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# The Right to a Healthy Environment in the Era of Epigenetics: Between Jurisprudence, Pollution, and Prevention

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**Abstract:** Environmental exposures linked to climate change and pollution can alter gene expression through epigenetic mechanisms. Legal systems have only begun to take account of this. The paper examines what these findings mean for the right to a healthy environment. It reviews the case law of the European Court of Human Rights, recent advisory opinions of international courts, and selected European and Romanian rules, including the compulsory iodization of salt in Romania. A separate section asks whether epigenetic biomarkers can help applicants meet the evidentiary requirements of environmental litigation, in particular the victim-status test set out in *Verein KlimaSeniorinnen*. The paper argues that such evidence can corroborate traditional proof but cannot replace it, and that the precautionary principle offers the most suitable framework for risks that remain scientifically uncertain. It ends with proposals *de lege ferenda* for Romanian law.

**Keywords:** epigenetics; right to a healthy environment; EctHR; precautionary principle; environmental litigation; public health

## Introduction

Climate change and the wider ecological crisis are no longer distant projections. Their effects on health can already be measured. Rising temperatures, air pollution, and the degradation of ecosystems are associated with a growing burden of cancer, metabolic disease, and neurodegenerative disorders, and epigenetic mechanisms are one of the pathways through which these exposures reach the body.

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This paper is based on the premise that the environment acts as both a biological and a legal determinant, capable of influencing gene expression and affecting individual and collective health. Against this background, the judgment of the European Court of Human Rights of April 9, 2024, in *Verein KlimaSeniorinnen Schweiz and Others v. Switzerland*[1] is of particular significance for climate-related human rights litigation. The Court held that Article 8 of the European Convention on Human Rights encompasses a right to effective protection by state authorities against the serious adverse effects of climate change on individuals' lives, health, well-being, and quality of life.

The paper also draws on the work of physicians active in environmental medicine, notably Joachim Mutter, and on the reflections of the Romanian physician Pavel Chirilă.[2] Despite their different backgrounds, they share one conviction: human health cannot be protected in isolation from the environment.

Methodologically, the paper combines a doctrinal analysis of constitutional, European, and international legal instruments with an examination of the case law of the European Court of Human Rights (ECtHR) and of other international and national courts, and with a narrative review of the biomedical literature on environmental epigenetics. It does not try to settle contested scientific questions. Its aim is narrower: to assess what weight such evidence can carry in the legal protection of health.

## The right to a Healthy Environment in ECtHR Jurisprudence and Comparative Law

Although the European Convention on Human Rights does not explicitly enshrine the right to a healthy environment, the case law of the Strasbourg Court has developed considerably, mainly through an evolutive interpretation of Article 8 of the Convention (right to respect for private and family life) that extends to protection against environmental harm that affects life and health.

In *López Ostra v. Spain* (1994),[3] the Court found a violation of Article 8 on account of the nuisance caused by a waste-treatment plant operating near the

[1] *Verein KlimaSeniorinnen Schweiz and Others v. Switzerland* [GC], no. 53600/20, § 519 (ECtHR, April 9, 2024).
[2] See, among others, Joachim Mutter et al., "Amalgam Studies: Disregarding Basic Principles of Mercury Toxicity," *International Journal of Hygiene and Environmental Health* 207, no. 4 (2004): 391–97, https://doi.org/10.1078/1438-4639-00305; Pavel Chirilă, *Fața tristă a medicinei contemporane* (Editura Christiana, 2011).
[3] *López Ostra v. Spain*, no. 16798/90, Series A no. 303-C (ECtHR, December 9, 1994).

applicant's home. In *Fadeyeva v. Russia* (2005),[1] it held that prolonged exposure to emissions from a steel plant in a heavily polluted city fell within the scope of Article 8 and that the State had failed to strike a fair balance between the interests at stake. In *Tătar v. Romania* (2009),[2] the Court found a violation of Article 8 because the authorities had failed to assess adequately, and to inform the public about, the risks posed by the use of sodium cyanide in gold mining at Baia Mare.

The Court's case law concerning Romania is particularly relevant to the subject of this paper. In *Bacila v. Romania*, the Court found a violation of Article 8 because the authorities had failed to strike a fair balance between the economic interest in keeping the Sometra non-ferrous metals plant in Copșa Mică in operation and the applicant's right to respect for her home and her private and family life, despite the plant's emissions of lead, cadmium, and sulfur dioxide.[3]

These cases outline a consistent trend toward the indirect recognition of the right to a healthy environment, particularly when physical or mental health is affected.

