Environmental causes of disease in the Anthropocene. A paramount PNEI view

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***Abstract**: We (the humans) live in a terrestrial environment, where we find and use air, water, food and all the necessary resources for our survival and activity needs. Everyone engages in a daily and intimate relationship with the environment, where one should consider that we are not owners but guests, in a reciprocal, natural and responsible interaction with all other forms of life.*

One World view (in the sense that we all live on the same unique planet) and One Health view (in the sense that all live beings on the planet share many health and disease mechanisms) are the basic philosophical, biomedical and logical paradigms of ecology on Earth: the common house for all live beings, including us, on this planet (the only one available for the known ecosystems so far).

We received terrestrial resources from our ancestors (and their ecological cohabitants), through our parents, and we leave what remains as a basic heritage to our children and descendants, who should hopefully be able to live on Earth in future times with the same chances and quality of life that was offered to each one of us.

The environment however accumulates the consequences of all the preceding insults caused by us and by our human predecessors, who started centuries and centuries ago to extract, construct, modify, pollute every part of the planet, which now carries all the human modifications evident in the present times (Anthropocene).

Since the industrial revolution (started less than three centuries ago) humans potentiated enormously their capacity to modify the environment, often for improving human life, but almost always by destroying ecosystems and depauperating the natural resources in many aspects.

The PNEI paradigm that inspires us, a group of physicians and health professionals of the 21st century, and also human beings intellectually able to recognize and appreciate the mind-body relationships within each individual, may be very useful to interpret the complex interplay network equilibria existing in the ecological systems between different forms of life and regulating health and disease in every living organism. Such a network-based PNEI paradigm can be, at present, the best basic knowledge to appreciate and correct the environmental causes of disease, before it is too late, for humans and for other forms of life. Climate changes on Earth in the current decades show us that it may be already too late to revert the situation to previous sustainable equilibria.

We shall discuss here some peculiar aspects of these complex but fundamental issues regulating ecosystems, in a One Health perspective and with the PNEI paradigm well in focus.

Key words: *Environment, Anthropocene, One Health, Prevention, Pollution, Climate*

Introduction

Homo sapiens appeared on Earth approximately three hundred thousand years ago and developed on the planet an unprecedented ability to modify its environment with all sorts of extractions, constructions and use of resources. The vast variety of anthropic changes deserved the term of Anthropocene (designating the latest and current geological era, in which very prevalent are indeed the human modifications of the environment). For a more extensive and updated explanation of Anthropocene, see: https://en.wikipedia.org/wiki/Anthropocene.

Civilizations and knowledge advances potentiated progressively the human ability to modify the environment until the industrial revolution (XVIII century), when energy control (through carbon and petrol burning, steam engine machines, electricity and new technologies) multiplied enormously the human capacity to build, extract, navigate and change the humanized environment and generally the terrestrial environment in all endeavors.

In such prolonged and intense process of change, all parts of the environment were modified, so that air, water, food, heat production and even climate were affected in their composition, and planetary distribution by human actions.

Pollution is a word and a concept that emerged as early as in the XIVth century (according to the Merriam-Webster Dictionary, 2010 ed.) and indicates the introduction of contaminants into the natural environment that cause harm. This happened, and still happens, mainly in the most industrialized areas of the world, where the changes were and still are, quicker and more evident from all points of view.

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But human biology (and the biology of other live beings) does not have sufficient (evolutional) time to adapt to many of these fast environmental changes, so that many discrepancies and pathophysiological consequences emerge, in the form of diseases related to environmental changes. We will screen the most evident changes and the most evident diseases related to them, in the modern integrated view of One World perspective (all species share the basic biological rules of living) and of the One Health perspective (what is good or bad for one species, may be good or bad for other species as well) (Lingiardi, 2025) and inspired by the newest pathophysiological network view called PNEI, Psycho-Neuro-Endocrine-Immunology. PNEI is active in each individual live being and regulates in a wide network organization, indeed, all the most important bodily regulatory systems, involving brain functions, psychic functions, endocrine equilibria and immunological responses (Bottaccioli, 2020, English Edition).

