Pollution and Law

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Abstract

Pollution law is the result of decades of legislative evolution in environmental law. The inherent complexity of pollution has legal consequences. Pollution norms are not compiled into one single harmonised pollution law and much less a "pollution code". This makes it much harder to know, interpret, apply, monitor and implement pollution laws, and to apply sanctions to the violations of those laws. The final reason that explains and justifies efforts to regulate, tax, charge for, clean up, supervise and sanction pollution is protection of the victims of pollution. Intensive linear economic activity, which ignores the limits of the environment and the resulting long-term damage, is depleting the planet's resources. It is therefore crucial to implement strategies and solutions that enable pollution prevention and that maximise the value of resources. Pollution prevention must be proactive and needs a pre-planned strategy. Current and future generations deserve a pollution-free world. Pollution is a battle that can be won.

Keywords

Pollution law · Pollution costs · Prevention · Precaution · Polluter pays · Circular economy

1 Pollution and Pollution Law

Pollution can take a number of forms. The legal regime governing pollution is flexible enough to include the various forms of pollution. Historically, laws began by regulating classical chemical pollution that contaminated air, water, soil or living organisms. Currently, other more subtle forms of pollution, such as electromagnetic radiation, thermal pollution or nano pollution, are also regulated by law.

In this context, the legal regime for industrial pollution, known as "integrated pollution prevention and control" or IPPC, defines 'emission' as "the direct or indirect release of substances, vibrations, heat or noise from individual or diffuse sources in the installation into air, water or land".[1]

Furthermore, nowadays legal norms consider not only the impacts of pollution in the direct vicinity of the polluting installation or activity,

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[1] Article 3 of Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control).

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but also long-distance pollution[2] and even extra atmospheric space pollution.[3]

From an economic point of view, according to economic theory, pollution is an *externality* caused by a market failure (Marshall 1890; Coase 1960). As will be explained, the polluter pays principle is the perfect instrument to impose internalisation of pollution costs.

2 Legal Approaches and Regulation of Pollution

Pollution law is the result of decades of legislative evolution in environmental law. Considering their scope of application and the legislative approach, existing environmental norms can be divided into two major categories: green environmental law and grey environmental law.

Green environmental law deals with the conservation of natural areas, including habitats and species. It can be regarded as a synonym for biodiversity law. At the international level, one example is the 1992 UN Convention on biodiversity.[4] In the European Union, it mainly equates to the *Natura 2000* directive,[5] which creates the largest network of nature conservation sites in the world.

Grey environmental law describes the large number of legal rules developed to combat different forms of environmental degradation, mostly caused by emissions of chemical substances, ionising radiation, light, noise and waste. Grey environment law is broadly synonymous with pollution law. The most prominent examples at the international level are the Convention on long-range transboundary air pollution[6] (Geneva, 13 November 1979), and the Convention on the protection and use of transboundary watercourses and international lakes[7] (Helsinki, 17 March 1992), relating to atmospheric pollution and water pollution, respectively. In Europe, one key example is the industrial emissions directive, also called the *integrated pollution prevention and control rules* (European Union 2010).

Institutionally there has been a parallel development of institutions oriented towards green or grey environmental laws. For example, the Intergovernmental Panel on Climate Change (IPCC) was set up in 1988 to deal with atmospheric pollution caused by greenhouse gases (IPCC 2021) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES 2019), was set up in 2012, to strengthen the science-policy interface for biodiversity and ecosystem services. The work of these specialised hybrid organs, composed of government representatives, scientists and associations, is fundamental for the evolution of green and grey laws.

Grey environmental law has expanded along two lines of development. Firstly, it has increased the types of pollution regulated by law: from the obvious initial cases of air,[8] water (European Community 2000) or noise pollution, to less

[2] 1979 Geneva Convention on Long-Range Transboundary Air Pollution (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:21979A1113%2801%29).

[3] The United Nations Committee on the Peaceful Uses of Outer Space adopted a set of Space Debris Mitigation Guidelines which were later endorsed by the General Assembly in 2007. (https://www.unoosa.org/oosa/documents-and-resolutions/search.jspx?view=documents&match=ST/SPACE/49).

[4] https://www.cbd.int/doc/legal/cbd-en.pdf.

