How the Montreal Protocol Applied The Age-Old Philosophy of the Precautionary Principle to Global Stewardship of the Atmospheric Commons

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Abstract

This paper documents the intellectual development of what is now called the "Precautionary Principle," and its application under the Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol) (United Nations, 1987; Weiss, 2009). The Montreal Protocol is renowned for beginning the global phaseout of the production and consumption of ozone-depleting substances (ODSs) long before the science was certain—on the age-old premise of "better-safe-than-sorry." That ODS phasedown avoided catastrophic consequences of both ozone depletion and climate change. By tracing the evolution of the Precautionary Principle inside and outside the Montreal Protocol, this paper organizes the foundation documents for anyone making the case for taking fast action when the consequences of taking no action are potentially catastrophic and/or irreversible but the science is uncertain. Circumstances where the Precautionary Principle could be applied involve protection of the atmosphere, health, oceans, or cultural and historic treasures (Biermann, 1996; Fisher et al., 2006).

Introduction

This paper documents that the first complete application of the Precautionary Principle for global environmental protection was orchestrated with like-minded partners by United Nations Environment Programme (UNEP) Executive Director Dr. Mostafa Tolba in the crafting and managing of the Montreal Protocol. The Montreal Protocol qualifies as a complete application of the Precautionary Principle since over 98% of all ozone-depleting substances (ODSs) are phased out in production and consumption (Willi et al., 2021). The paper also documents prior consideration of precaution in the management of ecological resources and environmental quality during the twentieth century and going as far back as recorded history on topics of health, safety, and agriculture. Here we present indicative examples of some of the origins of the Precautionary Principle including: 1) Greek physician Hippocrates' ethical code, 2) the German principle of 'Vorsorgeprinzip', and 3) the pioneering writings of Professor S.V. Ciriacy-Wantrup at University of California Berkeley.

The Precautionary Principle is an approach to guiding decisions when there is a plausible risk of irreversible consequences that would be unacceptable (World Commission on the Ethics of Scientific Knowledge and Technology, 2005). It can be applied ***proactively*** to stop questioned human actions or can be applied ***reactively*** to mitigate future damage from natural disasters and human-caused despoilment that would get worse without intervention.

Proactive application of the Precautionary Principle implicitly foregoes the tangible benefits of a proposed human activity to avoid consequences that may be irreversible. An example of the Precautionary Principle applied proactively is the Montreal Protocol that began the phaseout of production and consumption of chemical substances with uncertain consequences to the stratospheric ozone layer that shields Earth against ultraviolet radiation that causes skin cancer, cataracts, suppression of the human immune system, damages agricultural and natural ecosystems, and deteriorates the built environment (Albrecht and Parker, 2019; Andersen et al., 2021, 2018; Andersen and Sarma, 2002; DeSombre, 2000; Jacobs, 2014; Percival, 2006).

Reactive application of the Precautionary Principle expends resources to avoid a portion of the uncertain consequences that may be irreversible. An example of the Precautionary Principle applied reactively would be the removal of greenhouse gases (GHGs) such as carbon dioxide and methane from the atmosphere when all other actions to cut climate forcing emissions might not be enough to avoid climate tipping points.

The Precautionary Principle is an underlying rationale for national regulations and multilateral agreements for environmental protection, food security, health, trade, and sustainable development. It has naturally led to what can be called "science-based decisions informed by assessments of technical and economic feasibility." Actual application can be informed by risk analysis and scientific modeling but ultimately requires executive judgment of the likelihood of potentially irreversible harm. Appendix A presents indicative examples.

The Precautionary Principle is driven by the realization that many human activities have already had consequences that are irreversible in human time dimensions. Examples of realized irreversible consequences include desertification, invasive species, fossil groundwater depletion, persistent pollutants, and species extinction.

Finally, consider that the Precautionary Principle is a limited-time opportunity that is lost by policy procrastination. Further delays may put us in the position of being too late for avoiding many climate consequences.

