

Pernicious Plastics and the Precautionary Principle

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Introduction

Plastics account for the vast proportion of the 70,000 synthetic materials derived from oil by-products [1] which remain untested for their effects on human health. History has shown that several plastics, originally considered completely benign, have since proven harmful to eco-systems, animals and ultimately to human health, demanding their control and in some case elimination from use. This essay discusses the effects of PVC on human health and debates the need and practicality of adopting the precautionary principle to limit any adverse effects.

Scope of the problem

The first truly synthetic plastic was created in 1907 by Leo Baekeland [2] from phenol formaldehyde and christened 'bakelite' which is now known to degrade into acrylonitrile, butadiene, styrene, cyanide and nitrous oxides which include irritants, suspected carcinogens and toxic respiratory system irritants [2a].

Since then, the 'progress' of plastics has been fast and furious: in 1924 Edmund Rossiter created 'urea thiourea formaldehyde, superseded by 'urea formaldehyde' in 1932 (now a recognised carcinogen [3]) swiftly followed, after the war, by PVC (alleged to be the most environmentally damaging plastic [4]), melamine (a known irritant and potential carcinogen [5]), polyethylene, polystyrene (a suspected endocrine disruptors and carcinogen [6]) and nylon (toxic if burnt [7]). This, extremely basic, 'ancient history' of plastics illustrates the magnitude of the problem and the ignorance of employing poorly understood materials.

The synthetic nature of plastic, whilst affording it uniquely exploitable properties, ultimately limits its safe passage through the ecosystem and produces enormous potential for the distribution of toxic substances throughout the environment. Given the body of evidence from the past and that less than 2 per cent of synthetic materials have been tested for their effects on human health and more than 70 per cent have not been tested at all[1] it seems prudent to re-evaluate the ways in which we introduce these new potential contaminants (Fig 1) into our environment.

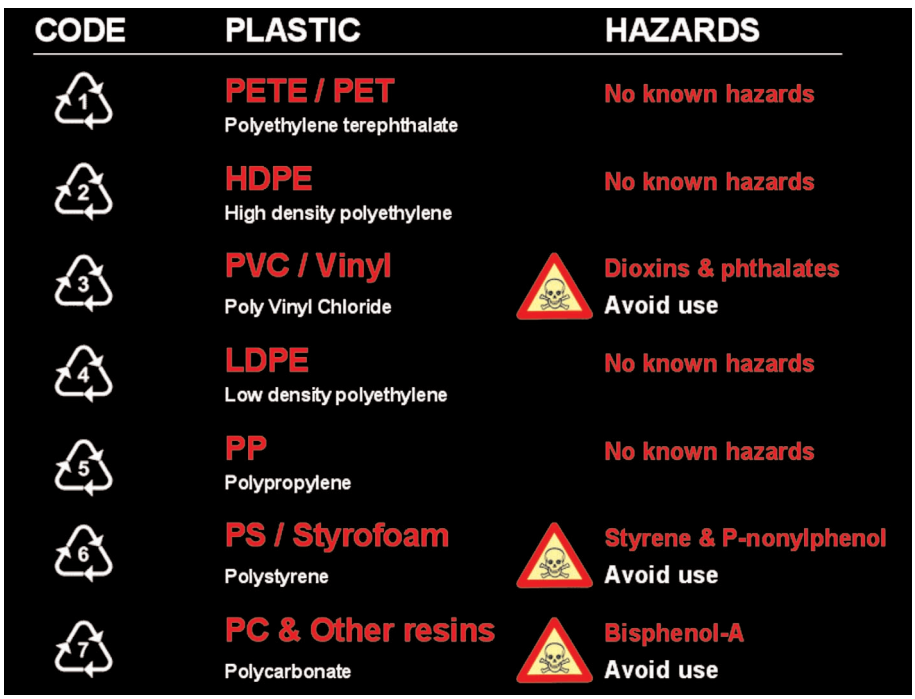
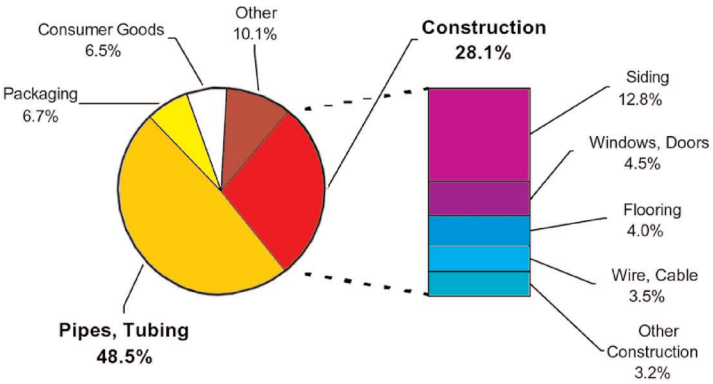