[5] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31992L0043.

[6] https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXVII-1&chapter=27&clang=_en.

[7] https://unece.org/environment-policy/water.

[8] Directive 75/439/EEC on waste oils is a historic European Community Directive that marked the start of the European Community's environmental policy. It imposed a duty on waste producers to reuse or recycle waste oils instead of discarding or destroying them. The Association of Waste Incinerators in France questioned the validity of the Directive in a French Court. In a landmark preliminary ruling procedure the European Court of Justice upheld the interpretation that the Directive was valid and that it established a proportional protection of an emerging European value: environmental quality as a *sine qua non* condition for the quality of life (Case 240/83 Judgment of the Court of 7 February 1985) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A61983CJ0240).

visible yet equally dangerous forms of pollution, for instance, radioactive pollution, persistent organic pollutants, heavy metals or pollution caused by nanomaterials.

Pollution appears in a wide variety of forms, coming from different pollution sources, emitting heterogeneous pollution substances, affecting a diversity of receiving media, and causing a profusion of environmental victims.

This inherent complexity of pollution has legal consequences. Pollution norms are not compiled into one single harmonised pollution law and much less a "pollution code". This makes it much harder to know, interpret, apply, monitor and implement pollution laws, and to apply sanctions to the violations of those laws.

Pollution law is classified differently according to the regulatory approach adopted: it can be organised by the receiving media (atmospheric pollution law,[9] water pollution law[10]) or by the polluting vector (greenhouse gas pollution,[11] persistent organic pollutants,[12] mercury pollution[13]) or by the source of pollution (industrial emissions,[14] emissions from motor vehicles[15]).

3 Legal Principles Applicable to Pollution

The legal regulation of pollution is inspired by environmental principles (De Sadeleer 2020). The main principles shaping pollution laws are prevention, precaution, correction at the source and the polluter pays.

These principles have formally been part of the European Treaties since 1986. Currently they are incorporated in Article 191 (2) of the Treaty on the Functioning of the European Union:

> 2. Union policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Union. It shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay

Besides these core principles established in the Treaty, it is also very relevant to consider the transparency principle and the right of access to information.

3.1 Relevance of the Principles

The reason why environmental principles tend to induce adhesion and generate consensus is because they are the legal translation of intuitive rules of common sense, efficiency and fairness.

Moreover, the principles are binding not only on the EU institutions but also on the Member States, who are obliged to pursue "sincere cooperation" with the EU to "ensure fulfilment of the obligations arising out of the Treaties or resulting from the acts of the institutions of the Union".[16]

More importantly, in EU law the principles are applicable to pollution arising from a wide range of policies and activities. As a result of the integration principle, the European Institutions and the Member States are obliged to consider the

[9] Long range transboundary https://unece.org/convention-and-its-achievements.

[10] Article 194 and 195 of the International Convention on the Law of the Sea https://www.un.org/depts/los/convention_agreements/convention_overview_convention.htm.

[11] 1992 UN Framework Convention on Climate (https://unfccc.int/resource/docs/convkp/conveng.pdf).

[12] Stockholm Convention (http://www.pops.int/).

[13] https://www.mercuryconvention.org/en.

[14] EU Industrial Emissions Directive https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32010L0075.

[15] REGULATION (EU) No 540/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 April 2014 on the sound level of motor vehicles https://eur-lex.europa.eu/legal-content/en/TXT/?uri=celex%3A32014R0540.

[16] Article 4(3) of the Treaty on the European Union: "Pursuant to the principle of sincere cooperation, the Union and the Member States shall, in full mutual respect, assist each other in carrying out tasks which flow from the Treaties. The Member States shall take any appropriate measure, general or particular, to ensure fulfilment of the obligations arising out of the Treaties or resulting from the acts of the institutions of the Union. The Member States shall facilitate the achievement of the Union's tasks and refrain from any measure which could jeopardise the attainment of the Union's objectives".

environmental principles when acting in all the competence domains and in every EU policy field: "environmental protection requirements must be integrated into the definition and implementation of the Union's policies and activities, in particular with a view to promoting sustainable development" (Article 11 of the Treaty on the Functioning of the European Union). Hence, industry, agriculture, fisheries, forestry, mining, energy, transport, tourism, health, scientific research, space, defence, security, taxes, cohesion, consumption or cooperation with third countries are just some examples of policies that must deal with pollution, taking into account the fundamental principles of environmental law.