One Health

The evident concept that we have only one planet to live on (so far), together with all other forms of life, is stressed by many authors and is indeed an obvious fact, although it deserves high attention (Berners-Lee, 2021). If there is an alteration of the terrestrial environment, such an alteration may affect the life and pathophysiology of all the living species on Earth. Therefore, the good health of any species may reflect the well-being and the health of many other species. This is the basis of One Health approach, an holistic view considering the global health of the planet together with the good health of each single individual and posing the basis for interdisciplinary collaboration in problem analysis and in problem solving (Capua, 2020). The World Health Organization mentioned the issue and expanded this field of activity in an official document in 2017 and creating afterwards a consulting structure in 2021: the One Health High-Level Expert Panel (OHHLEP). This entity is indeed an advisory group for Quadripartite organizations: the Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Program (UNEP), World Health Organization (WHO) and World Organization for Animal Health (WOAH). For additional informations and details, see reference WHO-One Heath (2021).

As already mentioned, humans have modified in a very substantial way the environment, because of their capacity of using all sorts of natural resources (minerals, water, plants, animals, through all forms of technologies starting with agriculture and farming) and potentiating such phenomena with energy availability (coal, petrol, steam, electricity) in almost infinite ways since the industrial revolution of the 18th century and beyond. We must now analyze in general terms the most important environmental changes of our world today and try very quickly to apply

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remedies (most of which are already existing); this concept (which is social and political, and involves truth and honest behavior) must be achieved immediately by as many citizens as possible (Berners-Lee, 2025) to avoid very rapidly the completion of the dramatic polychrisis in progress for the humanity. This concept of the current polychrisis is very well described and analyzed in detail by Mike Berners-Lee in his latest book, written and directed to «all those who think about the rest of the world». We highly recommend reading it, together with the relative editorial review by Corriere della Sera (De Carolis, 2025), although we summarize here some of the main concepts presented in this especially important book (Berners-Lee, 2025).

Polychrisis is not only a climate crisis, it is also at the same time a biodiversity crisis, a food security crisis for a rising population, it is a crisis of escalating, permanent pollution and far more. Not to mention the population disparity, superrich and super poor people, states and economies, with the deriving conflicts.

«Every single year we degrade our environment by an even larger amount than we did the year before».

So, we are all invited to think responsibly, to change our approach and to be honest in analyzing the facts, to be accurate in the political choices and to require honesty by those receiving our votes to manage nations and enterprises. «What can each of us do right now to help? » The most important answers are in the book by Berners-Lee (2025).

Now we must analyze very briefly the elements of the current polychrisis which are most able to affect human and planetary health, to pay appropriately our clinical (medical, psychological, health services) attention to the various aspects of the pathogenic environment and see how to apply our PNEI view to them. Some issues are newly studied and deserve specific attention, like pollution in all forms (air pollution, water pollution, soil pollution, building of waste, micro plastic waste and biological diffusion; forever chemicals – i.e., poorly degradable and non-biologically modifiable chemicals- burning of fuels, etc. etc.). We will specifically mention the most relevant issues in this (partial) list, but we want at the same time to draw the attention of our readers to several key risk factors that can save a decade of life for each individual, according to a very recent and extensive report (Global Cardiovascular Risk Consortium, 2025). If some essential lifestyle changes (mostly quit smoking, lowering blood pressure, cholesterol control, diabetes control and overweight control), are in action, the advantages are indeed very consistent, according to the just mentioned survey, performed on over two million people and across 39 countries. This is indeed a fundamental basis of prevention.

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Pollution of air, water and soil

Pollution regards all areas of natural sites, air, water and soil and the living organisms therein. Natural atmosphere on Earth until the industrial revolution was affected only by natural forces (winds, volcanic eruptions, natural burning of grasslands and forests) with local and moderately extensive effects. We know for instance that some important volcanic eruptions may have affected air quality and climate of the planet, by analyzing climate data and Antarctic ice samples revealing tracks of such events.

After the industrial revolution, coal and petrol burning by human activities have enormously increased the production of combustion products and of particles liberated in the air, leading to a local, regional and planetary diffusion of fumes, chemicals and particulate matter (PM) of various sizes. Among the air pollution elements there is also a vast variety of chemicals affecting lung diseases and cardiovascular diseases (CO, Ozone, SO2, NOx, etc.) (Rajagoplan, 2021); volatile organic compounds having specific health effects as carcinogens, skin irritants and responsible of gastrointestinal diseases; lead having specific neurotoxic effects and PM of various sizes having mostly pulmonary effects. PM produced are pushed by winds and fall-out on the land surrounding the combustion sites (that is, mostly industrialized areas and towns with intense vehicular traffic and heating plants).