The Spectacular Application of the Precautionary Principle in Protecting Stratospheric Ozone

> In the early 1970s, Dr. Paul Crutzen and others warned that nitrogen from human activities could migrate to the stratosphere where it would destroy stratospheric ozone and impact climate (Crutzen, 1970).
>
> In response to the ozone and climate by Crutzen and colleagues, the US Department of Transportation (DOT) sponsored the Climatic Impact Assessment Program (CIAP) that

reported in 1974 that the conjectured ozone-depletion effects might be serious and recommended further investigation (Grobecker, 1974; Parson and Fisher-Vanden, 1995).

In June 1974, Dr. Mario J. Molina and Dr. F. Sherwood Rowland warned that chlorofluorocarbons (CFCs) could destroy the stratospheric ozone layer, which protects Earth against the harmful effects of ultraviolet radiation (Molina and Rowland, 1974).

In December 1974, Molina and Rowland considered the uncertain risk to stratospheric ozone so grave that they called for a ban on the use of CFCs as aerosol propellants for hairspray, deodorants, and pesticides with the argument that it was better to be safe than sorry by halting CFC use and avoiding potential consequences of uncertain magnitude and reversibility (Willi et al., 2021).

In 1975, Dr. Veerabhadran Ramanathan warned that CFCs are also powerful greenhouse gases (GHGs) and could rival carbon dioxide (CO_2) greenhouse gas (GHG) emissions, if unabated (Ramanathan, 1975).

In 1975, in response to the ozone warnings and environmental activism by Molina, Rowland, and Ramanathan, American consumers boycotted CFC cosmetic and convenience aerosol products, which stimulated the rapid commercialization of alternatives and substitutes (Cagin and Dray, 1993). The United Nations Environment Programme (UNEP), under the leadership of Dr. Mostafa Tolba, began organizing for atmospheric protection through multilateral environmental agreements (MEAs) such as treaties (Andersen and Sarma, 2002; Birmpili, 2018; Canan and Reichman, 2017).

In 1976 the United States (US) banned the use of CFC aerosol cosmetic and convenience products and within a few years, Canada and a few Nordic countries also banned specified uses. In making the case for the US ban, Russell Peterson, then Chair of the Council on Environmental Quality (CEQ), who had spent twenty-six years as a chemist for DuPont, called for immediate regulation of CFC arguing "We cannot afford to give chemicals the same constitutional rights that we enjoy under the law. Chemicals are not innocent until proven guilty." The head of the Food and Drug Administration (FDA) Dr. Alexander M. Schmidt added, "It's a simple case of negligible benefit measured against possible catastrophic risk. Our course of action seems clear beyond doubt" (Kovar, 1977; Schmidt, 1976).

In 1977, then UNEP Executive Director Mostafa Tolba, through the UNEP Governing Council, adopted a World Plan of Action on the Ozone Layer and established The Coordinating Committee on the Ozone Layer (CCOL) to build the scientific basis for global action (International Institute for Sustainable Development, n.d.).

In 1981, Dr. Mario Molina and Alan Miller testified before the Senate Committee on Environment and Public Works. Molina warned that ODSs "…threatened to alter the very nature of the stratosphere and could substantially affect the earth's climate." Miller (then at the Natural Resources Defense Council (NRDC)) added that making regulatory decisions in the face of significant scientific uncertainty would inevitably be necessary. He

warned that the risks of ozone depletion were real and that the costs of waiting ten years would be high (Cagin and Dray, 1993).

In 1982, Dr. Mostafa Tolba pleaded with governments to act because "If scientific observations over the next few years turn the theory of ozone depletion into unchallengeable fact, then the hazard of increased ultra-violet light exposure due to ozone depletion is a legacy we will pass on to future generations" (Johnson, 2012). Tolba later reflected that the Montreal Protocol was "the first truly global environmental treaty, and moreover it dealt with an issue still shrouded in scientific uncertainties, one that posed a threat, not immediately, but in the future, one that potentially affected everyone on earth today, and far into the future" (Canan and Reichman, 2017; Johnson, 2012; Rummel-Bulska, 2007).