The application of these principles to pollution law is illustrated by the European Directive that deals with the most classic case of pollution: European Directive 2010/75/EU,[17] which establishes the industrial emissions regime. In fact, industrial pollution gives rise to the vast majority of typical pollution conflicts involving multiple parties: the operator, the neighbours, the workers, non-governmental organisations and the public authorities are some of the interested parties and stakeholders. Industrial pollution also provides a good illustration since the dilemmas of tolerating or proscribing a polluting industrial activity[18] have been addressed at different levels, from courts of human rights[19] to initiatives by national administrations supported by the European Union, such as Impel,[20] which produced a *neighbourhood dialogue toolkit* to support national administrations facing public opposition and demonstrations against proposed investments at the local level.[21]

3.2 Transparency Principle

Transparency and access to environmental information are now central values in EU environmental law. Directive 2003/4/EC of the European Parliament and of the Council, of 28 January 2003, on public access to environmental information establishes the right of access of any applicant (at his request and without his having to state an interest) to environmental information held by public authorities (Article 3 (1)).

For the purposes of the Directive 'Environmental information' includes both pollution and pollution sources. According to Article 2 (1) 'Environmental information' means "any information in written, visual, aural, electronic or any other material form on (. . .) (a) the state of the elements of the environment, such as air and atmosphere, water, soil, land, landscape and natural sites including wetlands, coastal and marine areas, biological diversity and its components, including genetically modified organisms, and the interaction among these elements; (b) factors, such as substances, energy, noise, radiation or waste, including radioactive waste, emissions, discharges and other releases into the environment, affecting or likely to affect the elements of the environment referred to in (a);

[17] Directive of the European Parliament and of the Council of 24 November 2010 on industrial emissions https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32010L0075.

[18] Job creation, investment attraction, increasing production scale and widening of the market for products and services are some of the benefits usually associated with industrial development.

[19] European Court of Human Rights, Fadeyeva vs. Russia, no. 55723/00, 9 June 2005, steel industry; Băcilă vs. Romenia, no. 19234/04, 30 March 2010, smelting industry; Cordella and others vs. Italy, no. 54414/13 and 54264/15, 24 January 2019 smelting industry.

[20] The European Union Network for the Implementation and Enforcement of Environmental Law is an international non-profit association of the environmental authorities of the European Union Member States and a few other European countries. The Network's objective is to create the necessary impetus in the European Union to make progress on ensuring a more effective application of environmental legislation (https://www.impel.eu/).

[21] The *neighbourhood dialogue toolkit* is aimed at authorities and companies who want to use or promote a direct dialogue approach to solving environmental conflicts between residents and industrial sites. A number of Member States have been involved in a series of projects on establishing neighbourhood dialogues, which collected and evaluated examples of how environmental conflicts between companies and their neighbourhoods could be solved by dialogue (https://www.impel.eu/tools/neighbourhood-dialogue-toolkit/).

(f) the state of human health and safety, including the contamination of the food chain, where relevant, conditions of human life, cultural sites and built structures inasmuch as they are or may be affected by the state of the elements of the environment referred to in (a) or, through those elements, by any of the matters referred to in (b) and (c).

Furthermore, "public authorities must organise the environmental information which is relevant to their functions (. . .) with a view to its active and systematic dissemination to the public, in particular by means of computer telecommunication and/or electronic technology, where available" (Article 7, on dissemination of environmental information).

However, there are other cases of transparency regarding pollution. The norms on disclosure of non-financial and diversity information by certain large undertakings and groups (European Union 2014) impose corporate social and environmental responsibility requirements, in order to promote sustainable development through accountable, transparent and responsible business behaviour. The 2014 European regime obliges large companies to reveal the risks they pose to the environment, their employees and society, as well as the policies pursued and the outcome of those policies, demonstrated by relevant key performance indicators (Preamble, §7 "where undertakings are required to prepare a non-financial statement, that statement should contain, as regards environmental matters, details of the current and foreseeable impacts of the undertaking's operations on the environment, and, as appropriate, on health and safety, the use of renewable and/or non-renewable energy, greenhouse gas emissions, water use and air pollution").