A turning point came with the 2024 ECtHR ruling in *Verein KlimaSeniorinnen v. Switzerland*,[4] which, for the first time, held that a state's failure to adopt adequate climate-change mitigation measures violated Article 8 of the Convention. The violation was found on the application of an association representing older women particularly exposed to heatwaves, whereas the complaints of the four individual applicants were declared inadmissible for lack of victim status. The judgment strengthens the justiciability of environmental claims in Europe and is likely to encourage actions brought by associations. It builds on the pollution cases discussed above.

The Court has since extended this line of reasoning to the right to life. In *Cannavacciuolo and Others v. Italy*, concerning the large-scale illegal dumping and burning of waste in the "Terra dei Fuochi" area, the Court found a violation of Article 2 and applied the pilot-judgment procedure. It held that, in line with a precautionary approach, the absence of scientific certainty about the precise health effects of the pollution could not negate the existence of a protective duty.[5]

From the perspective of comparative law, several European states have constitutionally enshrined environmental protection. France integrated the 2004 Environmental Charter into its Constitution in 2005, establishing clear ecological

[1] *Fadeyeva v. Russia*, no. 55723/00, ECHR 2005-IV (ECtHR, June 9, 2005).
[2] *Tătar v. Romania*, no. 67021/01 (ECtHR, January 27, 2009).
[3] *Bacila v. Romania*, no. 19234/04, § 73 (ECtHR, March 30, 2010).
[4] *Verein KlimaSeniorinnen*, no. 53600/20.
[5] *Cannavacciuolo and Others v. Italy*, no. 51767/14 and others, § 391 (ECtHR, January 30, 2025).

obligations for public authorities.[1] In Germany, the Federal Constitutional Court ruled in 2021 that climate protection is a positive obligation of the state, directly linked to the rights of future generations.[2] Norway's Constitution, through Article 112, guarantees the right to a healthy environment and mandates the conservation of natural resources.[3] Notably, the Supreme Court of Justice of Colombia has recognized the Colombian Amazon as a subject of rights, entitled to protection, conservation, maintenance, and restoration.[4]

At the national level, Article 35 of Romania's Constitution provides that every person has "the right to a healthy and ecologically balanced environment."[5] In practice, however, Article 35 has seldom served as an autonomous basis for legal action, and the case law built on it remains thin. The absence of a clear accountability framework for public authorities often renders this right declarative rather than enforceable.[6]

Giving effect to this right also requires engagement with the medical evidence on how environmental exposures affect human biology.

## Climate Change and Environmental Exposures as Drivers of Epigenetic Change: Medical and Scientific Contributions

Over the past two decades, advances in molecular biology have brought renewed attention to the concept of epigenetics, defined as the set of modifications in gene expression that occur without altering the DNA sequence. These modifications are influenced by external factors such as diet, stress, pollution, and exposure to heavy metals or industrial chemicals. The broader notion of the exposome, which covers all environmental exposures, including lifestyle factors, from the prenatal period onward, places epigenetics in context: it is one of the pathways through which these exposures act on the body.[7] In other words, the environment imprints itself on

[1] Charte de l'environnement de 2004, incorporated by Loi constitutionnelle no. 2005-205 du 1er mars 2005 relative à la Charte de l'environnement, *Journal officiel de la République française*, March 2, 2005.
[2] Bundesverfassungsgericht [Federal Constitutional Court of Germany], Order of the First Senate of March 24, 2021, 1 BvR 2656/18 et al. (*Neubauer et al. v. Germany*).
[3] Constitution of the Kingdom of Norway, art. 112.
[4] Corte Suprema de Justicia [Supreme Court of Justice of Colombia], Sala de Casación Civil, STC4360-2018, April 5, 2018.
[5] Constituția României [Constitution of Romania], art. 35.
[6] For a comprehensive treatment of Romanian environmental law, see Mircea Duțu, *Dreptul mediului. Tratat. Abordare integrată*, vol. 1 (Editura Economică, 2003); Andrei Duțu-Buzura, *Tratat de dreptul mediului* (Universul Juridic, 2026).
[7] Christopher P. Wild, "Complementing the Genome with an 'Exposome': The Outstanding Challenge of Environmental Exposure Measurement in Molecular Epidemiology," *Cancer*

human health not only through direct contact, but also via subtle epigenetic mechanisms, with possible intergenerational consequences; transgenerational epigenetic inheritance, although documented in animal models, remains debated in humans.