Figure 1:
Threats from Plastics. Roughly 60% of all plastics in use today fall into categories 1 - 6, the rest fall into the 7th bracket 'Other resins'.

Problems with PVC

Labelled by Greenpeace 'the poison plastic' PVC (poly vinyl chloride) is a very common plastic with an extremely wide range of uses which represents a 14.6 billion pound industry in the US and Canada alone [8]. More than three quarters of all PVC ends up in pipes and construction materials [8] (Fig 2).

Figure 2: Uses of PVC [8]



The problems with PVC concern its entire 'life cycle' from production to disposal (Fig 3). The main concerns; that PVC manufacture creates dioxins and other persistent pollutants as by-products, its usage can leach phthalate plasticisers, lead and other heavy metals into the environment and that, due to a lack of recycling its disposal releases further dioxins [9], remain hotly contested - mainly by the plastics manufacturing industry.

Figure 3: The PVC 'death route' (it's not alive and there is no cycle!) [9a]

Health matters - dioxins

The main concerns (and least understood aspects) with PVC are the release of dioxins and phthalates into the environment. Dioxins are a group of structurally related organochlorine compounds, including polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), both highly toxic and present in PVC, which are believed to cause a variety of health effects, including cancer, as well as possible effects on the immune and reproductive systems [13].

Dioxins are lipophilic, bioaccumulate up the food chain and are mainly (97.5%) found in meat and dairy products (Fig 4) [18]. They are also hydrophobic and hence 'seek' fish and other animals, working their way to the top of the food chain. Once present in women dioxins have only two routes of escape: by crossing the placenta into a growing infant or through the secretion of breast milk, again ending up in children, the ultimate receptors of dioxins. A fierce debate regarding the dangers

of dioxins to human health continues with increasingly conflicting views. As always with risk assessment the outcomes are extremely hard to evaluate successfully due to procedural incompatibility, ethical restrictions, cocktail effects and disturbing, but increasingly apparent, financially influenced reporting (see 'Who can we trust' Appendix A). However, the EPA, has concluded that dioxins 'can alter the fundamental growth and development of cells in many ways. For example, dioxins may: cause cancer, disrupt the endocrine system, and cause reproductive and developmental effects' [19] [20]. The British Plastics Federation assert that 'this is a view which is not widely shared' citing a report by the French Academie des Sciences concluding that 'there is no evidence of dioxins

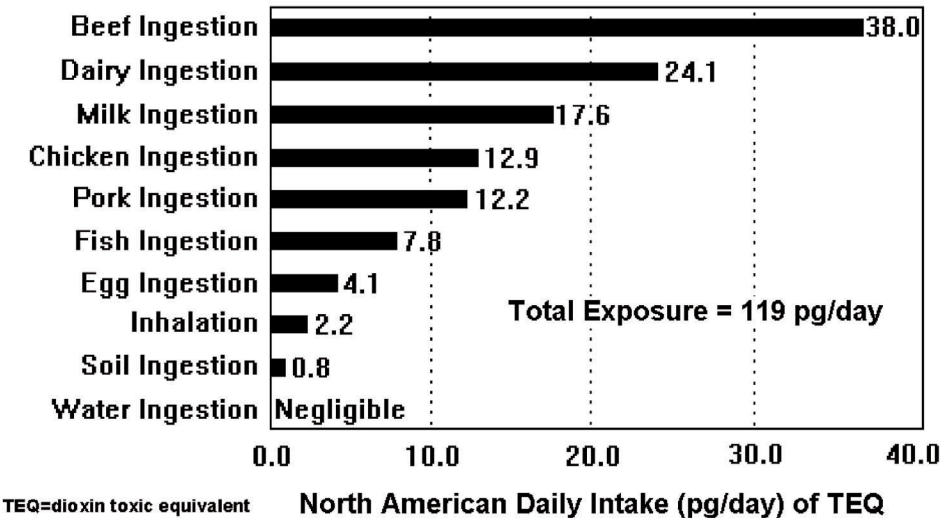


Figure 4: Sources by which humans ingest dioxins

posing a serious risk to public health' [14].