In March 1985, a decade after the CFC Molina and Rowland stratospheric ozone warning, the Vienna Convention for the Protection of the Ozone Layer (Vienna Convention) acknowledged the ". . . potentially harmful impact on human health and the environment through modification of the ozone layer" (United Nations, 1985).

In May 1985, Joseph Farman, Brian Gardiner, and Jonathan Shanklin warned of the unexpected disappearance of ozone over Antarctica during the Austral springtime (Farman et al., 1985). Dr. Rowland branded the discovery as an "Ozone Hole" and the global press, public, and policymakers expressed grave concern (Andersen and Sarma, 2002). However, mainstream science cautioned that the cause was unknown and that the ozone hole might be from threats other than fluorocarbon chemical substances (*Saving Planet Earth: Fixing a Hole*, 2019).

From August to November 1986, 18 scientists from four institutions came to the American McMurdo Station Antarctica to carry out an intensive stratospheric assessment aimed at explaining the ozone hole but were unable or unwilling to confidently blame fluorocarbons:

> "The results from the composite of experiments ***strongly suggest*** that chemistry (specifically, the chemistry of anthropogenically produced halocarbon species) ***probably plays*** an ***important role*** in the development of the Antarctic ozone hole" (Solomon, 1986), [emphasis added].

In September 1987, 26 countries and the European Commission (EC) signed the Montreal Protocol, which put in place the first international control measures on CFCs and halons to address ozone depletion despite scientific uncertainty.

In January 1988, in response to the Montreal Protocol, private companies began announcing ambitions to completely phase out the use of CFCs and halons and pledged to commercialize alternatives and substitutes as soon as approved by authorities. In response to annual and quadrennial scientific, environmental effects, and technical and economic assessments, the Montreal Protocol was continuously strengthened by amendments to add new controlled substances and by adjustments to accelerate the phaseout (Andersen et al., 2021, 2007; Andersen and Sarma, 2002; Birmpili, 2018; Sarma et al., 2012).

By late 1988, it was clear that CFCs and other ODSs catalytically destroyed stratospheric ozone, and scientists, therefore, turned to the vexing questions of how many ODSs would need to be controlled and how fast and far phasedowns must proceed to avoid environmental and health consequences of ultraviolet radiation and possible atmospheric tipping points beyond which there might be no recovery within human time dimensions (Zurer, 1988).

In 1992, Principle 15 of the Rio Declaration officially defined the Precautionary Principle as applied in the Montreal Protocol "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (United Nations, 1992). Following the adoption of the 1992 Rio Declaration, many multilateral and regional agreements, as well as national laws, include precautionary action in some form (*see* Appendix A).

In 1995, In presenting the Nobel Prize in Chemistry to Paul Crutzen, Mario Molina, and Sherwood Rowland, the Nobel Prize Committee declared: "Without a protective ozone layer in the atmosphere, animals and plants could not exist, at least upon land" ("The Nobel Prize in Chemistry 1995," n.d.).

In 2000, at a joint presentation by Mario J. Molina and F. Sherwood Rowland, Molina asked rhetorically, "Is it enough for a scientist simply to publish a paper? Isn't it a responsibility of scientists, if you believe that you have found something that can affect the environment, isn't it your responsibility to actually do something about it, enough so that action actually takes place?" Rowland concluded the lecture by answering a question about his move from the laboratory into advocacy: "If not us, who? If not now, when?" (Rowland and Molina, 2001).

Many papers have explored the "world avoided" by the boycotts and national bans of CFC cosmetic and convenience aerosol products urged by Molina and Rowland from 1975 and actions under the 1987 Montreal Protocol (Andersen and Miller, 1996; Morgenstern et al., 2008; Newman et al., 2009; Prather et al., 1996). Most recently Willi *et al.* (2021) estimated the added benefits if policymakers had taken the warnings of Molina, Rowland, and Ramanathan more seriously. These "world avoided" studies concluded that the ozone layer would have been highly depleted across the globe by the mid-21st century with catastrophic impacts on human health, agricultural and natural ecosystems, and the built environment if the Montreal Protocol had not been implemented. If ozone and climate warnings had come a decade or more later, climate forcing from ODSs would have equaled or exceeded the forcing of CO_2, and Earth would likely have passed climate tipping points beyond which there could have been no recovery within human time dimensions (Miller et al., 2021; Velders et al., 2007).

