, in its International Standards for Drinking Water, specifically recommends that laboratory results be expressed in terms of compound forms.<sup>33</sup> EPA has funded research into the use of speciation for testing hypotheses which seek to explain the widely varying results of epidemiological studies based upon measurements of total elemental quantities.<sup>34</sup> In fact, the entire approach which EPA has adopted for the control of organic chemicals recognizes the need to identify the actual compound contaminant, and at the same time, to make an extensive categorical evaluation of the hazards actually present at the site.<sup>35</sup> Speciation provides the technological means by which to implement similarly precise environmental controls for inorganic chemicals.

31. 29 C.F.R. § 1910, Subpart Z—Toxic and Hazardous Substances (1982).

32. Ricci, Colovos, Hester, Shepard & Haartz, *Suitability of Various Filtering Media for the Collection and Determination of Organoarsenicals in Air*, in CHEMICAL HAZARDS IN THE WORKPLACE—MEASUREMENT AND CONTROL (G. Choudhary, ed. 1981) (Am. Chem. Soc'y Symposium Series No. 149).

33. WORLD HEALTH ORGANIZATION, INTERNATIONAL STANDARDS FOR DRINKING-WATER 11 (3d ed. 1971), states: "Whenever possible, chemical components should be expressed in terms of ions . . ." Such a statement is tantamount to a recognition of the preference to identify compound forms of the § 141.11(b) elements.

34. U.S. ENVTL. PROTECTION AGENCY, PUB. NO. 600/S1-82-010, SPECIATION OF ARSENIC COMPOUNDS IN WATER SUPPLIES (1982).

35. See FWPCA amendments of 1977, 33 U.S.C. §§ 1316(b) & 1317 (1976 & Supp. V 1981), and the "Settlement Agreement" reached in *Natural Resources Defense Council v. Train*, 8 Env't Rep. Cas. (BNA) 2120 (D.D.C. 1976), *modified sub nom.* *Natural Resources Defense Council v. Costle*, 12 Env't Rep. Cas. (BNA) 1833 (D.D.C. 1979).

In New Jersey, speciation has been expressly recognized by the Department of Environmental Protection ("DEP") as the result of a 1980 case involving Vineland Chemical Co., Inc.<sup>36</sup> In December 1980, after DEP had claimed that a certain element at the Vineland site was an inorganic chemical contaminant in water, Vineland Chemical Co. provided DEP with an extensive genicity literature search and speciation testing report, which showed that at least ninety-five percent of that element existed in its clearly less hazardous organic form.<sup>37</sup> Furthermore, whereas the total amount of the element present at the site exceeded the standard set by the National Interim Primary Drinking Water Regulations,<sup>38</sup> the quantities of the hazardous inorganic forms of the element fell at or below the levels set by those regulations. After an administrative appeal was filed by Vineland in 1981, challenging the total elemental standards, a special committee headed by DEP's Chief of Enforcement fully reviewed the scientific principles and procedures of speciation. On the basis of that review, DEP issued an Administrative Consent Order which established new interim standards based upon and reflective of the genicities of organic compound forms actually present at a given site. Realizing the far-ranging potential applications of speciation, the Department went on to require speciation on bench scale experiments seeking to increase the efficiency of an existing on-line water treatment system.<sup>39</sup>

## CONCLUSIONS

The Safe Drinking Water Act provides that the National Interim Primary Drinking Water Regulations shall be amended "whenever changes in technology, treatment techniques, and other means permit greater protection of the health of persons, but in any event such regulations shall be reviewed at least once every three years."<sup>40</sup> Speciation represents a significant change in technology which pro-

36. In *The Matter of Vineland Chem. Co.*, N.J. Dep't of Env'tl. Protection, Div. of Water Resources (unpublished administrative consent order) (Dec. 21, 1981).

37. Unpublished and proprietary data compilations accompanying letter from Franklin J. Riesenburger to Keith Onsdorff, N.J. Dep't of Env'tl. Protection (Dec. 11, 1980).

38. In New Jersey, the standards set by these regulations have been extended by administrative regulation to many surface and ground water systems other than drinking water systems. See, e.g., N.J. ADMIN. CODE tit. 7, §§ 7:9-4.5(c)(6), 7:9-4.6; 7:9-6.6.

39. In *The Matter of Vineland Chem. Co.*, *supra* note 36, at 11.

40. 42 U.S.C. § 300g-1(b)(4) (1976 & Supp. V 1981).

vides a tool for determining the actual compound forms at water sites, evaluating the hazards present, and effectively controlling threats to public health and to the environment. EPA is currently reassessing the National Interim Primary Drinking Water Regulations, as the first step in the process of issuing new National Revised Primary Drinking Water Regulations.<sup>41</sup> This article specifically proposes that speciation be recognized by and incorporated into those regulations.

41. The advance notice of proposed rulemaking for the National Revised Primary Drinking Water Regulations, inviting public participation and comment, was issued by EPA on Oct. 5, 1983. 48 Fed. Reg. 45,502 (1983).