Recent data demonstrate that PM and wildfire smoke (containing small PM of various sizes and derivation) are particularly dangerous not only for lungs but also for brain health (Brooks, 2024). Key facts are that climate change favors the frequency of wildfires, that fine particle pollution from wildfires increases globally and that PM from smoke can affect lung health (asthma, COPD, lung cancer), heart and brain health (Elser, 2025; Du Plessis, 2025). Extensive data are available on the subject, also thanks to computerized models developed for assessing short-term and long-term health effects of PM of various sizes, especially for areas where monitoring station data are not available (Yu, 2023).

A graphic summarizing the most relevant forms of air, water and soil pollution is reproduced in figure 1 (Open source, modified to add the PNEI relationships).

In this vast endeavor, extraordinarily rich in studies and reports, we want to indicate as a reference the extensive report by UNEP (2021) which presents a scientific blueprint for how climate change, biodiversity loss and pollution can be tackled jointly within the framework of the Sustainable Development Goals. The report is a synthesis based on evidence from global environmental assessments.

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Plastics and micro plastics

Millions of tons of plastic are produced, used and discarded every year in the world, since early 1950s. Plastic products can contain thousands of different chemicals, most of which are poorly degradable and non-water-soluble; therefore, they are able to concentrate in fat tissues (animal fat, with potential endocrine disturbing effects). The hazards for human health and the environment are already well demonstrated, although they still need to be studied more extensively (Leslie, 2022; Trasande, 2024; Gross, 2025; Yakovenko, 2025).

A major issue in many countries is the presence of plastic waste in the water and soil due to the lack of appropriate disposal and recycling procedures. Enormous amounts of plastic waste are dispersed in landfills, burned in incinerators or casually dispersed and burnt in the fields and finally conveyed by streams and rivers to the seas and the oceans. Presence of plastics and mostly of micro plastics is demonstrated in many organisms and in many human tissues, including the brain (Amato-Lourenço *et al.*, 2024; Zaraska, 2025). This evidence implies probably the penetration of micro plastics directly in the brain via the respiratory bulb from atmospheric exposures; the following neuroinflammatory changes can be observed in exposed animals and in humans. Some neuropsychiatric alterations (anxiety, depression and social deficit) have been described in mice during experiments involving intentional plastic exposure of animals. Such micro plastic-induced neuropsychiatric symptoms may be mediated by microglia and may be the result of neuroinflammation and neurodegeneration (Ma, 2024; Zaraska, 2025).

Airborne microplastics are also ubiquitous and are assumed by respiratory function, particularly in indoor places (Yakovenko, 2025). Airborne suspended micro plastics are inhalable, if in the size range of 1-10 micrometers, and are very prevalent in most indoor places (homes, cars, buildings). Inhaled particles larger than 10 micrometers are generally retained in the upper respiratory tract, while smaller particles can penetrate deeper in the lungs and then even absorbed in the bloodstream. Dietary micro plastics may be assumed by animal and vegetable foods already contaminated, conserved in plastic wrapping, and even from chewing-gums (extraordinarily rich in micro plastics particles).

So, anywhere in the body, the presence of plastic particles can induce inflammation, lipid deposition and endocrine interference.

Some studies have moreover indicated that micro plastics in the bloodstream can induce cerebral thrombosis leading to neurobehavioral abnormalities (Huang, 2025). Concerning cardiovascular effects other reports have found presence of micro plastics in atheromas, where such compounds may play inflammatory and atherogenic roles (Marfella, 2024). Microplastics contribution to pulmonary carcino-

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genesis has been studied and data demonstrate that patients with asthma and COPD (chronic obstructive pulmonary disease) are at increased cancer risk from micro plastics (Paplinska-Goryca, 2025).

A further and particularly important issue concerning the diffusion of micro plastics in waters (rivers and oceans) consists in the ability of several bacteria to grow and thrive as biofilms on plastic fragments. Particularly serious is the discovery that some of the bacteria growing on plastic particles are antibiotic-resistant. The possibility exists, therefore, that the ubiquitous presence of plastic debris and of microplastics may favor proliferation and global diffusion of antibiotic-resistant bacteria, particularly in urban waters (Entezari, 2022; Gross, 2025).

Plastics and several chemicals derived from them have moreover a demonstrated effect as endocrine disruptors and even as carcinogens. The issue therefore is really of fundamental importance in modern times. None of those compounds were present in the environment before plastics were synthesized (early 1950s). The decrease in fertility in most industrialized countries is due in part to ED effects of pollutants.

