



# **‘Heavy Metals’ - What to do now: To use or not to use?**

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## Letter to the Editor

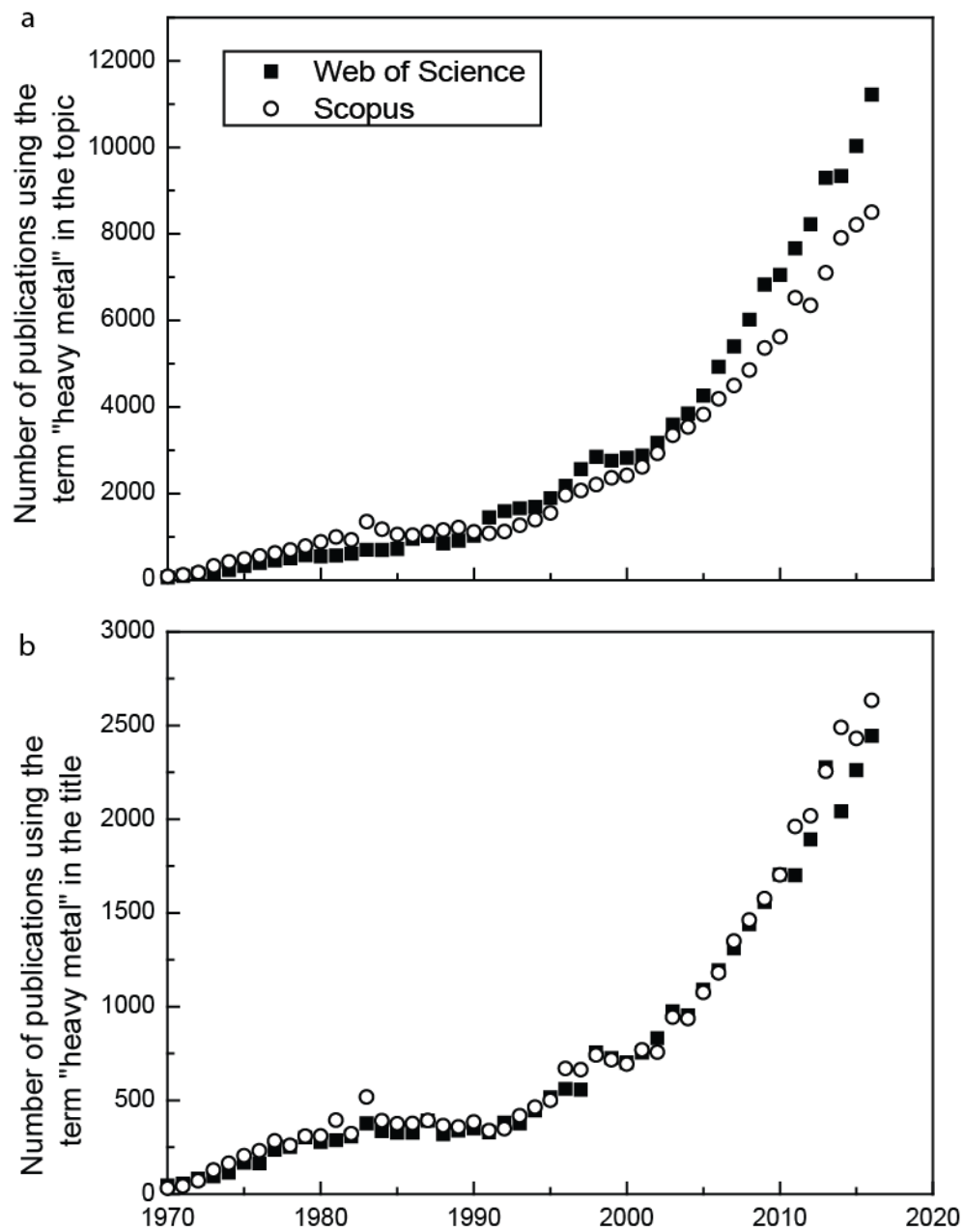
### “Heavy metal” - what to do now: To use or not to use?