3.3 Prevention Principle

The prevention principle highlights the duty, above all, to avoid pollution (De Sadeleer 1999). The effort required from the polluter is to invest whatever is necessary to make sure that pollution is not emitted at all, rather than investing in repairing damage caused by its emission. This can be done by changing the materials, reagents or other substances used in production, by transforming the way materials are extracted, transported or transformed into products or services, or by altering the way products or services are delivered, used or discarded.

In a linear economy, pollution can happen at every step of the production-consumption-disposal chain.[22]

Article 11 of the EU's Industrial Emissions (Integrated Pollution Prevention And Control) Directive is an example of how the law imposes prevention duties on polluters. Setting out the general principles governing the basic obligations of operators, this article provides as follows:

> Member States shall take the necessary measures to provide that installations are operated in accordance with the following principles:
> (a) all the appropriate preventive measures are taken against pollution;
> (b) the best available techniques are applied;
> (c) no significant pollution is caused;[23]
> (d) the generation of waste is prevented in accordance with Directive 2008/98/EC;
> (e) where waste is generated, it is, in order of priority and in accordance with Directive 2008/98/EC, prepared for re-use, recycled, recovered or, where that is technically and economically impossible, it is disposed of while avoiding or reducing any impact on the environment;
> (f) energy is used efficiently;
> (g) the necessary measures are taken to prevent accidents and limit their consequences;
> (h) the necessary measures are taken upon definitive cessation of activities to avoid any risk of pollution and return the site of operation to the satisfactory state defined in accordance with Article 22.

Implementation of the prevention principle gives rise to a number of questions regarding the level of preventive investment that is required of the polluter. How much effort, both financial and in terms of human resources, is the polluter required to make? The answer is provided by the proportionality principle, which stresses that

[22] The reality is quite different in a circular economy, as will be explained later.

[23] On the interpretation of the "do no significant harm" clause, see European Commission (2021a).

there must be a balance between the benefits and the costs of pollution prevention. Recognising the difficulty of comparing long-term environmental improvement and health benefits, on one hand, with short-term economic costs, on the other, some authors prefer to speak of eco-proportionality (Winter 2018). Eco-proportionality seems to indicate that the fictional conversion of long-term immaterial benefits into economic savings is neither mandatory nor advisable. For instance, the health benefits of pollution prevention can be expressed by avoided hospital costs or unused medicines. For the sake of comparability, this is one possible way, but it is surely a reductionist approach. There are numerous other advantages to not falling ill besides saving on medicines or other hospital costs. On the other hand, considering that pollution prevention often enables economic savings, eco-proportionality presupposes that preference should always be given to preventive solutions, except in cases where social costs add to the economic costs. This is the thinking behind the fair, green and digital transitions driven by the European green deal and supported by the Just Transition Fund in the EU.[24]

3.4 Precautionary Principle

Quite differently, the precautionary principle advocates a cautious approach to pollution in cases of uncertainty (Fisher et al. 2006). In fact, in many cases the need to adopt avoidance measures is not obvious. This uncertainty can arise when the source of the pollution is not clearly determined. One example would be water contamination appearing in a river, where several industries have discharge permits upstream and inspections to establish responsibilities are still pending. Another case is when the consequences of certain activities are uncertain, for instance the consequences of waste incineration when the composition of the waste is unknown. Finally, there may also be uncertainty when the chain of causation has not yet been proven. Here we may see the example of neighbours who have reported health issues associated with exposure to electro smog, although the connection between their symptoms and the electromagnetic fields has not yet been scientifically confirmed.

These are some examples of where the precautionary principle is useful, eradicating decisionmakers' inertia and imposing the adoption of safety measures to avert unproven risks. In practice, precaution means the burden of proof lies with the potential polluter to demonstrate that a certain activity, substance, technology or procedure does not pose a risk of serious pollution. All the while he is unable to prove that his activity, substance, technology or procedure is innocuous, he is required to adopt protective measures to adequately prevent any potential pollution.