A last-minute fact is the failure of the World Conference on Plastics (Plastic Treaty) held in Geneva in august 2025. A report by Rossano Ercolini, President of Zero Waste Italy, calls for a strong responsibility of the failure by Saudi Arabia and by other petrol exporting countries (including USA, whose actual President, Donald Trump, is one of the principal deniers of climate change and one of the most favorable about unlimited petrol drilling).

Millions of plastic tons are produced yearly from petrol and several of them end up as plastic waste in the oceans and everywhere (as we have mentioned). It is unacceptable that for the gains of few (the petrol producers), many dies of plastic-related diseases and of hydrocarbon carcinogenesis and the ecosystem accumulates amounts of waste impossible to eliminate. Therefore, it is unacceptable that One World and One Health views are systematically ignored and insulted by those few. (Ercolini, 2014; Ercolini, 2025).

A fundamental concept is therefore the limitation of plastic use, through the industrial planning avoiding plastic packaging and disposable, single use plastic items. Plastic contacts for humans must be limited and mainly the correct disposal of plastic waste (for extensive One Health prevention) must be observed. All physicians and sanitary professionals should know very well these concepts and communicate these facts to the general population (patients, family members, all contacts). Basic for this is to limit and possibly to abandon at once the practice of disposable plastic goods of any kind.

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Forever chemicals: PFAS and endocrine disruption

Perfluoroalkyl substances (PFAS) are human made chemicals used in a wide variety of consumer and industrial products characterized by high persistence and limited degradability (waterproof linings of tissues, ignifugous foams, etc.): they are sometimes called "forever chemicals", because they break down slowly and accumulate in the environment and are traced for long time in animal and human tissues (Aubert, 2025).

In some detail, PFASs have been widely used in industrial products since 1940 and in everyday use objects, because of their water, oil, stain and heat-resistant properties, and they are contained in food wrappers, non-stick cookware, fire-extinguishing foams, water repellent fabrics, paints, personal care products etc. and in contaminated water and soil, since they are very persistent pollutants.

Their metabolism in biological systems (although slow) demonstrates alterations in several critical biological processes, like fat metabolism and thyroid pathophysiology. Effects on developmental disorders, cardiovascular disease, metabolic disease and many types of cancer have been ascertained. A recent study (Goodrich, 2023) shows that PFAS exposure has effects on thyroid hormone function, puberty distress, growth, metabolism, diabetes, obesity, cardiovascular disease and cancer. Further data on thyroid metabolism (Yu, 2025) have evidentiated that PFAS exposures may affect peripheral thyroid hormone sensitivity, with several health implications spanning from developmental disturbances to obesity and diabetes.

Presence of PFAS in drinking water and in many environmental sites (mostly near industrial production sites and related wastewater disposals) raises important concerns about public health (Gao, 2024), although it appears that boiling water before drinking it may reduce substantially the active PFAS concentration in the water samples for human and animal use (Dagorn, 2023; Aubert, 2025). Statistic data analysis has identified in Europe at least 20 PFAS producers; 23,000 sites where PFAS contamination has been detected; 232 PFAS industrial users; and over 21,500 presumptive contamination sites (Dagorn, 2023, updated in 2024): therefore, PFAS compounds represent one of the most relevant chemical pollution problems worldwide, mostly in the industrialized regions.

Data about PFAS carcinogenicity has been long debated, but these compounds are now included in group I carcinogens by IARC and are the subject of a very recent IARC Monograph published in February 2025 (IARC, 2025). In their quality of endocrine disruptors, PFAS are of extremely high concern for pathophysiology in humans, animals and ecosystems. Any clinical professional with PNEI basic formation should keep this element in great consideration.

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Climate change and related issues

An extensive description of the multiple relationships between climate changes, extreme heat and health may be found in recent review papers published in the last few years in top rated medical journals (Haines, 2019; Perera, 2022; Bell, 2024; Kazi, 2024; Solomon, 2024). Such pathological relationships affect mostly the vulnerable subjects (children and aged people) and deal in particular with cardiovascular diseases (acute coronary syndrome, myocardial infarction, heart failure), kidney diseases (acute renal failure, nephrolithiasis, urinary tract infections), respiratory diseases (asthma and COPD – chronic obstructive pulmonary disease- pulmonary infections and pulmonary edema), mental disorders (anxiety, depression, aggressive behavior, mental fatigue) and adverse birth outcomes (stillbirth, etc.). All these facts impact significantly on morbidity and mortality worldwide.

There is no logical possibility of being doubtful about the causes of climate changes: they are related to the enormous amount of fossil fuels extracted, burnt and used worldwide since the industrial revolution.