Dear Editor,

In 1980, Nieboer and Richardson proposed the term “heavy metal” should be replaced by a more biologically and chemically significant classification of metal ions. According to the International Union of Pure and Applied Chemistry (Duffus, 2002), the term “heavy metal” is considered imprecise at best, meaningless at worst, because there is no standardized definition for a *heavy* metal. Use of this term, is thus strongly discouraged.

“Heavy metal” is a very imprecise term, never rigorously defined by any authority, and loosely used to refer to an element and its compounds (Hodson, 2004; Madrid, 2010; Chapman, 2012). The term is based on categorization by density, which is rarely a biologically significant property. It is often used as a group name for metals (and also metalloids, like arsenic) that have been associated with contamination and potential toxicity. However, the assumption that all so-called “heavy metals” and their compounds have highly toxic properties are not supported by facts. Additionally, the list of “heavy metals” is not clearly defined and has no basis in their chemistry. By considering this, the best way to describe studied elements is clearly to name them or to consider them as a group of metals and metalloids.

Nevertheless, the term is increasingly used in the scientific literature (**Figure 1**), especially in articles pertaining to multidisciplinary environmental issues (see **Table 1** for the year 2016).



**Figure 1** Number of publications using the term “heavy metal” (a) in the topic and (b) in the title (from Scopus and Web of Science using “heavy metal\*” search, data accessed on August 1<sup>st</sup> 2017).

It has been argued that a proposed replacement for this term may seem non-intuitive to environmental scientists (Hübner et al., 2010). This is probably why in 2016 the ten most common sources of this disputed term included renowned environmental journals with a considerable impact (including *Science of the Total Environment*; **Table 1**).

**Table 1** Number of publications during 2016 using the term “heavy metal” in the topic for the ten most common sources and *Environmental Science & Technology* (selected as a reference journal); proportion of documents using the term “heavy metal” is indicated into brackets (from Scopus and Web of Science using “heavy metal\*” search, data accessed on August 1<sup>st</sup> 2017).

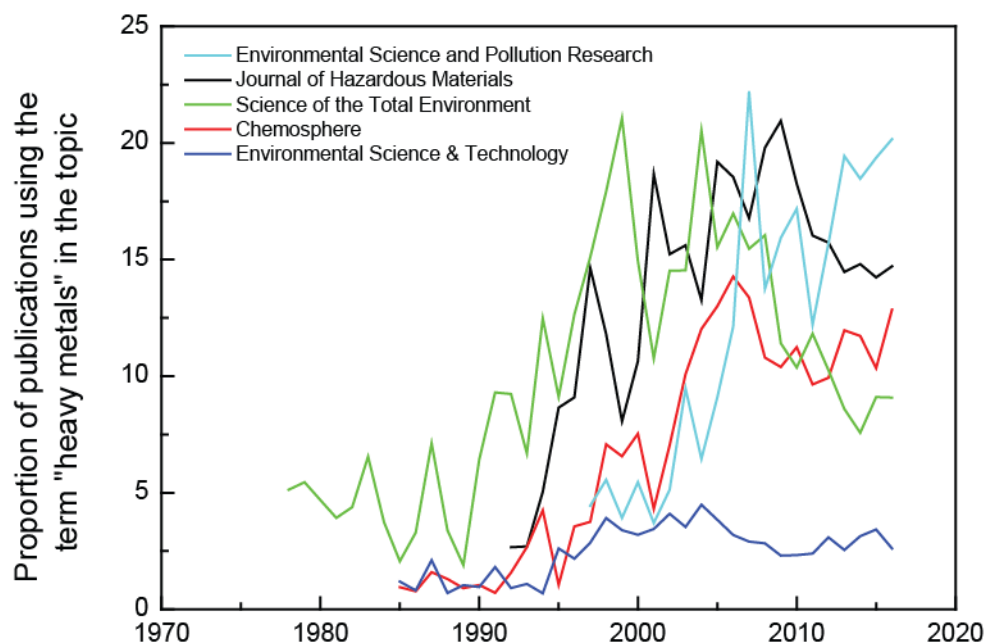
|   | Scopus    | Web of Science |
|---|-----------|----------------|
| <i>Environmental Science and Pollution Research</i> | 363 (15%) | 558 (20%)      |
| <i>Desalination and Water Treatment</i>             | 218 (8%)  | 378 (14%)      |
| <i>Chemosphere</i>                                  | 166 (10%) | 222 (13%)      |
| <i>Science of the Total Environment</i>             | 148 (5%)  | 238 (9%)       |
| <i>Environmental Monitoring and Assessment</i>      | 143 (17%) | 152 (21%)      |
| <i>Marine Pollution Bulletin</i>                    | 137 (13%) | 123 (13%)      |
| <i>Environmental Pollution</i>                      | 109 (11%) | 133 (14%)      |
| <i>Environmental Earth Sciences</i>                 | 105 (7%)  | 171 (11%)      |
| <i>RSC Advances</i>                                 | 105 (1%)  | 194 (1%)       |
| <i>Journal of Hazardous Materials</i>               | 98 (12%)  | 140 (15%)      |
| <i>Environmental Science &amp; Technology</i>       | 37 (3%)   | 41 (3%)        |