Dioxins are present in natural materials and are mainly released into the environment by incineration (even burning wood emits dioxins) either naturally, in municipal waste disposal or accidental fires. Many bodies argue that 'study after study has shown that the presence or absence of PVC in an incinerator makes no difference to the level of dioxins emitted' [14], however a report by William Caroll entitled 'The relative contribution of wood and PVC to emissions of PCDD and PCDF from house fires' clearly states that while wood has an emission factor of 0.01-173μg/t PVCs emission factor is 3-6554μg/t clarifying its potentially large contribution to dioxin pollution.

The Vinyl Institute, a subsidiary of the American Plastics Council (APC), quotes that less than 1 percent of dioxins in the air are the result of PVC production [10].

Health matters - Phthalates

Phthalates are a family of chemical compounds that exist in a wide range of products (e.g. Nail polish, perfume, PVC). About 80 percent of all phthalates are used as plasticisers to make plastics flexible, most goes into PVC and some types of flexible PVC can contain up to 50% (by weight) phthalate esters. It is widely accepted that phthalates leach out of PVC products.

Joel Tickner from The Science and Environmental Health Network explains that the main phthalate used in PVC toys is DINP (diisononyl phthalate) which, in laboratory experiments, (submitted by plastics companies) has in some cases, been linked to liver and kidney lesions, cell line transformations, liver tumours, cancer and impacts on the reproductive system [11]. The main previous plasticiser used in PVC, Diethylhexyl phthalate (DEHP), was withdrawn from use in toys in the mid-1980s after being listed as a possible human carcinogen.

The APC insist that 'there is little evidence, if any, to indicate that phthalates have a significant effect on the environment'[10]. The institute quotes Ann Brown from the Consumer Product Safety Commission (CPSC) as saying "Few, if any, children are at risk from phthalates because children

don't ingest enough of the chemical for it to rise to a harmful level" however, even the European Council for Plasticisers and Intermediates, an understandably pro-plastic body admits 'phthalate release from PVC toys [has been] confirmed by the Dutch Nutrition and Research Institute (TNO) as suitable for routine enforcement of legislation' [12]. Whilst not enough is known about the long term effects of phthalates on humans they are listed as potential endocrine disruptors by several scientific bodies and remain the most abundant human-made contaminants found in the environment, sufficient for the U.S. Centre for Disease Control to initiate cautionary screening of the U.S. population [11].

Where's it all going to go?

It is also argued that PVC 'can be recycled and its residual energy tapped in energy from waste plants'[14] ie. via incineration. This, the most tenuous use of the term 'recycled', presents further opportunities for the release of dioxins and contributes the further problem of toxic fly ash.

Approximately 100,000 tones of toxic fly ash is produced each year by the UK MSW incineration industry alone which is then landfilled at considerable cost due to toxic heavy metals and PCDD/F content [15]. Other routes for the disposal of PVC are costly down-cycling to create inferior quality products (hence only delaying the release of dioxins) and landfilling. The APC point out that 'well-managed landfills use thick plastic liners to prevent leachate from entering groundwater and also control biodegradation by preserving rather than decomposing waste'[16], again only delaying the problems of dioxin emissions. They propose that 'you could think of it as "land recycling and reuse" made possible by the stability of today's high-tech "nondegradable" landfills', an obviously irresponsible attempt to appear environmentally conscious. They even state that 'with these safeguards in place, the disposal of plastics will continue to be problem-free' [16]! Such sweeping statements are unfounded, irresponsible and recalcitrant towards the entire environmental movement.

Peter Montague explains that despite claims of double lined 'monofills' (landfills containing only toxic fly-ash) locking up polluting substances indefinitely, the molecular structures of (plastic polymers) monofill liners are inherently unstable and will decompose within years or, 'at most a few decades' [17]. It seems ludicrous to ignore such warnings and in the face of uncertainty, whilst any potential threat to human health exists, precaution seems a prudent choice.

The Precautionary Principle

The Rio Declaration 1992 states that: 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.