Indicative Philosophical Antecedents of the Notion of a Precautionary Principle

Through source collection and analysis concerning the development and evolution of the Precautionary Principle, multiple theoretical and philosophical sources have emerged as consistent antecedents.

The Precautionary Principle is a broad epistemological, philosophical, and legalistic approach that emphasizes precaution and scientific knowledge before action. The core essence of the Precautionary Principle is reflected in idioms such as, "better to be safe than sorry," "a stitch in time saves nine," or "an ounce of prevention is worth a pound of cure."

The Hippocratic Oath

The earliest intellectual formation of a general Precautionary Principle might have been from the Ancient Greek physician Hippocrates of Kos in his ethical code known as 'The Hippocratic Oath', "I will prevent disease whenever I can, for prevention is preferable to cure" ". . . I will do no harm or injustice. . ." (North, 2002).

S.V. Ciriacy Wantrup Origin of the Precautionary Principle in Resource Conservation

Professor S.V. Ciriacy-Wantrup (University of California Berkeley) advocated legal frameworks and governance that would allow economic choice only among sustainable activities. Ciriacy-Wantrup's criteria for sustainability included the "Safe Minimum Standard" (the threshold beyond which loss is catastrophic), irreversibility, and unknown future probability. In total, this can be considered comparable to the Precautionary Principle.

Ciriacy-Wantrup (1938) addressed irreversibility ("permanency of destructive exploitation") at least as early as 1938, at a time long before environmental policy focused on protecting biodiversity and atmospheric integrity (Ciriacy-Wantrup, 1938). Ciriacy-Wantrup insisted that "flow resources" such as soil, water, plants, and animals) should not be allowed to decline below a safe minimum standard of conservation where decline becomes economically irreversible within human time dimensions. Wantrup warned that irreversible destruction of the breeding stock or natural habitats could permanently eliminate species and cause civilizations to decline.

Continuously from 1938 until his death Ciriacy-Wantrup perfected and promoted the safe minimum standard for application in benefit/cost analysis of water projects, in soil and wildlife conservation, and in making the case for public support for game and non-game species and habitat protection. Eventually, Ciriacy-Wantrup presented a theory of hierarchical decision systems with the highest level (incorporating legislative, executive, and judicial branches of government as well as international environmental agreements) putting rules in place that compel lower-level decision-makers (household, firms, and other organizations) to not engage in activity that risks tipping points and other irreversible outcomes (Bishop and Andersen, 1985; Ciriacy-Wantrup, 1952).

Precautionary Principle in Germany from the 1970s

Some other scholars trace the contemporary use of the Precautionary Principle to the German environmental principle of 'Vorsorgeprinzip,' which translates to foresight or precaution (Bertrand, 2019; Dinneen, 2013).

The practical origins of Vorsorgeprinzip are uncertain. It is claimed to have an origin in the 1930s German notion of good household management, as a foundation of the Swedish Environmental Protection Act of 1969, and in various subsequent actions in the 1970s in response to sea pollution and forest degradation. Konrad von Moltke contends that 'Vorsorgeprinzip' was first enunciated by the German Federal Government's Royal Commission on Environmental Pollution in 1976. Von Moltke is cited by some scholars as the originator of the phrase "Precautionary Principle" (Freestone and Hey, 1997).

The Precautionary Principle had been practiced in Germany, Sweden, and the larger European community, but Hans Jonas assisted in formalizing the notion, taking this practical heuristic and creating a theoretical procedure.

The popularity of 'Vorsorgeprinzip' and its probable descendent, the Precautionary Principle, has increased rapidly throughout Europe and the international community.