Heat is itself a direct hazard: it increases mortality and morbidity, including complications of pregnancy.[1] Climate change also acts on health through the exposures described above, since it worsens air pollution and the contamination of water and soil. Short-term exposure to traffic-related particles, for example, has been associated with rapid DNA hypomethylation,[2] and epigenetic dysregulation is increasingly recognized as a mechanism through which environmental exposures contribute to chronic inflammation and to diseases such as cancer, cardiovascular disease, and type 2 diabetes.[3]

This relationship has also been documented during the prenatal period: the review by Baccarelli and Bollati highlights how prenatal exposure to environmental chemicals can alter epigenetic marks in the developing organism, with potential consequences for later health.[4]

Walter Crinnion[5] has linked exposure to environmental toxicants with hormonal and metabolic dysfunctions, while Shanna Swan[6] has drawn attention to the effects of endocrine disruptors (notably phthalates and BPA) on fertility and fetal development. Claudia Miller has proposed the theory of toxicant-induced loss of tolerance (TILT)[7] as an explanatory model for multiple chemical sensitivity, fibromyalgia, and chronic fatigue syndrome; its applicability to these conditions is still under investigation.

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*Epidemiology, Biomarkers & Prevention* 14, no. 8 (2005): 1847–50, https://doi.org/10.1158/1055-9965.EPI-05-0456.

[1] Kristie L. Ebi et al., "Hot Weather and Heat Extremes: Health Risks," *Lancet* 398, no. 10301 (2021): 698–708, https://doi.org/10.1016/S0140-6736(21)01208-3.

[2] Andrea Baccarelli et al., "Rapid DNA Methylation Changes after Exposure to Traffic Particles," *American Journal of Respiratory and Critical Care Medicine* 179, no. 7 (2009): 572–78, https://doi.org/10.1164/rccm.200807-1097OC.

[3] Andrew P. Feinberg, "The Key Role of Epigenetics in Human Disease Prevention and Mitigation," *New England Journal of Medicine* 378, no. 14 (2018): 1323–34, https://doi.org/10.1056/NEJMra1402513.

[4] Andrea Baccarelli and Valentina Bollati, "Epigenetics and Environmental Chemicals," *Current Opinion in Pediatrics* 21, no. 2 (2009): 243–51, https://doi.org/10.1097/MOP.0b013e32832925cc.

[5] Walter Crinnion, *Clean, Green, and Lean: Get Rid of the Toxins That Make You Fat* (Wiley, 2010).

[6] Shanna H. Swan with Stacey Colino, *Count Down: How Our Modern World Is Threatening Sperm Counts, Altering Male and Female Reproductive Development, and Imperiling the Future of the Human Race* (Scribner, 2021).

[7] Claudia S. Miller, "Toxicant-Induced Loss of Tolerance - An Emerging Theory of Disease?" *Environmental Health Perspectives* 105, suppl. 2 (1997): 445–53, https://doi.org/10.1289/ehp.97105s2445.

Taken together, these findings give the right to a healthy environment a biological dimension. If environmental exposures leave lasting marks on the body, the question of who is responsible for them becomes, at least in part, a legal question.

**Mercury toxicity and epigenetic risk in autism**

Physicians working in environmental medicine, among them Joachim Mutter, have drawn attention to chronic mercury toxicity as a possible factor in the rising incidence of autism spectrum disorders (ASD) in children. In the peer-reviewed literature, Mutter and colleagues have reviewed the evidence supporting this hypothesis.[1]

One potential source of mercury exposure in pregnant women is dental amalgam, which consists of approximately 50% elemental mercury.[2] Animal studies have shown that mercury released from maternal amalgam fillings crosses the placenta and accumulates in fetal tissues,[3] and Mutter and colleagues have proposed reduced mercury detoxification capacity as a factor in the vulnerability of some children to neurodevelopmental disorders, although, as they acknowledge, several epidemiological studies have found no association between thimerosal exposure and autism.[4] Epidemiological data further suggest that prenatal mercury exposure is associated with changes in DNA methylation in newborns;[5] whether such changes affect genes involved in central nervous system development, and with what clinical consequences, remains to be established.

