

## Article

# Chemicals Denial—A Challenge to Science and Policy

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**Abstract:** Much research shows that science denial regarding climate change is widespread and problematic for science and scientists, as well as for policy-makers. Climate denial delays goal achievement. As shown in this article, science denial commonly occurs also in the field of chemicals assessment and policy, but the research on the topic is scarce. The peer-reviewed studies that exist mostly concern a limited number of specific cases, such as DDT, CFCs and endocrine disrupting chemicals. The characteristics of ‘chemicals denial’ show similarity with those of climate denial, including reliance on fake experts, cherry-picked facts and attacks on scientists, with a key aspect being the questioning of causal relationships. Considering the gaps between chemicals policy goals and the state of the environment, further scientific exploration in the field is needed. Developing a better coordinated research agenda and a common terminology are therefore warranted strategies. A key concept in such endeavors could be ‘chemicals denial’.

**Keywords:** chemicals denial; science denial; doubt; manufacturing uncertainty; chemicals; risk; policy; environmental goals

## 1. Introduction

A recent review of journal articles exploring environmental science denial shows that the topic of climate change dominated the research in the field from 1990–2015 [1]. Titles or abstracts of more than 5000 publications were scanned, and about 80 percent of the 161 articles eventually analyzed in depth are climate-related. These focus on various types of climate denial, such as ‘trend attribution and impact denial’ [2], and ‘literal, interpretative and implicatory denial’ [3]. Whereas the former taxonomy concerns scientific aspects, the latter also includes social dimensions. Implicatory denial, for example, refers to situations in which climate science is not questioned per se, but where the implications of science, given climate goals, are questioned on a non-scientific basis. The analyzed articles also explore attributes and explanations of denial, as well as counteracting strategies. The characteristics of science denial are well-studied and include belief in conspiracy theories, reliance on fake experts, cherry-picked supportive facts, neglect of refuting information, and impossible expectations of what research can deliver, as well as attacks on science and scientists [4]. Regarding measures for coping with denial, these are more sparsely researched, which is problematic considering the negative impact of denial on policy-making [1].

Besides the climate issue, the articles in the environmental science denial review (hereafter referred to as the ‘ESD Review’) focus on science denial more generally or on a limited number of other environmental issues. Only a few of these articles concern issues related to chemicals and chemicals policy, foremost on stratospheric ozone depletion [5–7]. This is surprising, given the often intensive debate on the effects of various chemical substances and chemicals policy, both within academia and in politics [8–10], and given the gaps between the state of the environment and chemicals policy objectives [11,12].

Aiming to promote science-based policy, this study examines if denial is not more common and researched in the field of chemicals than what the results in the ESD Review show. According to the review, this has not been systematically investigated before.

In the following, the term ‘chemical’ refers to chemical substances (in themselves, preparations or goods) that are assessed to cause problems or risks for human health or the environment, or which are considered hazardous, i.e., have a potential to cause risks or problems, where there is sufficient scientific evidence for making such claims. The focus is placed on chemicals in ambient indoor or outdoor environments, and the field of medicine is not covered. The term ‘science denial’ is used for ‘an activity aimed at renouncing some well-justified assertion or theory in mainstream science’ [4], irrespective of whether this activity targets research or policy-making. Combining these terms results in the key concept of ‘chemicals denial’, which is used throughout this study. (The ESD Review shows that, in relation to climate issues, both ‘climate denial’ and ‘climate science denial’ occur in the scientific literature. In this study, ‘chemicals denial’ is used because there is no single scientific discipline that is taken as the starting point for the investigation.) Moreover, the focus is placed on organized, not ignorant, denial [13].

More specifically, the study identifies issues where chemicals denial occurs and is scientifically targeted and in doing so focuses on (i) who the deniers are, (ii) how they operate, and (iii) which counteracting strategies that are proposed. The article explores potential patterns in the findings, and discusses similarities or differences compared to environmental science denial in other areas, as well as further research needs.

Whereas the focus is placed on scientific studies in the field, the initial identification of chemicals denial goes beyond peer reviewed journals and includes grey literature, media and other popular publications. The intention is not to provide a full appraisal, but instead complement the ESD Review.

In the following, the next section explores whether chemicals denial is common, followed by a section analyzing scientific studies in the field, divided into a general part and one focusing on endocrine disrupting chemicals (EDCs). The article ends with a discussion.