Other Plausible Origins of the Precautionary Principle

- Do not kill the goose that lays golden eggs (Aesop, 620-564 BC)
- Prevention is better than cure (Desiderius Erasmus, 1466-1536 AD)
- A stitch in time saves nine (coined by Thomas Fuller in 1523, popularized by Benjamin Franklin)
- Better safe than sorry (coined by Samuel Lover in 1837)
- Intellectuals solve problems; geniuses prevent them (Albert Einstein, 1879-1955)

The Precautionary Principle's application is as rich as its diverse history and has proven to be dramatically instrumental in the protection of the natural environment. The principles' millennia-long evolution will continue as the world needs prevention and the cure for climate change.

Appendix A. Multilateral and Regional Agreements, National Laws, and Other Applications of the Precautionary Principle

Indicative Multilateral Environmental Agreements

- 1972 Stockholm Declaration of the United Nations Conference on the Human Environment
    - Description: UN conference focused on human rights and the natural environment. Natural resources management, pollution, and uneven development of nations were among the principles.
    - Link
- 1985 Vienna Convention for the Protection of the Ozone Layer

    - Description: Multilateral environmental agreement that provided frameworks for international reductions of CFCs. Influential to the formation of the Montreal Protocol
    - Link
- 1987 Montreal Protocol on Substances that Deplete the Ozone Layer
    - Description: Intentional treaty that protected the ozone layer through reductions in ozone-depleting substances, most impactfully, CFCs
    - Link
- 1989 Basel convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
    - Description: international treaty which aimed to reduce the transfer of hazardous materials from the developed to less developed countries.
    - Link
- 1992 Rio Declaration on Environment and Development
    - Description: list of 27 principles designed to guide countries into sustainable development.
    - Link
- 1992 United Nations Framework Convention on Climate Change.
    - Description: Intentional environmental treaty to combat greenhouse emissions.
    - Link
- 1994 United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa
    - Description: Convention to combat desertification.
    - Link
- 1997 Kyoto Protocol to the United Nations Framework Convention on Climate Change
    - Description: Intentional treaty that extended and added to the 1992 UNFCCC's commitment to reduce greenhouse gas emissions.
    - Link
- 2000 Lisbon Treaty
    - Description: Amended treaties which formed the basis of the EU constitution. Paragraph 2 of article 191 laid out a framework for precautionary principle use in union states.
    - Link
- 2000 Rio Cartagena Protocol on Biosafety to the Convention on Biological Diversity
    - Description: The protocol seeks to protect preserve and protect biodiversity from GMOs.
    - Link
- 2006 Rio Convention on Biological Diversity
    - Description: Relationship between the Montreal Protocol and biodiversity.
    - Link
- 2019 Kigali Amendment to the Montreal Protocol
    - Description: Amendment to the Montreal Protocol. Legal binds nations to reduce HFCs.
    - Link

Indicative National and Sub-National Applications

- 1997 Environmental Protection Agency Food Quality and Protection Act
    - Description: Law that managed the use of pesticides and other chemicals to protect babies and infants.
    - Link
- 2002 San Francisco Precautionary Principle Ordinance
    - Description: Required the city to weigh the environmental and health effects of spending through the Precautionary Principle.
    - Link
- 2004 France Charter for the Environment
    - Description: Proclaimed environmental rights for the French people.
    - Link
- 2006 New South Wales Telstra Corporation Limited V Hornsby Shire Council
    - Description: This case dealt with the application of the precautionary principle in the emission of radiofrequency electromagnetic energy.
    - Link
- 2021 Seattle's Climate Resilience and the Climate Mayors Program
    - Description: A bipartisan network of more than 470 U.S. mayors who demonstrate climate leadership in their communities.
    - Link

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Acronyms and Abbreviations

CCOL	Coordinating Committee on the Ozone Layer (UNEP)
CEQ	Council on Environmental Quality (US)
CFC	chlorofluorocarbon
COMEST	World Commission on the Ethics of Scientific Knowledge and Technology
CO_2	carbon dioxide
EC	European Commission
EPA	Environmental Protection Agency
GHG	greenhouse gas
IGSD	Institute for Governance & Sustainable Development
NRDC	Natural Resources Defense Council
ODS	ozone-depleting substance
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States