Raffensperger lists four central components of the precautionary principle (PP):

1. Taking preventive action in the face of uncertainty;
2. Shifting the burden of proof to the proponents of the activity;
3. Exploring a wide range of alternatives to possibly harmful actions; and
4. Increasing public participation in decision-making [21].

In light of the evidenced detailed above the manufacture, use and disposal of PVC would seem like a perfect case for PP however, not everyone agrees it is the best solution. The APC reports 'The plastics industry supports this (precautionary) approach to assure responsible action in the face of uncertainty [22]'. They go on to point out: 'there are some who misinterpret this principle, confusing hazard (the likelihood of harm) with the mere suggestion of risk. The result of such misinterpretation, if it were to find its way into law or regulation, could be restrictions or even bans of some products

without any proof or demonstrable evidence that these products pose a threat to human health or the environment' [22]. This statement, whilst showing an inherent lack of understanding of PP, displays a paranoia of 'restrictions' and 'bans' not mentioned by PP which instead promotes 'exploring alternatives'. The entire point of precaution is that you do not need 'proof or demonstrable evidence' in order to avoid a potential threat. Despite this, genuine criticisms of PP remain;

1. Regulatory procedures (risk assessment) are already precautionary;

2. PP is not scientifically sound because it advocates making decisions without scientific justification; and

3. That PP could stifle innovation [23].

They are also easily answered:

1. Applying risk assessment to a situation does not invite precaution, it delays preventative action until risk can be 'proved'. It also assumes that 'precise numbers can be assigned to the possibility of harm' [24] which is very rarely the case and also assumes 'that lack of numbers means there is no reason to take action' [24]. Evaluated risks are also easily manipulated by those with a stake in their outcome (see 'Who can we trust' Appendix A).

2. PP actually demands better science, it admits that science may not be adequate to provide immediate answers regarding complex long term problems and provides a framework for better scientific practice. It seeks to avoid humans and the environment being used as the testing grounds for unknown technologies in order that species remain intact whilst science searches for new methodologies and answers. It promotes 'conservation medicine'[23a] and 'joining edge' research to synthesise the results of the many disparate scientific disciplines.

3. In reality PP demands more innovation. It does not seek to eliminate any technology, only limit risks whilst less harmful alternatives can be found. This encourages 'ethical' innovation.

With regard to PVC, manufacturers argue that 'there is no evidence of harm, given 40 years of use without apparent ill effects' [23]. Such reasoning is flawed by the fact that absence of evidence of harm is not the same as evidence of absence of harm and, regardless, if less harmful alternatives exist why accept even a small, highly uncertain risk? It also seems probable that the current speed of innovation is responsible for the vast proportion of environmental degradation - would it not be better to 'stifle innovation', than to suffer unexpected, long term, damage to eco-systems?

The Precautionary Principle embodies certain values that run counter to the 'economics-first' paradigm. This explains its threat to industry but also reveals its power as tool for implementing sustainable development. Demanding inter-generational views, making commitments to the future and proceeding at more considered pace seems entirely necessary to avoid leaving our descendants a legacy of toxic pollution and degraded eco-systems.

Alternatives to PVC

There are several alternatives to PVC (Fig 5) that are less environmentally damaging, less hazardous to health and hence more sustainable [25], proving the practicality of PP. Greenpeace host an extensive database of alternatives to PVC and there are several examples of buildings, including the entire Sydney Olympic Village, that have built without the use of PVC.

Utilising alternatives is a practical option given that 'there is little or no additional cost for using less hazardous materials' [8]. Roughly 50 per cent of PVC use is for DWV (drain, waste and vent) piping and even though alternatives are not common, they can be found. HDPE, clay and metal pipes can perform the same functions as PVC with less of a risk to health.