In EU Law, Article 59 (2) and (3) of the Industrial Emissions Directive (on control of emissions) refer to the duty of the operator of the installation to demonstrate that the emission limit value for fugitive emissions is not technically and economically feasible and that the best available techniques are being used.

3.5 Correction at the Source Principle

The correction at the source principle reflects an option regarding the time and place for pollution abatement. Pollution can be dealt with either at the point of emission or elsewhere and at a later time, in a dedicated installation or through mitigation techniques applied at the point of impact. This is the case, for instance, of greenhouse gas emissions from industrial boilers that can be prevented "at the source" by replacing fossil fuels with renewable energy sources. Alternatively, it is possible to capture the greenhouse gases and use them in another industrial process (for instance for carbonated drinks) or inject them

[24] A political agreement approved on 10 November 2020 by the European Parliament, EU Member States in the Council and the Commission, on the next long-term EU budget and Next Generation EU (https://ec.europa.eu/commission/presscorner/detail/en/IP_20_2354).

into geological caverns (for carbon capture and storage). Another example is reducing noise pollution from aircraft by limiting the operational period of airports to daytime hours. Alternatively, installing double glazed windows in the neighbourhoods surrounding the airport can also limit the effects aircraft noise may have on health. Several arguments can be used to support postponing pollution control measures to a later stage or transferring the responsibility for pollution abatement to third parties:

- postponing reduces pollution impacts without requiring heavy investment by the polluter;
- transferring allows specialisation in production and economies of scale, allowing some operators to specialise in dealing with pollution and polluters to outsource pollution control and abatement;
- operators specialised in treating pollution are likely to have better equipment and greater technical competence for the purpose.

However, postponing or transferring responsibility can only occur if risks and environmental impacts are not increased as a result of the geographical displacement of the polluting substances (for example, CO_2 transportation by road consumes fossil fuels and generates risks of road accidents) and provided that the overall level of environmental protection is not lowered (for example, sound insulation is not efficient for public spaces and open air activities and even in the home, during summertime when windows are left open).

As a consequence, there is a preference for measures being taken immediately at the source rather than later and elsewhere. This is the justification for the introduction of circular processes (such as reuse of cooling water for turbines) or eco-efficient technologies (such as local microgeneration of renewable energy for self-production).

3.6 Polluter Pays Principle

The Polluter Pays Principle can be found in a variety of legal sources (European Court of Auditors 2021). Many constitutions around the world have direct references to the Polluter Pays Principle (Aragão 2022). In international or supranational law, several sources define a legal regime of pollution compatible with the PPP. These sources are very useful in interpreting the principle (Schwartz 2018).

3.6.1 The PPP in EU Law

The main legal regime detailing the PPP in the European Union is the 2004 EU Directive on environmental liability with regard to the prevention and remedying of environmental damage, including damage caused by pollution (European Community 2004).[25] In the words of the directive: "the prevention and remedying of environmental damage should be implemented through the furtherance of the 'polluter-pays' principle, as indicated in the Treaty and in line with the principle of sustainable development" (preamble, §2).

Where there is an imminent threat of environmental damage occurring, the operator must take the necessary preventive measures without delay. Where environmental damage has already occurred, the operator must take all practicable steps to immediately control, contain, remove or manage the damage factors in order to limit or to prevent further environmental damage and consequent adverse effects on human health, without delay (Article 6). Naturally, the costs for the preventive and remedial actions shall be borne by the operator, directly or through insurance or other financial security (Article 14).

The regime of integrated pollution prevention and control establishes obligations on operators that clearly reflect the PPP. The operators of

[25] "According to the 'polluter-pays' principle, an operator causing environmental damage or creating an imminent threat of such damage should, in principle, bear the cost of the necessary preventive or remedial measures. In cases where a competent authority acts, itself or through a third party, in the place of an operator, that authority should ensure that the cost incurred by it is recovered from the operator. It is also appropriate that the operators should ultimately bear the cost of assessing environmental damage and, as the case may be, assessing an imminent threat of such damage occurring" (§18 of the Preamble of the Directive).

industrial installations are responsible for taking all the measures to ensure that the permit conditions are complied with. This includes taking all appropriate preventive measures against pollution, applying the best available techniques, not causing significant pollution, taking the necessary measures to prevent accidents and limit their consequences, and returning the site of operation to a satisfactory state. The operator may also be required to update the permit conditions when the laws setting environmental quality standards are updated, when the emission values established in the permit prove to be excessive or when the establishment does not seem to be safe enough.