## 2. Denial in the Field of Chemicals

A conceivable explanation for the few articles on chemicals that were identified in the ESD Review is that chemicals denial does not exist more than marginally, or is seldom heard about. If so, few would study the topic and the findings would be scarce. However, a basic internet search on the key terms elaborated above, as well as publications other than scientific journals, reveals occurrence of chemicals denial.

To start with, a number of news articles over the years indicate that chemicals denial is common. One early illustration is provided by the many science denying reactions in media and campaigns following the publication of Rachel Carson’s *Silent Spring* in 1962 [14], often criticizing Carson personally [15]. *Time* magazine, for example, published a piece that claims that DDT, a substance that Carson strongly criticized the use of, is ‘harmless’, and that Carson’s case was ‘unfair, one-sided, and hysterically overemphatic’ [16]. Carson’s book and messages continued to be debated and criticized for at least half a century, despite increasing scientific support for her argumentation [15,17–19]. Another example concerns ozone layer depletion, which is mainly caused by emissions of chlorofluorocarbons (CFCs). The researchers who first raised warnings for the ozone depleting potential of CFCs, Mario Molina and Sherwood Rowland [20], were often criticized. In media and advertisements, ozone depletion and the role of CFCs were downplayed, for example in the *Los Angeles Times*, in which a company representative stated that the criticism of CFCs was ‘orchestrated by the ministry of disinformation of the K.G.B.’ [21]. The main CFC producer, Du Pont, did not change its basic view on CFCs until 1988, long after the first science-based warnings and years after factual observations of severe ozone depletion [21,22]. A third illustration is provided by science denying reactions on the book *Our Stolen Future* in 1996, which presents risks and problems of EDCs to the wider public [23]. The book and its authors were strongly criticized by the chemicals industry, not least the first author,

Theo Colborn, who was exposed to similar types of campaigns and accusations as were directed towards Rachel Carson more than three decades earlier [24].

In the three cases of DDT, CFCs and EDCs, various organizations and commentators also supported the criticized researchers and their warnings [15,21], but the deniers and their activities still caused serious policy delay.

More recent examples of chemicals denial are provided by the investigative journalists Stéphane Horel, who has revealed how for example industry groups worked in order to obstruct European Union legislation on EDCs [25], and Eric Lipton, who has uncovered denial within the U.S. Environmental Protection Agency linked to for example risk assessment processes [26,27]. In these cases, several stakeholders have been pointed out as denying scientific knowledge on problems and risks of common industrial chemicals. In addition to this evidence in the media, different organizations also describe chemicals denial. One example is the *Union of Concerned Scientists*, which in its 'Disinformation Playbook' points out commonly occurring strategies, as well as concrete stories where chemicals denial is claimed to exist [28].

Even more so, there are examples when scientists, active in the field of chemicals in a broad sense, themselves claim that industry groups try to manipulate their findings, for example in a large call by researchers in *Le Monde* [29]. Here, EDCs are often a recurring and controversial theme. The same became obvious during a researchers' roundtable seminar on denial and delay linked to EDCs ('Closing the science-policy gap for endocrine disrupting chemicals: denial and delay', held in Stockholm, 14 March 2017). Participants at the meeting confirmed that partial and irrelevant industry criticism of scientific studies in general, and of scientists in particular, is a severe but familiar problem for researchers active in the fields of toxicology, ecotoxicology, regulatory toxicology and chemicals policy.

Moreover, chemicals denial has been described in the grey literature and academic books. An example of the former is given by two comprehensive reports on 'late lessons from early warnings' in a number of environmental issues, published by the European Environment Agency [30,31]. The reports cover, for example, denial in case studies on benzene, asbestos, PCBs, halocarbons, tributyltin [30], as well as on lead, mercury, vinyl chloride, bisphenol A (BPA) and DDT [31]. The reports conclude that early science-based warnings for health or environmental risks and problems have often been met with everything from fierce opposition in public debate to legal challenges, voiced and driven by companies, politicians, and, occasionally, some scientists that have gone far beyond normal scientific dialogue. An example among academic books is *Merchants of Doubt*, by the two historians of science Naomi Oreskes and Erik M. Conway, who explore how climate denial resembles previous science denial linked to tobacco, acid rain and ozone depletion [32]. Chemicals denial is also described by historians Gerald Markowitz and David Rosner in *Deceit and Denial*, focusing on industry group's campaigns to downplay lead pollution [33], and by epidemiologist David Michaels in *Doubt is Their Product*, which explores how industries 'manufacture uncertainty' about, for example, hazardous asbestos and lead [34].