Mutter has also questioned the methodology of studies that found dental amalgam to be safe, arguing that they disregarded basic principles of mercury toxicity.[6]

In response to growing scientific concern about mercury's risks, especially for children and pregnant women, the European Union adopted in 2024 a regulation banning the use of dental amalgam from January 1, 2025, except where the dental practitioner deems it strictly necessary on the basis of the specific medical needs of the patient. A temporary derogation allowed Member States in which dental amalgam was the only filling material publicly reimbursed at a rate of at least 90

[1] Joachim Mutter et al., "Mercury and Autism: Accelerating Evidence?" *Neuro Endocrinology Letters* 26, no. 5 (2005): 439–46.
[2] Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), *Opinion on the Safety of Dental Amalgam and Alternative Dental Restoration Materials for Patients and Users* (European Commission, 2015).
[3] M. J. Vimy, Y. Takahashi, and F. L. Lorscheider, "Maternal-Fetal Distribution of Mercury ($^{203}$Hg) Released from Dental Amalgam Fillings," *American Journal of Physiology* 258 (1990): R939–45.
[4] Mutter et al., "Mercury and Autism."
[5] Kelly M. Bakulski et al., "Prenatal Mercury Concentration Is Associated with Changes in DNA Methylation at *TCEANC2* in Newborns," *International Journal of Epidemiology* 44, no. 4 (2015): 1249–62, https://doi.org/10.1093/ije/dyv032.
[6] Mutter et al., "Amalgam Studies."

percent, and in which persons with low incomes would have been disproportionately affected, to permit its use until June 30, 2026.[1] This measure implements the objectives of the Minamata Convention and is consistent with the concerns long raised by Mutter and other physicians regarding the neurodevelopmental risks associated with mercury exposure. The European Commission's scientific committee had, however, concluded in 2015 that the available evidence did not preclude the use of dental amalgam in the general population, while recommending, as a precaution, that alternative materials be preferred for pregnant women and young children; the phase-out was thus driven chiefly by environmental considerations and by the availability of mercury-free alternatives.[2]

## Electromagnetic Fields, Heavy Metals, and Chemical Exposures

Radiofrequency electromagnetic fields, including those used in mobile communications, have also been described as possible epigenetic factors, alone or combined with heavy metals. Pall attributes their effects to the activation of voltage-gated calcium channels,[3] the EUROPAEM guideline reviews reported effects on the central nervous system,[4] and it has been hypothesized that such fields increase the release of mercury from amalgam fillings.[5] These views remain contested. The International Agency for Research on Cancer classified radiofrequency fields as "possibly carcinogenic to humans" (Group 2B) in 2011,[6] ICNIRP considers exposure below its limits free of substantiated adverse health

[1] Council of the European Union, "Council Signs Off on Measures to Make the EU Mercury-Free," press release, May 30, 2024; Regulation (EU) 2024/1849 of the European Parliament and of the Council of 13 June 2024 amending Regulation (EU) 2017/852 on mercury as regards dental amalgam and other mercury-added products subject to export, import and manufacturing restrictions, art. 1 (inserting Article 10(2a) into Regulation (EU) 2017/852), *Official Journal of the European Union* L, 2024/1849, July 10, 2024. See also United Nations Environment Programme (UNEP), *Minamata Convention on Mercury* (UNEP, 2013), https://www.mercuryconvention.org.

[2] SCENIHR, *Opinion on the Safety of Dental Amalgam*; see also Regulation (EU) 2024/1849.

[3] Martin L. Pall, "Electromagnetic Fields Act via Activation of Voltage-Gated Calcium Channels to Produce Beneficial or Adverse Effects," *Journal of Cellular and Molecular Medicine* 17, no. 8 (2013): 958–65, https://doi.org/10.1111/jcmm.12088.

[4] Igor Belyaev et al., "EUROPAEM EMF Guideline 2016 for the Prevention, Diagnosis and Treatment of EMF-Related Health Problems and Illnesses," *Reviews on Environmental Health* 31, no. 3 (2016): 363–97, https://doi.org/10.1515/reveh-2016-0011.

[5] Gh. Mortazavi et al., "Increased Release of Mercury from Dental Amalgam Fillings due to Maternal Exposure to Electromagnetic Fields as a Possible Mechanism for the High Rates of Autism in the Offspring: Introducing a Hypothesis," *Journal of Biomedical Physics and Engineering* 6, no. 1 (2016): 41–46.

[6] International Agency for Research on Cancer, "IARC Classifies Radiofrequency Electromagnetic Fields as Possibly Carcinogenic to Humans," press release no. 208, May 31, 2011.

effects,[1] and a systematic review commissioned by the World Health Organization found, with moderate certainty, no increased risk of head tumors from mobile phone use.[2] The hypothesis is, at most, a reason for further research.