In Bell (2024), you can read clearly: «The Intergovernmental Panel on Climate Change (IPCC) concluded unequivocally that human activity, especially the combustion of fossil fuels, is responsible for overall warming of the atmosphere, land, and oceans; that changes in weather extremes driven by climate change are already observed; and that recent extreme heat events are attributable to climate change».

No scientific doubt therefore exists about that, although many politicians have diffused false statements and created antiscientific debates and campaigns about these issues, using inconsistent and scientifically illogical doubt as a weapon against scientists and top-quality scientific research and evidence.

Facts are that increasing temperatures are modifying the habitats and the ecosystems of live beings, in extending or restricting the areas where different species prefer to live and modifying the distribution of diseases on the globe (Thomson, 2022; Semenza, 2023). Therefore, the global distribution of major infectious diseases is involved: Malaria, Dengue, Zika, West Nile, Lyme disease, Chikungunya, Plague, etc. Emergence of new infectious diseases (zoonoses in particular) is also affected (Bologna, 2022). A study calculates that such infectious diseases may reach even London and Paris by 2035 (Radici, 2025). Climate issues, moreover, are interconnected with other fundamental themes, like endocrine disruptors (which increase several health risks, including cancer, neurodevelopmental harm, and infertility) (Woodruff, 2024), and air pollution (Keswani, 2022).

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Other issues

We also need to remind here to all readers about some major pathogenic habits, like tobacco smoke, dietary excess of alcohol, of animal derived fats and of red meats. These subjects are not detailed here but remain big pathogenic factors to be always considered for primary prevention of disease and for well-being (Global Cardiovascular Risk Consortium, 2025).

Moreover, there are several additional issues involving exposure to electromagnetic fields and several individual behavioral attitudes with related social stress, very much able to impact on neurophysiological and physical health.

Most of these are old and new self-applied pathogenic factors, like hallucinogenic drugs, ludopathies (compulsive gaming attitudes of all sorts, like video games and lotteries), electronic cigarettes (hiding hundreds of uncontrolled chemical compounds) (Anderer, 2025), tattoos (which chronically stimulate the immune system), smartphones (delightful but dangerous in some aspects), artificial intelligence practice and blind trust, leading to severe damage of personal brain capacities and critical thinking. The mentioned artificial intelligence (AI) and social media themes are studied nowadays even as a possible danger for democracy and political orientation. If I trust blindly the electronic answers by social media and by generative artificial intelligence (like ChatGPT and similar systems), I cannot know any more where my personal culture ends nor how to improve my personal experience and capacities, through personal study and research of truth and facts. This is a very vast and relevant issue at present since it can damage critical thinking and basic education.

"I know that I do not know" is a positive and constructive attitude, meanwhile "I think I have reached knowledge and the truth by AI and social media" is the end of knowledge search, critical thinking and passion for study and culture.

The subjects mentioned all have some possible or ascertained PNEI consequences.

We want here just to stress, for instance, how tattoos can be carcinogenic (for lymphomas) and how psychological stress may be dangerous in many ways. Tattoos are very diffused today and represent a chronic stimulation of the immune system, since they consist of extraneous molecules (not-self) introduced purposely under the skin (therefore beyond the "self" barrier), with the scope of remaining visible for long periods of time (often for the entire lifespan): these not-self components of tattooing inks stimulate the immune reactions chronically, with various consequences. In some cases, even lymphomas have been found in tattooed subjects (Nielsen, 2024). PNEI network influences may also increase the inflammatory status of the subject and modify personal behavior toward various types of psy-

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chopathologies (anxiety, depression, aggressive attitudes, sleep disturbances, etc.). Clinicians should be aware of that and take such elements into consideration when confronted with tattooed patients.

One more relevant aspect deals with fertility, mostly on the male side (sperm number and motility): endocrine disturbances by pollutants can have significant effects on limiting the fertility of people in the most polluted areas and with significant exposures to plastic derivatives and PFAS, as mentioned above.

We want also to remember, in this superficial but extensive exploration of the health problems of the Anthropocene, the issue of digital-derived anxiety in young generations. Many adolescents suffer from anxiety because of the judgement they receive in their lives from peers and on social media. They tend to fear the comparison with peers and may develop an avoidant behavior, ending up with extreme phases of total insulation from the social contacts (Hikikomori syndrome). These are serious situations needing special attention from parents, by teachers and by psychologists (Veltroni, 2025).