3.6.2 Who Is the Polluter?

Where pollution is the side effect of a production process (ex. tanneries, smelters, refineries, etc.) it seems quite clear that the polluter is the operator who is responsible for the activity.

If the pollution does not begin during production but, rather, is caused by consumers while using or disposing of the product (for example, noise from motorised vehicles, use of household cleaning detergents, discarding of batteries), the consumer is the *formal* polluter. The consumer is the individual who physically causes the pollution. However, the producer who manufactures the noxious product and places it on the market is the *material* polluter.

However, in reality the situation is more complex and very often pollution is generated at different stages along the value chain, e.g. during raw material extraction, assembly, manufacture, packaging, handling, transportation, use and disposal. This is called the "pollution chain" and has been investigated in the European Community since the seventies, having first been identified by the European Council in 1975.

Instead of struggling to determine who the "real" polluter is among all the economic agents and consumers who are involved in some way, the solution to this interpretative deadlock is a pragmatic *forward-looking* procedure, rather than a *backward-looking* application. This path was adopted long ago by the European Community (European Council 1975).

Instead of a quest to find who is *more responsible* than the others for pollution, the solution is an inquiry to discover the *polluter-that-should-pay*. The challenge then, is to find the best "payer" among the different polluters (whether direct or indirect, material or moral). This interpretation is fully aligned with the ultimate goals of the polluter pays principle. In fact, the objectives of the PPP are twofold:

- first, fairness: to impose the economic burden of pollution on whoever is materially or morally responsible for polluting activities.
- second, effectiveness: to change the practices of those who have the power to change the state of affairs that leads to pollution

  The final result of this interpretation of the PPP is a fair pollution prevention policy.

3.6.3 Is the PPP Unfair?

The principle has often been accused of being unfair. Does the PPP commodify pollution? Is the PPP a licence to pollute? Is the polluter buying the right to pollute?

Questions like these do not take into account that the PPP does not replace the classic sanctioning norms of administrative and criminal law. The PPP applies beyond these norms. In the case of illegal pollution that amounts to an administrative offence or a crime (Eurojust 2021) the appropriate procedure and the sanctions applicable are inspired by classic defence rights and liability principles, not by the PPP. The PPP applies only to polluting activities that are **legal** and **accepted** for the economic and social benefits they bring, when the polluters are supposed to be encouraged to reduce their pollution to the minimum possible.

Another criticism levelled at the PPP is that it is not, in fact, the polluter that really pays but rather the victim. If polluters are allowed to pass the payments on to their clients, who really bears the economic burden at the end of the day? It is important to demystify these sceptical questions. When polluters raise the price of their products to compensate for pollution payments, thus transferring the economic loss along the value chain to consumers, they are aware that they will probably lose clients. In a competitive economy, the

demand for the polluting product or service will fall. This ultimate indirect effect of the PPP is in accordance with its *rationale* and makes cleaner products (or less polluting ones) more attractive.

In short, the PPP guides policies aimed at nudging economic activities to a greener and fairer performance.

Besides, the philosophy and strength of the PPP lay precisely in its flexibility, by leaving the polluter the option between polluting and paying or paying not to pollute.

4 The Circular Economy and Pollution Prevention

Intensive linear economic activity, which ignores the limits of the environment and the resulting long-term damage, is depleting the planet's resources. It is therefore crucial to implement strategies and solutions that enable pollution prevention and that maximise the value of resources.

Pollution prevention focuses on the elimination of waste and emissions at their source. There are two main strategies for implementing pollution prevention: one is tactical, which acts at an operational level, namely, to change the operational process to eliminate waste; the other functions at a strategic level and involves investment in a management system. This demonstrates that pollution prevention must be proactive and needs a pre-planned strategy (Kusumowardani et al. 2022).

The global priority of waste and pollution prevention encompasses improvements in production and consumption systems and associated waste management and resource recovery. Government policies need to discourage and eventually eliminate indiscriminate and environmentally harmful disposal and burning, whilst promoting the use of quality recycled materials and fostering innovation (in products, technologies, business models, lifestyle and consumption patterns) (Fadeeva and Van Berkel 2021).