Grandjean and Landrigan have identified a growing number of industrial chemicals, including pesticides such as chlorpyrifos and DDT, as developmental neurotoxicants that can impair neurodevelopment, behavior, learning, and memory.[3] Endocrine-disrupting chemicals such as phthalates and bisphenol A have, in turn, been associated with adverse effects on fertility and reproductive development.[4] Whether such chemical exposures act cumulatively with the physical stressors discussed above remains an open research question.

Findings from environmental medicine and clinical toxicology further suggest that the health effects of cumulative toxicant exposure are frequently underdiagnosed and may contribute to multisystem symptoms such as fatigue, cognitive difficulties, and mood disorders.[5]

## Correlations between Environmental Degradation, Public Health, and Human Rights

Environmental protection is a precondition for the exercise of the rights to life, health, and human dignity.

A large body of epidemiological evidence associates chronic exposure to air pollution with a higher incidence of cardiovascular, respiratory, metabolic, neurodegenerative, and oncological diseases. For example, the World Health Organization (WHO) estimates that ambient (outdoor) air pollution caused 4.2 million premature deaths worldwide in 2019, and that the combined effects of ambient and household air pollution are associated with 6.7 million premature

[1] International Commission on Non-Ionizing Radiation Protection (ICNIRP), "Guidelines for Limiting Exposure to Electromagnetic Fields (100 kHz to 300 GHz)," *Health Physics* 118, no. 5 (2020): 483–524.
[2] Ken Karipidis et al., "The Effect of Exposure to Radiofrequency Fields on Cancer Risk in the General and Working Population: A Systematic Review of Human Observational Studies – Part I: Most Researched Outcomes," *Environment International* 191 (2024): 108983, https://doi.org/10.1016/j.envint.2024.108983.
[3] Philippe Grandjean and Philip J. Landrigan, "Neurobehavioural Effects of Developmental Toxicity," *Lancet Neurology* 13, no. 3 (2014): 330–38, https://doi.org/10.1016/S1474-4422(13)70278-3.
[4] Andrea C. Gore et al., "EDC-2: The Endocrine Society's Second Scientific Statement on Endocrine-Disrupting Chemicals," *Endocrine Reviews* 36, no. 6 (2015): E1–E150, https://doi.org/10.1210/er.2015-1010.
[5] Miller, "Toxicant-Induced Loss of Tolerance"; see also Crinnion, *Clean, Green, and Lean*.

deaths annually.[1] These effects are not evenly distributed: poorer populations, overcrowded urban communities, and vulnerable groups (children, the elderly, individuals with pre-existing conditions) are the most severely affected.

At the same time, the contamination of water and soil with pesticides, heavy metals, and other persistent chemical substances affects the food chain and leads to bioaccumulation, with documented impacts on human health, including endocrine disorders, impaired fertility, and hormone-sensitive cancers.[2] Where such risks are systemic and foreseeable, they also become questions of human rights.

The State must not only refrain from harming the environment but also protect it: to regulate, prevent, inform, and facilitate access to justice and compensation. These principles are supported by jurisprudence and international instruments, notably the Aarhus Convention[3] and the Minamata Convention.[4] Environmental degradation thus creates a systemic risk for the enjoyment of human rights.

***The compulsory iodization of salt as a test of proportionality***

The tension between public health measures and individual autonomy is illustrated by Government Decision no. 568/2002,[5] which mandates the iodization of the entire quantity of salt intended for human consumption. The measure pursues a legitimate and well-documented aim: universal salt iodization is the strategy recommended by the World Health Organization for preventing iodine deficiency disorders.[6] The regime is not absolute: by way of derogation, non-iodized salt may be sold, but only through PLAFAR stores, health-food stores, and pharmacies, in packages not exceeding 0.5 kg.[7] The question is therefore not whether an alternative exists in law, but whether it is effectively accessible to those who need it.