Taken together, this material reveals that chemicals denial has been occurring for decades. Evidently, silence about chemicals denial does not explain the few findings in the ESD Review. On the contrary, additional studies on chemicals denial ought to exist in peer reviewed journals. Tentatively, articles may have been published outside the time period covered by the ESD Review, or may have keywords not included in the review. On the former point, studies may date to before 1990, for example on DDT and CFCs. On the latter point, concepts such as 'doubt' and the phrase 'manufacturing uncertainty' are, as seen above, used in the literature. Moreover, the ESD Review search string is to a certain part quite specific (e.g., includes the comparatively narrow term 'endocrine' instead of the much broader 'chemicals') and may therefore miss hits of interest.

### 3. Chemicals Denial in Peer Reviewed Journals

In order to expand the investigation of existing research on chemicals denial, this study complements the ESD Review, which was largely based on the following search string:

(denial\* OR skeptic\*) AND (scien\* OR evidence) AND (environment\* OR climat\*)

In the present study, this string is modified by adding 'doubt\*' and by replacing (environment\* OR climate\*) with 'chemical\*', i.e.,:

(denial\* OR skeptic\* OR doubt\*) AND (scien\* OR evidence) AND chemical\*

This new search string generated a list of 1112 hits (within Title, Abstract, Keywords) in the scientific database Scopus (28 March 2019), and 871 hits after a limitation to final journal publications (articles, reviews, etc.) written in English. A further scoping to seven subject areas in Scopus (including 'environmental science' and 'pharmacology, toxicology and pharmaceuticals') resulted in 263 hits. The resulting search string is: TITLE-ABS-KEY ((denial\* OR skeptic\* OR doubt\*) AND (scien\* OR evidence) AND chemical\*) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "re")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO (SUBJAREA, "ENVI") OR LIMIT-TO (SUBJAREA, "PHAR") OR LIMIT-TO (SUBJAREA, "SOCT") OR LIMIT-TO (SUBJAREA, "ARTS") OR LIMIT-TO (SUBJAREA, "MULT") OR LIMIT-TO (SUBJAREA, "DECI") OR LIMIT-TO (SUBJAREA, "Undefined")). Scanning the titles of these articles, with the aim of the present study in mind, and with inclusion of a publication as the default principle in the case of uncertainty, gave a list of 73 publications. A read-through of the abstracts of these revealed that six publications describe chemicals denial in one way or another.

### 3.1. Denial, Doubt and Chemicals

The earliest of the six hits is an article in which Michaels, preceding his book three years later, calls on governments and their agencies to focus on data and analysis provided by scientists, not by industry groups that may manufacture uncertainty [35]. The study describes different cases in the U.S., in which science denial and, for example, insistence on impossible causal certainty, are concluded to have impeded decision-making, for example concerning chronic beryllium disease. Michaels mainly criticizes specific industry groups but also administrative bodies. Another study on denial focuses on the use of flawed science regarding emissions from smelters [36]. The authors describe how polluters made what is labelled as 'causality-denial' and 'biomagnification-denial' claims, and how this affected public health. Yet two other studies, focusing on litigation on asbestos in the U.S., show how certain pollution defendants routinely rejected solid facts and manufactured controversy and doubt [37,38].

In a review, Torretta et al. focus on a controversy following the classification by the International Agency for Research on Cancer (IARC) in 2015 of the herbicide glyphosate as 'probably carcinogenic to humans' [39]. The manufacturing company Monsanto reacted strongly on this classification and claimed that IARC's conclusion contradicted research in the field. Not long thereafter, the European Food Safety Authority (EFSA) claimed it 'improbable' that the molecule in question is carcinogenic to humans. In the following year, WHO and FAO stated that 'glyphosate is unlikely to lead to carcinogenic risk for humans as a consequence of exposure through the diet'. Based on this, Torretta and colleagues concluded that 'it is not possible to attribute a clear and unambiguous definition to glyphosate, especially regarding its potentially harmful effects on humans', but also that Monsanto commissioned a number of experts to evaluate the herbicide, that industry groups in various ways influenced EFSA, and that the WHO-FAO statement in 2016 took place 'for no clear reason'.

The most informative of the six publications is Bergman et al. [40], which is explored in more detail in the following.