Finally, we must mention the general stress of modern life, exacerbated by the uncertainty of the current geopolitical situation on a global level. Social stress, geopolitical stress, echo anxiety (everything may hide dangers in daily life) are indeed adding up: only scientific knowledge and savvy counseling by prepared clinicians and teachers can alleviate all this stress of the Anthropocene. Good teachers and good caregivers (physicians, psychologists, health professionals) represent overall the best care and the best medicines themselves.

Most of these themes need to be studied more deeply, under new and continuous scientific advances, but the interactions with the PNEI network make them truly relevant in any individual seeking help for personal health issues (Bottaccioli, 2024). Clinicians must be aware of that.

Conclusion

Modern world in our advanced Anthropocenic Era is full of potential harms due to various kinds of pollutants, linked to physical, chemical and social factors. Scientific knowledge about the pathophysiological consequences of pollutant exposure is growing but still lacks complete knowledge in all the numerous endeavors of pathogenic mechanisms and of different disciplines needing better integration. Primary prevention and caution principles are fundamental. Clinicians can provide advice to patients toward reducing most dangerous exposures, and examining carefully the anamnestic individual data, but policy change by governments is needed to establish legal requirements for comprehensive safety testing and to reduce health threats in particular from petrochemicals. Clinicians are important

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advocates for these changes and their formation in the PNEI paradigm can play a substantial role in this process of updating biomedical knowledge and betterment of social and individual care.

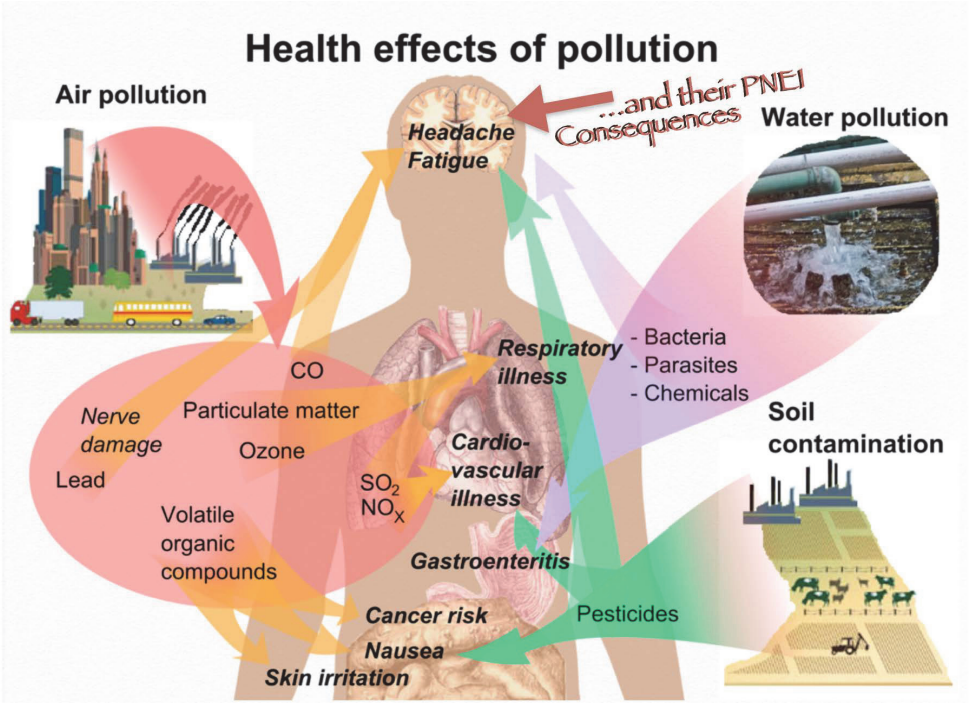

Figure 1 – Scheme synthesizing the environmental causes of disease, modified with the indication of the possible PNEI consequences in many different physiopathological pathways. Modified from: Häggström, Mikael (2014). "Medical gallery of Mikael Häggström 2014". *WikiJournal of Medicine* 1 (2). DOI: 10.15347/wjm/2014.008.

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Per- and polyfluoroalkylated substances are synthetic chemicals that are widely used in our daily lives and in industrial processes. They are highly resistant and almost indestructible in the environment, and their toxicity is increasingly documented. *Le Monde decoders*, January. https://www.lemonde.fr/en/les-decodeurs/article/2025/01/14/pfas-a-family-of-10-000-forever-chemicals-contaminating-all-of-humanity_6737024_8.html

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