Bioplastics are the ultimate alternative and undoubtedly the future of the plastics industry. These

Common PVC Use	Alternative Material
Piping	Cast iron, steel, vitrified clay, concrete, copper, and plastics such as HDPE (High Density Polyethylene)
Siding	Fiber-cement board, certified sustainable wood, polypropylene, acrylic, stucco, brick. aluminum
Roofing Membranes	Thermoplastic polyolefins (TPOs) and EPDM (ethylene propylene diene monomer) membranes, low slope metal roofing
Flooring and Carpet	Natural linoleum, bamboo, ceramic tile, carpeting with natural fiber backing, reclaimed or sustainable wood, cork, recycled rubber, concrete, Stratica and other nonchlorinated plastics.
Wall Coverings	Natural fibers (wood, wool, etc.), polyethylene, polyester, paint, tiles.
Electrical Insulation and Sheathing	Halogen free, linear low-density polyethylene (LLDPE), thermoset crosslinked polyethylene (XLPE)
Windows and Doors	Recycled, reclaimed or certified sustainable wood,

Figure 5: Examples of alternatives to PVC

extremely valuable alternatives to synthetic polymers can be manufactured from plant-based oils and corn starch and are undergoing intensive R&D [26]. The possibility of altering the genetic structure of a plant in order to obtain more abundant co-polymers for plastic manufacture has already been investigated by Monsanto.

Conclusion

History has shown that numerous plastics originally considered completely benign have eventually been found to possess harmful characteristics and the number of synthetic material on the market which remain untested for their effects on human health poses serious concern.

The safety of PVC remains hotly contested and although the hazards of phthalates and dioxins are widely accepted, indisputable scientific ‘proof’ of their association with PVC remains debatable. However, the potential risks show a definite need for precaution. Plus, the continual consumption of irreplaceable raw materials in its construction coupled with the lack of any entirely safe means of disposal or recycling make PVC an inherently unsustainable material.

The precautionary principle, recommending alternatives in the face of uncertainty seems specifically appropriate for such a potentially pernicious plastic. It also advocates considering ‘values’ and encourages the development of advanced scientific practices which, as we have seen, are desperately needed to concluded such contentious issues satisfactorily and promote sustainable development.

Appendix A

Who can we trust?

Risk assessment is fraught with disaster. Industry pays for scientific research and if they don't like the results, they don't 'pay' again. When scientist A is searching for things that only exist in parts per trillion it must be easy to get different results to scientist B. Both reports get written up and touted as truth when neither is really unequivocal proof of anything.

The plastics industry could be accused of being 'dark green', of using 'green wash' to support it's actions. Larry Thomas, president of the Society of the Plastics Industry hosted a strategic planning meeting of the society on January 15, 1990. The goal was 'to undertake a major program of unprecedented proportions to reverse the fast-moving tidal wave of growing negative public perception [to plastics and] to demonstrate the critical importance of plastic products and their contributions to environmental progress.' Mr. Thomas estimated that this effort would cost upwards of $50 million per year for three years [99]. Clearly, the main grounds for such a campaign would be protect the interests of the $409 billion plastics industry which employs nearly 2.4 million people [98] in the US alone, rather than encourage research and development into sustainable solutions and human health risks cause by plastics.

Greenpeace report that 'in an attempt to convince the public and decision makers that PVC can be and is being recycled, the PVC industry is supplying false information' and cites tests of seven so-called 'recycled' window frames, in which none of samples were really recycled and only two contained pre-consumer waste from PVC off cuts which had been coloured to resemble recycled products [97].

The British Plastics federation argues that Greenpeace campaigns 'have often been based on factual inaccuracies, outdated information and sheer emotion. The conclusions have been far-fetched and do not withstand close critical scrutiny'[14]. They go on to pronounce 'the benefits of the material (PVC) are all around us, are rock solid and indisputable and they are thoroughly documented and attested by the application of sound science. The criticisms are, sadly, often lacking in sheer knowledge, intellectual rigor and honesty and are often politically motivated. They provide absolutely no justification for Greenpeace's continuous exhortation to phase out PVC' [14].

Lies versus lies? Who can we trust? The argument that Greenpeace's campaign is politically motivated is hard to believe. What possible gain could an independent non-profit global organisation campaigning against environmental degradation, which does not solicit or accept funding from governments, corporations or political parties [96], make from attempting to ban PVC?

There seems more likelihood that an extremely powerful and financially motivated industry, comprised of 23 of the leading resin manufacturers in the US, which aims to 'demonstrate that plastics are a responsible choice, and promote the countless ways plastics make lives better, healthier and safer' [95], would have reason to distort the truth.

The only solace we have is that 'sound science', which remains our only 'truth', will develop advanced practices that yield unquestionable results thus providing conclusive evidence from which successful policy can be drawn. Only time will tell if this remains a feasible proposition, in the meantime prudence remains with precaution.

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