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Disinfection By-Products Regulation: Zero ng/L Target

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Abstract

Ten years ago, I was asked by a health agency about my opinion concerning the guidelines for drinking water quality. I suggested fixing the maximum acceptable concentration (MAC) to zero ng/L, once and for all for each pollutant. Such a proposition is founded on the fact that regularly the MAC is lowered following some considerations like 1) the lethal dose determination and toxicity studies, 2) the progress recorded in analytical methods and water treatment technologies and, 3) the technical-economic features of the country. Attaining the zero ng/L target is related to applying the best available technologies such as those used in the International Space Station. This work focuses on the hard challenges in dealing with the disinfection by-products (DBPs). This work concludes that, in terms of poisoning, unregulated products *vs.* regulated products, the question does not matter. DBPs formation should be absolutely avoided. Moreover, if DBPs are unwantedly produced, all of them must be securely removed from the water at the highest level as other organic matters. Finally, disinfection is killing microorganisms present in water; but, it is also killing human beings drinking water via its inherent toxic DBPs. Treating chemically water should be avoided.

Subject Areas

Chemical Engineering & Technology, Public Health

Keywords

COVID-19 Pandemic, Coronavirus, Hospital Wastewater, Disinfection, Chlorination, Disinfection By-Products (DBPs)

1. Introduction

Disinfecting water is considered as a main public health conquering since it considerably decreased waterborne illness and augmented life expectancy [1]. Nevertheless, a not planned sequel was the formation of disinfection by-products (DBPs), which are generated via the reaction of disinfectants (chlorine, chloramine, ozone, chlorine dioxide, ultraviolet (UV)) with natural and anthropogenic organic matter, bromide, and iodide [2] [3] [4]. Such compounds are produced for any specific objective but are generated throughout water treatment [5] [6] [7]. Until now, more than 700 DBPs have been defined, and of those, around only 100 have been strictly examined for their existence, generation, and quantitative analytical biological toxicity [8] [9] [10].

In the early 1970s, at most a few of DBPs were investigated, foremost trihalomethanes (THMs) [11] [12]. Later, such THMs were observed to be prevalent in chlorinated water and were as well discovered to be carcinogenic in laboratory animals [1] [13]. Consequently, the earliest DBP regulations were announced [14] [15] [16]. The emerging U.S. Environmental Protection Agency (EPA), which was instituted in 1970, started to regulate THMs (chloroform, bromoform, bromodichloromethane, and chlorodibromomethane) below the 1979 Safe Drinking Water Act [1]. Subsequently, more toxicity facts were acquired for five haloacetic acids, bromate, and chlorite; and these were attached to the regulation below the Stage 1 and Stage 2 [17] [18] [19]. The World Health Organization, European Union, and many different nations also have guidelines or regulations for some DBPs in drinking water [1].

This work focuses on the hard challenges in dealing with the disinfection by-products (DBPs). Fundamental interrogations relating DBPs monitoring are presented. The fact that regulating DBPs is important or not is also discussed.

2. Deep and Basic Questions

Richardson and Plewa [1], well-known experts in the DBPs field, posted a relevant question: "Are we controlling the right DBPs?" Previous researches on human epidemiology support the plan of regulating and controlling DBPs since numerous investigations noted a hazard of bladder cancer, colorectal cancer, miscarriage, and birth defects [1] [20] [21].

One more matter in question is that water is not as it was consumed seventy years earlier [1] [22] [23]. It is ever-changing [24] [25] [26]. During the time that regulations and ecological protection actions greatly enhanced the protection of water, potable water is unlike what it was a half-century ago [14] [27] [28].

If in the end all the different DBPs were as well decreased with the regulated DBPs, the situation would be better [1]. In fact, the more poisonous iodo-DBPs and nitrogen-containing DBPs (N-DBPs) [29] could be produced at much greater degrees when plants change to chloramine [30]. A change to ozone could as well lead to an augmented generation of bromate, as well as unregulated halonitromethane, haloaldehyde, haloketone, and haloacid DBPs, with secondary chlorination [15] [31] [32]. Paradoxically, UV could response with natural organic matter (NOM) to augment the production of considerably hazardous halonitromethanes if secondary chlorine is implemented [33] [34] [35]. Since ozone and UV do not provide a residual disinfectant, chlorine or chloramine is frequently injected as an additional disinfectant to keep disinfection in the distribution system [36] [37] [38].