With the Global Green New Deal (Barbier 2009), a new paradigm is emerging. Taking the European Union as an example, the Green Deal "is a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use. It also aims to protect, conserve and enhance the EU's natural capital, and protect the health and well-being of citizens from environment-related risks and impacts. At the same time, this transition must be just and inclusive" (European Commission 2019). Following the European Green Deal, other pro-environment initiatives are contributing to the desired socioeconomic metamorphosis driven by the PPP. This is the case of the circular economy action plan (European Commission 2020) and the zero-pollution vision for 2050 (European Commission 2021b).

The EU's 7th Environment Action Programme to 2020 advocated 'Living well, within the limits of our planet' and called for the vision of a Circular Economy, where nothing is wasted and where natural resources are managed sustainably. In the 8th Action Programme (European Council 2021), the EU proposes "advancing towards a regenerative growth model that gives back to the planet more than it takes, decoupling economic growth from resource use and environmental degradation, and accelerating the transition to a circular economy".

In China, the Circular Economy Promotion Law, passed by the Standing Committee of the National People's Congress, in 2008, has become a point of reference for circular initiatives. A circular economy is a mode of economic development that aims to protect the environment and prevent pollution, thereby facilitating sustainable economic development (Prieto-Sandoval et al. 2018). A Circular Economy is based on the reduction, reuse, recovery, and recycling of materials and energy, transforming the linear flow into circular flows (Abad-Segura et al. 2020).

Specific Circular Economy initiatives in some member countries of the G20 (an intergovernmental forum comprising 19 countries and the EU) provide comprehensive policies to perpetuate the circulation of material and energy in these economies and promote their efficient use, while focusing on an increase in

renewable inputs. They target several stages of the life-cycle—from design to return to the production-consumption cycles, and comprise a variety of laws, regulations and programmes (Fadeeva and Van Berkel 2021). For example, incineration and landfill taxation can effectively diminish the environmental impacts of pollution and resource use by reducing their pollutants while stimulating the reuse and recycling of materials, hence encouraging a circular economy. Appropriate design of these policies is key for circular economy strategies to obtain effective environmental results while minimising economic impacts (Freire-González et al. 2022).

In a "zero pollution" and circular economy scenario, polluters must find innovative ways to monetise externalities. Where certain undesired side effects of their activity cannot be avoided (whether these relate to solid substances, liquid discharges, gas emissions, heat, light, or radiation), they will need to be used in other production or consumption processes. To quote the European Commission in its zero-pollution communication, "we no longer need to accept pollution that affects people and the environment as an inevitable side product of progress". The circular economy is thought to have the capacity to "deliver substantial material savings throughout value chains and production processes, generate extra value and unlock economic opportunities" (European Commission 2021b).

Some important examples have demonstrated the key role of the circular economy in preventing pollution. One of most relevant examples are plastics. Although plastic is one of the materials that we most use in our daily lives, the current linear economy ('produce, use and dispose') engenders high risks to human health in terms of greenhouse gas (GHG) emissions and environmental pollution.

To reduce the amount of waste and pollution from plastics, it is crucial to study not only how to recycle plastic, but also how to create a circular value chain. One challenge that has been identified is to produce rules and legislation focused on regulating the end-of-life phase (e.g., waste management legislation), which means that other important factors are not addressed (Johansen et al. 2022). Clearly, global action—and coordinated action—is required for there to be a lasting societal and environmental change. Plastic pollution prevention can thus begin with policies for wider and more focused application of known good practices, through consistent policy and implementation, in collaboration with consumers, producers, farmers and other waste generators and formal and informal waste management sectors (covering collection, recycling, recovery and environmentally sound disposal). Responsible behaviour by all partners is necessary, along with business-like methods and systems (Fadeeva and Van Berkel 2021).

Implementation of circularity principles in agriculture is imperative for pollution control and will facilitate the transition towards planet healthy farming practices so that food production paths can be transformed in a manageable, replenishable, and sustainable way, in line with the aspirations of the UN-SDGs practices. This will promote resource conservation while regaining soil fertility and moisture content through improved soil carbon sequestration. Regenerative agricultural practices based on resource conservation and replenishment are therefore imperative to reduce negative environmental impacts (Dubey et al. 2021).

