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VALESOR
Valuation of environmental stressors

Policy Brief

Pollutants and chemical substances included in the ambient air quality directive (AAQD), and drinking water directive (DWD) and perspectives for health impact assessment

Key messages

- Chemical substances are related to various health effects
- AAQD and DWD regulate the monitoring and set limit values for dozens of pollutants, and chemical substances and their mixtures in ambient air, and drinking water
- Health impact assessment enables to quantify the health burden of several of the pollutants and chemical substances included in AAQD and DWD

Every day, people are exposed to multiple chemicals in the air, drinking water, food as well as consumer products and occupational environment. This can lead to a variety of health effects, influenced by the chemical type, exposure level and duration, and individual susceptibility. Short-term (acute) exposure may cause immediate health responses like respiratory distress, skin irritation, nausea, and organ failure. Long-term (chronic) exposure can result in cancers, neurological disorders, reproductive problems, and chronic diseases such as diabetes, liver and kidney damage. Endocrine disruptors can interfere with hormonal systems, causing infertility and developmental defects. About 5.7% of the global disease burden could be attributed to chemicals [1]. Moreover, in 2019 around 2 million lives and 53 million disability-adjusted life-years were lost due to exposure to selected chemicals [2]. However, these estimates included only small number of chemical substances as ambient air pollution itself was responsible for 4.5 million premature deaths in 2019 [3]. This highlights the need for regulations, thorough, more comprehensive risk and health impact assessments, as well as exposure reduction to protect health.

Ambient air quality directive, and drinking water directive

The Ambient Air Quality Directive (AAQD, Directive 2008/50/EC) is a European Union (EU) legislation aimed at maintaining and improving air quality across the EU. Enacted in 2008, subsequently amended and revised in 2024, it consolidates air quality legislation and sets limit values, target values, and threshold levels and monitoring requirements. The AAQD is periodically reviewed to incorporate the latest scientific knowledge and to promote monitoring of emerging pollutants, such as ultrafine particles, black carbon, and an increasing number of volatile organic compounds.

The Drinking Water Directive (DWD)aims to ensure high standards for potable water. It was originally enacted in 1998, and has undergone revisions to address emerging scientific and public health concerns. The latest revision of the DWD, adopted in December 2020,introduced several key updates as stricter limit values and inclusion of new substances like PFAS (per- and polyfluoroalkyl substances) and microplastics. Besides chemical parameters, DWD includes microbiological and indicator parameters (e.g. colour, taste).

EU member states are required to establish monitoring networks to measure ambient air and drinking water quality. If the air limit values are exceeded, countries must develop and implement air quality plans, and short-term actions to reduce air pollution emissions. If any drinking water quality parameter exceeds its permissible limit, immediate remedial actions are required. Regularly, the limit values are agreements built on epidemiological and toxicological evidence and the benefit of them is justified through health impact assessments (HIAs).

Table 1 presents the chemical substances regulated in AAQD and DWD. For each chemical, the main exposure routes, evidence of carcinogenicity and associated diseases, causality assessment, and available risk measures for an HIA are indicated.