The appropriate framework for assessing such a measure is the proportionality test developed by the ECtHR under Article 8 § 2 of the Convention. In *Vavřička and Others v. Czech Republic*, the Grand Chamber accepted that a statutory vaccination

[1] World Health Organization, "Ambient (Outdoor) Air Pollution," fact sheet, October 24, 2024, https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health.
[2] Gore et al., "EDC-2."
[3] United Nations Economic Commission for Europe (UNECE), *Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters* (Aarhus, June 25, 1998) (hereafter cited as *Aarhus Convention*).
[4] UNEP, *Minamata Convention on Mercury*.
[5] Hotărârea Guvernului nr. 568 din 5 iunie 2002 privind iodarea universală a sării destinate consumului uman, hranei animalelor și utilizării în industria alimentară, republished in *Monitorul Oficial al României*, Part I, no. 150, March 10, 2009.
[6] World Health Organization, *Guideline: Fortification of Food-Grade Salt with Iodine for the Prevention and Control of Iodine Deficiency Disorders* (WHO, 2014).
[7] Hotărârea Guvernului nr. 568/2002, art. 10(2).

duty interfered with private life but found it justified, emphasizing the wide margin of appreciation available to States in matters of public health policy and the value of social solidarity.[1] Applied to salt iodization, the test raises three questions: whether the measure pursues a legitimate aim, which is clearly the case; whether it is necessary, that is, whether less restrictive means, such as voluntary fortification combined with targeted supplementation, would achieve comparable results; and whether it strikes a fair balance between the collective benefit and the burden imposed on persons whose medical condition requires limited iodine intake.

On this last point, the decisive issue is less the existence of the obligation than the availability of an alternative for those who need one. Salt fortification is not a medical intervention within the meaning of Article 5 of the Oviedo Convention, but the principle of informed consent expressed in that provision is relevant by analogy when a population-wide measure leaves little practical choice to persons with specific clinical needs.[2] Few points of sale and small packages may make the alternative difficult to use in practice; to that extent, the framework remains open to criticism under the requirement of proportionality *stricto sensu*.

## Justiciability of the Right to a Healthy Environment: Legal Mechanisms and Perspectives

The right to a healthy environment is not yet explicitly enshrined in all international legal instruments, but it is increasingly being invoked before courts through the evolving interpretation of already recognized rights, such as the rights to life, physical integrity, privacy, and health. Within the Council of Europe system, the ECtHR has gradually built a framework of indirect protection through its interpretation of Article 8, and cases including *López Ostra*, *Fadeyeva*, *Tătar*, and *KlimaSeniorinnen*[3] have contributed to strengthening the justiciability of this right, particularly when there is documented health impact.

At the international level, both the UN Human Rights Council and the UN General Assembly[4] have recognized the right to a clean, healthy, and sustainable

[1] *Vavřička and Others v. Czech Republic* [GC], no. 47621/13 and 5 others (ECtHR, April 8, 2021).
[2] Council of Europe, *Convention for the Protection of Human Rights and Dignity of the Human Being with Regard to the Application of Biology and Medicine: Convention on Human Rights and Biomedicine*, ETS No. 164 (Oviedo, April 4, 1997), art. 5.
[3] *López Ostra*, no. 16798/90; *Fadeyeva*, no. 55723/00; *Tătar*, no. 67021/01; *Verein KlimaSeniorinnen*, no. 53600/20.
[4] Human Rights Council, Resolution 48/13, *The Human Right to a Clean, Healthy and Sustainable Environment*, UN Doc. A/HRC/RES/48/13 (adopted October 8, 2021); UN General Assembly, Resolution 76/300, *The Human Right to a Clean, Healthy and Sustainable Environment*, UN Doc. A/RES/76/300 (adopted July 28, 2022).

environment as part of international human rights law, although these resolutions are not legally binding.

This development has since been consolidated by international courts. In its advisory opinion of July 23, 2025, adopted unanimously, the International Court of Justice described the human right to a clean, healthy, and sustainable environment as essential for the enjoyment of other human rights, including the rights to life and health.[1] Earlier the same year, in Advisory Opinion OC-32/25, the Inter-American Court of Human Rights recognized a right to a healthy climate as a distinct but related component of the right to a healthy environment.[2]

In European Union law, although the Charter of Fundamental Rights[3] does not enshrine an individual right to a healthy environment, Article 37 requires that environmental protection requirements be integrated into EU policies in line with the principle of sustainable development. This approach is reflected in the EU's recent policy frameworks,[4] including the European Green Deal, the Fit for 55 package, and the Zero Pollution Action Plan, which highlight the link between the climate crisis, health, and fundamental rights. The Chemicals Strategy for Sustainability, which announced a targeted revision of the REACH Regulation, pursues the same goal of reducing exposure to hazardous chemicals.[5]

Collective actions, climate litigation (such as *Urgenda v. The Netherlands*)[6], administrative complaints, and advocacy campaigns in support of vulnerable groups are becoming increasingly common.[7] The Aarhus Convention already provides essential guarantees regarding access to information, public participation, and access to justice in environmental matters.[8]