Additional elements also influence water sources like population increases, climate change, water usage, and wastewater reuse [39] [40] [41]. As an example, climate change increases wastewater pollutants in water sources, as well as concentrates NOM, bromide, and iodide, constituting circumstances for worsening the hazardous effects on water [1] [42] [43] [44] [45].

3. DBPs Toxicity: Regulating DBPs Significance

Since the earliest DBP poisoning investigations launched five decades ago, more than 100 additional DBPs were rigorously analyzed for cytotoxicity, genotoxicity, endocrine disruption, and carcinogenicity [46] [47] [48]. Several unregulated DBPs were found more dangerous than regulated ones [1] [49] [50].

More technical details can be found in the excellent discussion performed by Richardson *et al.* [1] and references cited in.

Finally, treatment master plans must be adopted to avoid the formation of DBPs, whether regulated or unregulated [51] [52] [53]. Viable techniques involving the usage of granular activated carbon or membranes to retain DBP precursors (then injecting a smaller injection of chlorine for killing pathogens), utilizing UV pursued by a smaller dosage of chlorine [1] [14] [54] (**Figure 1**).

4. Conclusions

Considered as the latest technique, post-disinfection is extremely crucial for the classical potable water treatment [55] [56] [57]. Disinfection target is to kill microorganisms that cause diseases in water to make certain the potable water security [58] [59] [60]. But, the quality of the fountainhead water becomes worse and worse due to rising natural and artificial water contaminations [61] [62] [63]. DBPs are generated at what time disinfectants (chlorine, chlorine dioxide, chloramines or ozone) interact with NOM, anthropogenic contaminants, bromide, and iodide in the potable water treatment chain [64] [65] [66]. As well the regulated DBPs (such as THMs, HAAs, bromate and chlorite), several additional unregulated DBPs have been detected [67] [68] [69]. Nitrosoamines are the elements of these new DBPs, which are strongly carcinogenic, mutagenic, and teratogenic [70] [71] [72]. The main points drawn from this review may be drawn as:

1) The first objective of water treatment is to render water secure to consume by making certain that it is without of pathogens and poisonous compounds; the second target is to render it a desirable drink by eliminating unwanted turbidity, tastes, colors, and odors [73] [74] [75]. Considering the first objective render

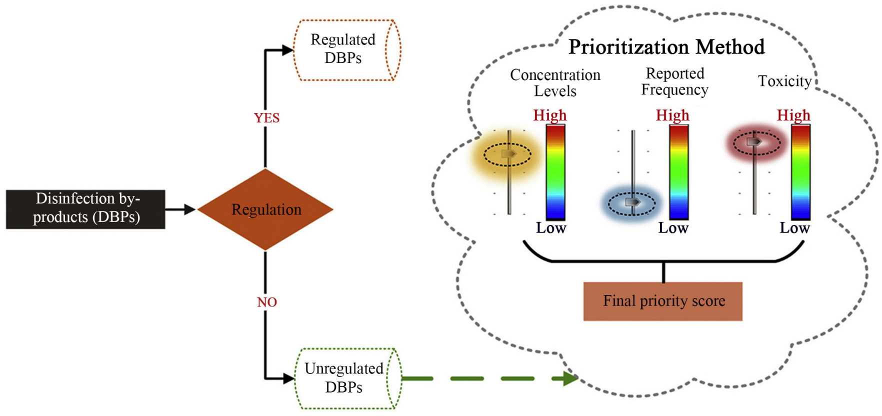

Figure 1. Regulated DBPs vs. unregulated DBPs [53].

water without pathogens and toxic matters, it is obvious that disinfecting by injecting chemicals is an impossible compromise since disinfection kills microorganisms but forms DBPs [76] [77]. Consequently, injecting chemical products into water must be avoided even if the mentioned reason is disinfecting water [14] [15].

2) Instead of chemical therapy, sure techniques such as physical processes like distillation and membrane processes should be urgently adopted to remove pathogens and organic compounds [14] [15].

3) Finally, at the COVID-19 period, this study arrives at its time since the Environmental Engineers and the Green Chemistry specialists have largely opened the discussion about polluting industry and preserving nature [78] [79] [80] [81].

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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