### 3.2. Denial and Endocrine Disrupting Chemicals—An Example

The 2015 commentary by Bergman et al. [40] contains a comprehensive and detailed rebuttal of criticism in 2014 from ten private consultants and researchers in Lamb et al. [41] regarding two 2013 UNEP-WHO reports on EDCs [42,43]. Lamb et al. had claimed that the UNEP-WHO reports neither provided 'a balanced picture' nor reflected 'the state of science' on EDCs because they, for example, considered that evidence of causation had often been absent and that inadequate review methods had been used. Lamb et al. had revealed that their work had 'been conducted with funding support from

several sponsors: American Chemistry Council (ACC), CropLife America (CLA), CropLife Canada (CLS), CropLife International (CLI), European Chemical Industry Council (Cefic), and European Crop Protection Association (ECPA)', and that the 'sponsors were provided an opportunity to review a draft of the paper and offer comments for consideration by the authors'. Lamb et al. had also admitted that they had worked as consultants to industry within the field of concern.

The 24 authors in Bergman et al. were all lead or co-authors of the main UNEP-WMO report (most of them were also involved in writing the 'Summary for Decision-Makers' [43]) and largely constituted a group of well-merited researchers at universities and public institutes. They claimed no conflicts of interest. Their commentary shows in detail how Lamb et al. in various ways had promoted misinterpretation of the UNEP-WHO reports by manufacturing doubt, in a way that risks misleading non-experts, for example, public policy decision-makers. Bergman et al. summarized the lack of scientific understanding and rigor in Lamb et al. by a comparison with the tactics applied by the tobacco industry, as identified by Ulucanlar et al. [44], including the use of 'tweezers' (partial quotes and omission of qualifying information) and 'mimicked scientific critique' (detailed inspection of individual studies for methodological rigor in order to reject a larger body of evidence). In a 2015 follow-up comment on Bergman et al., Lamb et al. [45] avoided refuting most of the criticism by Bergman et al. and merely raised some additional topics, for instance claiming a hazard-risk divide (this is an overstated controversy, see: [46]).

It is of interest to see how Bergman et al. and the follow-up comment by Lamb et al., both published in 2015, have been referred to and commented on in the scientific literature. The Scopus database (28 March 2019) gave 25 citations of Bergman et al. [40] and 10 (overlapping) citations of Lamb et al. [45]. A read-through of the abstracts of these publications, and in case of doubt, the main texts as well, revealed that eight are of relevance for the present study.

To start with, four publications explicitly comment on the dispute. A response letter to Bergman et al. from a group of companies states that they supported Lamb et al. to 'seek an independent (sic!) expert opinion' on the UNEP-WHO report [47]. No substantive remarks are made in the letter though. The opposite is the case in an essay by Trasande et al. who claim that the criticism of the UNEP-WHO report 'included many scientifically inaccurate comments', that the report was agreed to by over 100 countries, and that there were mainly four industry organizations who registered disagreement [48]. Trasande and colleagues also object to the phrase 'sound science', which they consider industry-coined (they refer to Michaels op. cit. who traced the phrase back to the tobacco industry), and instead call for 'best science', stated to include peer review of publications and grant applications. Moreover, Clahsen et al. analyze the different argumentation in the two publications, but while the varying normative starting points are explored, the study does not 'evaluate potential fallacious reasoning' and is therefore less relevant for the present study on chemicals denial [49]. Finally, Beronius and Vandenberg state that Lamb et al. erroneously presume the existence of agreed methods for systematic reviews of EDCs [50].

The remaining four publications refer to chemicals denial more generally. Aho shows how industry works to weaken regulation on EDCs, not by trying first-hand to persuade scientists to change their views, but rather by seeking to convince the public, and in particular politicians, to support their positions [51]. Aho claims that 'the regulatory structures have precipitated' industry's opportunities to do so. In line with that, Vandenberg and Prins, in an editorial, consider that manufacturing of doubt is a main explanatory factor for disputes over chemicals, and they briefly refer to the case of BPA [52]. More in-depth, Trasande focuses on the regulatory process in the U.S. for the endocrine disrupting pesticide chlorpyrifos [53]. He highlights when the then new U.S. EPA Administrator Pruitt denied revoking food residue tolerances for chlorpyrifos, as the EPA originally had proposed, and motivated his decision with claims of 'predetermined results'. Trasande, one of the scientists behind the underlying studies, rejects the accusation and emphasizes that the research in question was relevant, of high quality and had been peer reviewed. He also stresses that the social costs of exposure to chlorpyrifos had not been adequately considered in the EPA decision. Trasande similarly regards policy-making on brominated flame retardants, phthalates and bisphenols as being delayed, 'despite