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[1] *Obligations of States in respect of Climate Change*, Advisory Opinion (International Court of Justice, July 23, 2025).
[2] Inter-American Court of Human Rights, *Climate Emergency and Human Rights*, Advisory Opinion OC-32/25 of May 29, 2025, Series A No. 32.
[3] Charter of Fundamental Rights of the European Union, art. 37, *Official Journal of the European Union* C 326 (October 26, 2012): 391–407.
[4] European Commission, *The European Green Deal*, COM(2019) 640 final (Brussels, December 11, 2019); European Commission, *"Fit for 55": Delivering the EU's 2030 Climate Target on the Way to Climate Neutrality*, COM(2021) 550 final (Brussels, July 14, 2021); European Commission, *Pathway to a Healthy Planet for All: EU Action Plan "Towards Zero Pollution for Air, Water and Soil,"* COM(2021) 400 final (Brussels, May 12, 2021).
[5] European Commission, *Chemicals Strategy for Sustainability: Towards a Toxic-Free Environment*, COM(2020) 667 final (Brussels, October 14, 2020).
[6] *Urgenda Foundation v. State of the Netherlands*, Rechtbank Den Haag [District Court of The Hague], June 24, 2015, ECLI:NL:RBDHA:2015:7145, aff'd, Hoge Raad [Supreme Court of the Netherlands], December 20, 2019, ECLI:NL:HR:2019:2007.
[7] On the turn toward rights-based arguments in climate litigation, see Jacqueline Peel and Hari M. Osofsky, "A Rights Turn in Climate Change Litigation?," *Transnational Environmental Law* 7, no. 1 (2018): 37–67, https://doi.org/10.1017/S2047102517000292.
[8] UNECE, *Aarhus Convention*, arts. 4–9.

**Epigenetic Evidence before the Courts: Causation, Victim Status, and Biomarkers**

The claim that epigenetic science can strengthen the justiciability of the right to a healthy environment must be tested against the evidentiary requirements that courts actually apply. The most demanding of these is victim status. In *Verein KlimaSeniorinnen*, the Court held that an individual applicant must show both a high intensity of exposure to the adverse effects of climate change and a pressing need to ensure his or her individual protection; on that basis, the complaints of the four individual applicants were declared inadmissible, while the applicant association was granted standing.[1] The threshold is deliberately high, because the Convention does not allow an *actio popularis*. It was, moreover, formulated for climate change; its transposition to other pollution cases cannot be taken for granted.

This is where epigenetic data may become legally relevant. Changes in DNA methylation have been associated with specific environmental exposures, such as short-term exposure to traffic-related particles,[2] and DNA methylation–based "epigenetic clocks" make it possible to estimate biological age and, potentially, to detect accelerated biological aging in exposed individuals.[3] An epigenetic clock does not, however, identify the pollutant responsible for such acceleration. In principle, such biomarkers could help an applicant document an individualized exposure and its biological consequences, thus giving concrete content to the criterion of a "high intensity of exposure."

The limits of such evidence are considerable. Most epigenetic associations are established at the population level and cannot, by themselves, prove that a particular exposure caused a particular person's illness. Epigenetic marks vary across tissues and over time, differ with individual susceptibility, and are influenced by numerous confounding factors, including smoking, diet, and socioeconomic status, and the clinical significance of many observed changes remains uncertain.[4] The probative value of a biomarker therefore depends on its validation for the exposure in question, on its reproducibility and specificity, and on the control of confounding factors. Courts would therefore need to distinguish between general causation, which epigenetic research may support, and specific causation, which it rarely establishes on its own. Moreover, epigenetic data are

[1] *Verein KlimaSeniorinnen*, no. 53600/20, §§ 487–88, 527.
[2] Baccarelli et al., "Rapid DNA Methylation Changes."
[3] Steve Horvath, "DNA Methylation Age of Human Tissues and Cell Types," *Genome Biology* 14, no. 10 (2013): R115, https://doi.org/10.1186/gb-2013-14-10-r115.
[4] See Mark A. Rothstein, Yu Cai, and Gary E. Marchant, "The Ghost in Our Genes: Legal and Ethical Implications of Epigenetics," *Health Matrix* 19, no. 1 (2009): 1–62.

likely to qualify as health data, and possibly as genetic data, within the meaning of Article 9 of the General Data Protection Regulation, which requires strict safeguards for their collection and use in litigation.[1]

Epigenetic data are therefore best treated as corroborating evidence. They can make an individual exposure visible and lend plausibility to a causal link, but they will rarely prove it on their own.