Substances	**Directive inclusion**	**Exposure route**	**IARC[1]**	**Health outcomes**	**Causality**	**Available risk measures for HIA**
Acrylamide	DWD	Inhalation, ingestion	2A	Neurotoxicity and (oral) cancer	Likely to be causal	Unit risk available
Antimony	DWD	Inhalation, ingestion	2A	Lung cancer	Likely to be causal	No risk measure available[2]
Arsenic	AAQD, DWD	Inhalation	1	Lung, liver, kidney, and bladder cancer incidence. Bladder cancer mortality, CVD[4], and diabetes	Causal	RR[3], unit risk available
Benzene	AAQD, DWD	Inhalation	1	Acute myeloid leukemia	Causal	RR available
Benzo(a)pyrene	AAQD, DWD	Inhalation, ingestion	1	Lung cancer	Causal	Unit risk available
Benzo(b&k)fluor-anthene, benzo-(ghi)-perylene, and indeno (1,2,3-cd) pyrene	AAQD, DWD	Ingestion	2B	Lung cancer	Suggestive to be causal	Unit risk available
Bisphenol A	DWD	Ingestion	3	Diabetes type 2, CVD, asthma, preterm birth, and pre-eclampsia. Breast, and thyroid cancer	Inadequate to infer causality	RR available
Boron	DWQ	Ingestion		Reproductive and developmental toxicity	Likely to be causal	No risk measure available
Bromate	DWQ	Ingestion		Cancer	Likely to be causal	Unit risk available
Cadmium	DWQ	Inhalation, ingestion	1	Lung, renal cancer, chronic bone diseases, and Fanconi's syndrome	Causal	RR, unit risk available
Carbon monoxide (CO)	AAQD	Inhalation	2B	AMI[5] hospital admission	Likely to be causal	RR available
Chlorate and Chlorite	DWQ	Ingestion		Thyroid dysfunction, nervous system disorders, anemia	Inadequate to infer causality	No risk measure available
Chromium	DWQ	Inhalation, ingestion	3	Lung cancer	Inadequate to infer causality	RR available
Copper	DWQ	Inhalation, ingestion	3	Liver and kidney damage, CVD	Inadequate to infer causality	No risk measure available
Cyanide (Acrylonitrile)	DWQ	Inhalation	2B	All cancer incidence and mortality	Suggestive to be causal	RR available
1,2-dichloroethane	DWQ	Ingestion	2B	All cancer incidence	Suggestive to be causal	Unit risk available
Epichlorohydrin	DWQ	Inhalation	2B	All cancer incidence	Suggestive to be causal	Unit risk available
Fine particles ($PM_{2.5}$)	AAQD	Inhalation	1	Long and short-term natural mortality, long-term CVD, respiratory, and lung cancer mortality. Incidence of asthma, COPD, IHD[6], stroke, hypertension, dementia, and lung cancer. Hospitalization due to CVD and respiratory diseases	Causal	RR available
Fluoride	DWQ	Ingestion	3	Goiter, dental fluorosis, hypertension	Inadequate to infer causality	RR available
Haloacetic acids (HAAs)	DWQ	Ingestion		Small for gestational age, and overall cancer incidence	Inadequate to infer causality	RR available
Lead	DWQ	Inhalation, ingestion	2A, 2B & 3	Overall cancer incidence, low IQ, and premature mortality	Likely to be causal	Unit risk available
Microcystin-LR	DWQ	Ingestion	2B	Overall cancer incidence, reproductive toxicity	Inadequate to infer causality	No risk measure available

Substances	Directive inclusion	Exposure route	IARC	Health outcomes	Causality	Available risk measures for HIA
Mercury	DWQ	Ingestion	3	CVD mortality, IQ loss (MeHg)	Suggestive to be causal	RR available
Nitrogen dioxide (NO_2)	AAQD	Inhalation	2B	Long-term natural and respiratory mortality, short-term natural mortality, respiratory hospitalization. Incidence of asthma in children and adults, and acute lower respiratory infections in children	Causal	RR available
Nickel	AAQD, DWQ	Inhalation	1	Incidence of lung cancer	Causal	Unit risk available
Nitrate and Nitrite	DWQ	Ingestion	2A	Thyroid, colon, and stomach cancer. Preterm birth and neural tube defects	Likely to be causal	RR, unit risk, available
Ozone	AAQD	Inhalation		Natural mortality (long- term)	Causal	RR available
Particulate matter (PM_{10})	AAQD	Inhalation	1	Post-neonatal infant mortality, short-term natural, CVD, respiratory, and cerebrovascular mortality, long-term natural mortality	Causal	RR available
Pesticides[7] (glyphosate, pyrethroids, permethrin, dimethoate, chlorpyrifos)	DWQ	Inhalation	2A	Hodgkin's and non-Hodgkin's lymphoma, multiple myeloma, follicular lymphoma, and chronic lymphocytic leukemia	Likely to be causal	RR available
PFAS (PFOA/PFOS/PFNA/ POFA/ PFHxS/ PFuNDA)	DWQ	Ingestion	1	Kidney, liver, and testicular cancer. Eclampsia, gestational diabetes, type 2 diabetes, miscarriage, and pregnancy related hypertension	Suggestive to be causal	RR available
Sulphur dioxide (SO_2)	AAQD	Inhalation	3	Short-term mortality including respiratory and cerebrovascular mortality; IHD and cerebrovascular hospitalization	Suggestive to be causal	RR available
Tetrachloroethene and Trichloroethene (Chlorinated hydrocarbons: Trichloroethylene, Dichloromethane, PCBs, Trichloroethylene)	DWQ	Inhalation	1	Overall, pancreatic and bladder cancer	Suggestive to be causal	RR available
Trihalomethanes (Trihalomethanes Total, Bromodichloromethane, Bromoform, Chlorophorm, Dibromochloromethane)	DWQ	Ingestion	3 & 2B	Overall, renal, and large intestine cancer, and hepatic adenoma and carcinoma	Suggestive to be causal	RR, unit risk available
Uranium	DWQ	Ingestion		Overall cancer mortality	Inadequate to infer causality	RR available
Vinyl chloride	DWQ	Ingestion	1	Hepatic (HC) and pancreatic cancer (PC)	Causal for HC, inadequate to infer for PC	RR available