Management of industrial fruit by-products is important not only to decrease the volume of food waste accumulated in landfills, but also to develop strategies through re-use with the purpose of valorising and adding economic value. The disposal of food waste leads to different global impacts in different sectors, such as social, environmental and economical. Integration of the valorisation concept allows fruit waste to be converted into high-value products with relevant potential applications for human consumption, such as extraction of specific molecules and the production of antioxidant extracts and functional flours. Such transformation requires food, nutraceutical and pharmaceutical industries to open their doors to improving the biological activities of current products, as well as the development of novel products (Campos et al. 2020).

5 Rationale of Pollution Law

The final reason that explains and justifies efforts to regulate, tax, charge for, clean up, supervise and sanction pollution is protection of the victims of pollution. Pollution is harmful to people, animals, plants, microorganisms, ecosystems, rivers, lakes, mountains, forests, the atmosphere, the stratosphere, the planet and other planets. According to the Lancet Commission on Pollution and Health (2017), pollution is now the largest environmental cause of death in the world—1 in 6 people die from pollution-related causes (Landrigan et al. 2018). The new concept of Planetary Health was discussed in Helsinki in December 2019 (Finnish Institute for Health and Welfare -THL 2019), by researchers, policymakers, and regulators, and highlighted the urgent need to act as scientific evidence shows that human activities are causing climate change, biodiversity loss, land degradation, overuse of natural resources and pollution (Halonen et al. 2021).

Current and future generations deserve a pollution-free world. However, what is surprising is that human communities are not uniformly exposed to pollution (WHO 2019; Aragão 2021). The effects of pollution on health have recently been placed under the spotlight as several studies have revealed that minorities and the most vulnerable persons are more exposed to environmental pollution and unhealthy environments than the average population (EEA 2018). What is worse, the prevalence of vulnerable social groups living in deteriorated environments is growing (Eurostat 2019).

Territorial injustice, also called spatial justice, is the result of several of these inequities occurring in the same region, community or place. Furthermore, territorial injustice caused by pollution can also occur between countries, and hence territorial injustice is a crosscutting problem with international incidence.

In fact, most pollutant emissions—air pollution, water pollution, soil pollution, noise, radiation—are more severe near their source, and gradually fade as they move away from it. Consequently, those living in the vicinity of sources of pollution and hazards are the most vulnerable populations (UN HRC 2018).

More shockingly, the most vulnerable individuals or groups are also those who are less resilient and unable to take self-protection measures. Abandoning a contaminated area and moving to live elsewhere is only possible when the environmental victims have the economic capacity to leave their home (selling it for a low price or simply leaving it) and try to resettle somewhere else. Consequently, the more economically disadvantaged victims are forced to stay and endure the slow violence (Nixon 2011) of living in a polluted and unhealthy environment.

This is why the preventive approach is so important. The social effects of pollution are unfair and must, therefore, be averted.

6 Conclusion and Future Perspectives

The legal regime of pollution, shaped by the fundamental environmental principles, seeks to achieve higher levels of environmental protection, as required by the European Treaties (for instance, Article 3(3) of the Treaty on the European Union states that "the Union shall work for sustainable development of Europe based on balanced economic growth and price stability (. . .) and a high level of protection and improvement of the quality of the environment").

Pollution is a battle that can be won. In the latest results of the Global Burden of Disease, for example, the age-standardised death rates for all causes of air pollution were reported to have fallen by 23% between 2006 and 2016 (Das and Horton 2018). There is still a long way to go, so it crucial to accelerate our joint efforts and response. All governments and decision makers need to address the health impacts of pollution and major environmental threats on a regular basis to prompt timely and definitive actions. A shift from fragmented approaches to policy and practice towards systematic actions will promote human and Planetary Health. Global, regional,

national, local, and individual initiatives are called for and multidisciplinary and multi-sectorial actions and measures are needed to stop the consequences of pollution. Systems thinking will feed into conserving nature and biodiversity, and into halting climate change (Halonen et al. 2021).

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