Despite the repeated calls to stop (Nieboer and Richardson, 1980; Duffus, 2002; Madrid, 2010), and the apparent regular reading of the papers related to this controversy (**Table 2**), the use of the term “heavy metal” appears not to have declined in the scientific literature (**Figure 1**). Indeed, the use of the term is increasing rather than declining. If we look in to this with more detail, and choose four “heavy metal” highly cited journals (i.e., *Journal of Hazardous Materials*, *Chemosphere*, *Science of the Total Environment* and *Environmental Science and*

*Pollution Research*) we notice an exponential increase during the last 30 years, related to the increasing number of articles; however, the proportion of articles using the term “heavy metal” remains stable at around 3% for *Environmental Science & Technology* (selected as a reference) whereas *Science of the Total Environment* and *Chemosphere* have stabilized their use (between 10% and 15%), and *Journal of Hazardous Materials* or *Environmental Science and Pollution Research* still have a high use of this term (up to 20%) (**Figure 2**). Are there any editorial policies behind these trends?

**Table 2** Type of article and number of citations of papers related to the controversy use of the term “heavy metal” (data accessed on August 1<sup>st</sup> 2017).

| Reference                     | Type of article   | Number of citations |                |
|-------------------------------|-------------------|---------------------|----------------|
|                               |                   | Scopus              | Web of Science |
| Nieboer and Richardson (1980) | Full paper        | 697                 | 637            |
| Duffus (2002)                 | Full paper        | 267                 | 273            |
| Hodson (2004)                 | Invited paper     | 32                  | 17             |
| Chapman (2007)                | Letter            | 5                   | -              |
| Hübner et al. (2010)          | Perspective paper | 14                  | 13             |
| Madrid (2010)                 | Letter            | 8                   | 6              |
| Appenroth (2010)              | Review            | 19                  | 16             |
| Nikinmaa and Schlenk (2010)   | Editorial         | 1                   | -              |
| Chapman (2012)                | Letter            | 3                   | -              |
| Batley (2012)                 | Letter            | 6                   | -              |



**Figure 2** Proportion of publications using the term “heavy metal” in the topic among time for highly “heavy metal” citing journals (from Web of Science using “heavy metal\*” search, data accessed on August 1<sup>st</sup> 2017).

Although the term has recently been defended by Batley (2012) and Alloway (2013), let us consider definitively banning this terminology from scientific papers, whatever the corresponding research field (for geochemistry: see Hodson, 2004; for plant physiology, see Appenroth, 2010). Unfortunately the present authors committed in the past this unforgivable mistake: of course, we now apologize for this, and we can conclude that nobody’s perfect!

Due to our experience of reviewing scientific papers for a number of environmental journals, we strongly suggest to remove “heavy metals” from all future key-words lists, and to replace it in the title, abstract and full text of every newly submitted paper with words like

“potentially toxic metal(s)/element(s)” or “trace metal(s)/element(s)”, according to the context.

Journals like *Science of the Total Environment* should take a position on this and have a related editorial policy. As Chapman (2007) proposed “heavy metal” is relevant for musical terminology only, not for science.

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