[1]IARC – International Agency for Research on Cancer (A – carcinogenic …, 2A – probably …, 2B – possibly carcinogenic to humans), [2]No risk measure available from epidemiological studies, [3]RR – relative risk; [4]CVD – cardiovascular disease, [5]AMI – acute myocardial infarction, [6]IHD – ischemic heart disease, [7]HBM4EU substances

Perspectives for health impact assessment

The health impact assessment (HIA) concept can be applied to quantify the health burden of chemical substances. It is a systematic, objective, and practical assessment process that helps to quantify the impacts on health and wellbeing, as well as any effect a policy, intervention program, or project may have on the health burden in the population or specific groups affected. For HIA calculations three different sets of data are needed: (1) data on pollutant/chemical substances exposures, (2) exposure-response functions or unit risks, and (3) baseline mortality/morbidity rate as well as population data (Figure 1).

Besides health impacts assessment that use relative risk (RR), also unit risk factors (URFs) have been used. A URF refers to the estimated increase in cancer risk associated with a one-unit increase in exposure to a specific carcinogenic substance. For example, a unit risk of 1 x 10^{-6} per µg/m^3 suggests one additional cancer case per million individuals exposed for a lifetime. It is preferably derived from epidemiological studies, but can also be calculated from animal studies that derive a dose-response relationship.

In summary, altogether 35 chemical substances or substance groups are considered in the AAQD and DWD directives (Table 1). These regulated substances are associated with various health outcomes, and many of them are causally classified as carcinogenic (1) or probable (2A) or possible (2B). In terms of available risk parameters for HIA, majority of the analyzed substances have either RR or unit risk data available. If the exposure data are available, this will enable calculation of health burden of those chemicals.

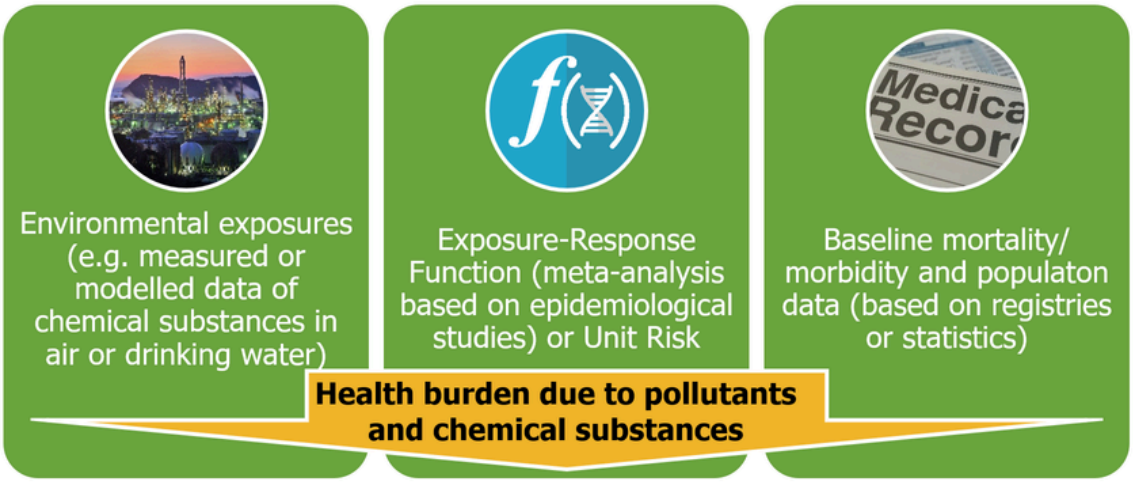

Figure 1. Data needed for burden calculation in health impact assessment.

References:

[1] EEA. 2020. Living healthily in a chemical world. European Environmental Agency, Copenhagen. www.eea.europa.eu/signals-archived/signals-2020/articles/living-healthily-in-a-chemical-world
[2] WHO, 2021. The public health impacts of chemicals: Knows and unknowns. Data addendum for 2019. World Health Organization: Geneva. iris.who.int/bitstream/handle/10665/342273/WHO-HEP-ECH-EHD-21.01-eng.pdf?sequence=1
[3] Fuller R, Landrigan PJ, Balakrishnan K, et al. 2022. Pollution and health: a progress update. Lancet Planetary Health. 6(6):e535-e547.

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