substantial evidence for serious public health concern', and that scientists in the field not seldom are attacked by certain industries or their consultants, for example through accusations of various forms of scientific misconduct. A historical example of denial is provided in a study of Union Carbide Corporation's (UCC) use of so-called 'anti-warnings' in the 1960s and 1970s concerning chrysotile asbestos products [54]. Despite awareness of the products' carcinogenic properties, UCC utilized anti-warnings in publications, customer communications and public speeches, which provided false information, partial truths and misinformation. Finally, the comprehensive Endocrine Society's Second Scientific Statement on EDCs advises 'readers of papers on EDC effects' to 'consider whether articles are peer reviewed and whether there might be a conflict of interest of reviewers, editors, or publishers with industry connections ...' [55].

#### 4. Discussion

This study explores the research on the occurrence and characteristics of chemicals denial, including similarities or differences with environmental science denial in other fields, whether researchers describe how to counter denial, and if further research is needed. The question whether chemicals denial after all is a target for scientific inquiry can be answered affirmatively—scientists do study the topic.

The results moreover show that great concern exists over chemicals denial and that its characteristics are strikingly similar to the well-described attributes of climate denial. Compared to the trend-attribution-impact types of climate denial, human attribution denial is not much of an issue in the field of chemicals. Denial of pollution trends exists, but it is foremost denial of negative impacts that is occurring and of significance; examples include claims that pesticides are not particularly harmful for non-target organisms, that CFCs do not deplete the ozone layer, and that EDCs—such as BPA—are hardly problematic for public health and the environment, especially not at low concentrations. In these and several other cases, there is also evidence of literal as well as interpretative and implicatory chemicals denial.

The deniers, commonly being different industry groups and their consultants, sometimes operating under a disguise of science, apply similar tactics and methods as seen among climate deniers, including relying on fake experts, cherry-picking data, and questioning the integrity of researchers. Since chemicals denial, as far as is known, does not seem to concern the public as much as climate denial does in some countries, conspiracy theories have not been shown to flourish in the field of chemicals.

The main common element of chemicals denial is to question causal relationships, even when assertions are based on assessments that are scientifically justified (to distinguish from situations when scientific uncertainty is apparent). Deniers commonly have unreasonable expectations on what research can deliver and often argue for placing the burden of proof on those who claim the existence of risks or problems, arguing that such an order applies 'sound science'. However, as the question of where to place the burden of proof is normative, this argumentation is a naturalistic fallacy (and 'sound science' is tautological) that serves to delay decision-making. Reversing the burden of proof according to the precautionary principle, and thus erring on the side of safety, would be just as accurate an order, albeit more in line with goals in chemicals policy [56].

Regarding research on counteracting strategies, the results are meagre. The peer-reviewed studies analyzed in this article mainly focus on refuting denial in specific cases. While research on chemicals denial is scarce in general, the issue on how to cope with science denying activities is overlooked in particular. Here, proposals from research on how to counter climate denial might be valuable to consider, for example how to best communicate these issues (see [1,4] for examples).

As both the ESD Review and the literature search in this study indicate, there is no uniform terminology for denial linked to chemicals. As far as can be seen, neither is there any coordinated research in the field. Even if the literature survey would be complemented with additional search terms (e.g., combinations with 'manufacturing uncertainty' and 'sound science'), the hits would most likely still be few, at least compared to the number of studies focusing on climate denial. Interestingly, the keywords in the scientific articles referred to in this study differ significantly. Most of them

focus on substance issues (e.g., ‘endocrine disruption’, ‘glyphosate’, ‘biomagnification’, ‘weight of evidence’, and ‘expert roles’), and among the few that express a denial dimension (e.g., ‘doubt science’, ‘manufacturing uncertainty’, ‘anti-warnings’) there is no uniform use of terms. This fact—and the content of the identified articles—point to the conclusion that denial as such is less studied than the specific problems at hand in each case. In academic writing, it is foremost the books by Oreskes and Conway [32], Markowitz and Rosner [33] and Michaels [34], that portray and elaborate on chemicals denial more generally.

Considering the magnitude of problems and risks for public health and the environment at hand, and what additional delay in chemicals policy goal achievement could cost society [30,31,55,57,58], further general research and case studies on chemicals denial are highly warranted, and a better coordinated research agenda with peer-reviewed publications as outputs should be aimed for. Such research could help to close the chemicals policy-environmental state gap and would benefit from a common terminology. A suitable concept and keyword for such research endeavors could be ‘chemicals denial’.

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