## The Precautionary Principle and Proposals *de Lege Ferenda*

Because many of the health effects discussed in this paper are plausible but not fully established, the precautionary principle offers the most appropriate legal framework for addressing them. Enshrined in Article 191(2) TFEU, the principle allows public authorities to adopt protective measures where scientific evaluation reveals reasonable grounds for concern, even if the risk cannot yet be determined with sufficient certainty.[2] The Court of Justice has held that, where there is uncertainty as to the existence or extent of risks to human health, the institutions may take protective measures without having to wait until the reality and seriousness of those risks become fully apparent.[3] The ECtHR referred to the principle in *Tătar v. Romania*[4] and has more recently relied on a precautionary approach in *Cannavacciuolo*.[5]

On this basis, several proposals *de lege ferenda* can be formulated for the Romanian legal order. First, the assessment of effects on population and human health already required by Law no. 292/2018 should be strengthened by a specific health impact assessment, with explicit attention to vulnerable groups.[6] Second, the State should establish human biomonitoring programs in historically polluted areas, such as Copșa Mică and Baia Mare, and make their results publicly accessible, in line with the Aarhus Convention. Third, in environmental health litigation, the legislature could ease the burden of proof by introducing a rebuttable presumption of causation where legal emission limits have been exceeded and the claimant

[1] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data (General Data Protection Regulation), art. 9, *Official Journal of the European Union* L 119 (May 4, 2016): 1–88.
[2] Treaty on the Functioning of the European Union, art. 191(2); European Commission, *Communication from the Commission on the Precautionary Principle*, COM (2000) 1 final (Brussels, February 2, 2000).
[3] Case C-180/96, *United Kingdom v. Commission*, ECLI:EU:C:1998:192, para. 99.
[4] *Tătar*, no. 67021/01, § 120.
[5] *Cannavacciuolo*, no. 51767/14 and others, § 391.
[6] Legea nr. 292/2018 privind evaluarea impactului anumitor proiecte publice și private asupra mediului.

belongs to the exposed population. Fourth, the standing of environmental associations, already recognized in administrative proceedings,[1] should be expressly extended to actions concerning the protection of health, following the logic of *KlimaSeniorinnen*. French law offers a useful model: since 2016, Articles 1246–1252 of the Civil Code provide for the reparation of ecological damage and grant standing, among others, to environmental protection associations.[2] Finally, compulsory public health measures such as salt iodization should be accompanied by effective access to alternatives for persons with documented medical needs.

## Conclusions

Environmental exposures shape human health in ways that the law can no longer treat as mere background. The evidence reviewed in this paper indicates that air pollution and toxic substances can leave measurable epigenetic marks, some of them detectable as early as birth. Individuals are thus not simply carriers of a fixed genetic program; the way they live, and the environment they live in, influence how that program is expressed.

From a legal standpoint, epigenetic evidence can support the traditional requirements of proof, but it cannot replace them. Its main value lies in making individual exposure visible and in informing decisions taken under the precautionary principle.

The case law of the ECtHR, from *López Ostra* to *KlimaSeniorinnen* and *Cannavacciuolo*, shows a clear movement toward the effective protection of health against environmental harm. Romanian law already contains a constitutional basis for such protection in Article 35, but the provision has produced little case law. The proposals set out above are meant to close this gap: a specific health impact assessment, the biomonitoring of polluted areas, an easier burden of proof, and broader standing for associations.

Prevention has to start early. Many chronic diseases now appear at younger ages, and their causes combine genetic, behavioral, and environmental factors. Protecting children and pregnant women from avoidable exposures is therefore both a public health priority and part of the State's positive obligations.

[1] Legea contenciosului administrativ nr. 554/2004, art. 2(1)(s).
[2] Code civil [France], arts. 1246–1252, inserted by Loi no. 2016-1087 du 8 août 2016 pour la reconquête de la biodiversité, de la nature et des paysages.

The old medical maxim *primum non nocere*, first, do no harm,[1] applies with equal force to public authorities. Where the science is uncertain but the risk is plausible, the precautionary principle allows them, and at times obliges them, to act before definitive proof is available. The right to a healthy environment will become effective only when law and medicine are read together.

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[1] Hippocrates, *Epidemics* 1.11, in *Hippocrates*, vol. 1, trans. W. H. S. Jones, Loeb Classical Library 147 (Harvard University Press, 1923). The Latin formula *primum non nocere* is a later rendering of the Hippocratic precept "to help, or at least to do no harm."

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