1 CHEMICAL AVALANCHE

'There are poisons that blind you, and poisons that open your eyes.'
August Strindberg, *The Ghost Sonata*

The pallid light of a mid-winter afternoon, filtering through a tiny window set high in the wall of the small bathroom, illuminated mother and child in a moment of exquisite tenderness and pathos. Eugene Smith shifted uncomfortably in the cramped chamber to reframe the image: shrapnel wounds sustained in Okinawa as a war correspondent almost thirty years earlier still troubled him. Sightless, deaf, lame, claw-handed and emaciated, Tomoko Uemura lay helplessly in the bath, cradled in her mother's loving arms. Sixteen years earlier she had sustained terrible damage as she still lay in the womb, the venom that crippled her leaching unseen and undetected from the outlet pipe of the nearby chemical plant into the surrounding sea that furnished the food for her village.[1]

Smith was a veteran photographer and photo-journalist who had seen it all – war, suffering, human courage, character and compassion, industry and politics – and depicted it in an epic series of photographic essays, many published in *Life* magazine over several decades. Aroused by growing evidence of the devastation being inflicted on ordinary people by chemical pollution, Smith and his wife Aileen moved in 1971 to the town of Minamata, Japan, following reports of a mysterious disease that had been afflicting its inhabitants since the mid-1950s, to document its impact in images and words. The disease was caused by methylmercury, a substance so poisonous it has no 'safe' level of

exposure, no matter how small the dose. It originated in discharges from the local chemical plant. Smith wrote:

> *The nervous system begins to degenerate, to atrophy. First, a tingling and growing numbness of limbs, and lips. Motor functions may become severely disturbed, the speech slurred, the field of vision constricted. In early, extreme, cases victims lapsed into unconsciousness, involuntary movements and often uncontrolled shouting. Autopsies show the brain becomes spongelike as cells are eaten away. It is proven that mercury can penetrate the placenta to reach the fetus, even in apparently healthy mothers.*[2]

The Smiths came for three months. They stayed three years and it almost cost the photographer his life. On 7 January 1972, barely a month after he captured the immortal image of Tomoko and her mother – later to be known as the 'Madonna of Minamata' – he accompanied a group of mercury-poisoning victims to cover a meeting arranged with a manager of the Chisso company which was responsible for running the chemical plant, and thus also for the mercury-laden discharges into local waters where they contaminated the marine food chain on which locals relied. The manager failed to show up. Smith later recounted:

> *But suddenly, a mob of workers rounded a factory building . . . They hit. They hit me hardest, among the first. The last exposure, bad, blurred, shows the man on the left, his foot at that moment finishing with my groin, reaching my cameras. The man on the right was aiming for my stomach. Then four men raked me across an upturned chair and thrust me into the hands of six who lifted me and slammed my head into the concrete, outside, the way you would kill a rattlesnake if you had him by the tail.*[3]

Battered and bruised, his cameras smashed, Smith survived but lost partial sight in one eye. It turned out to be his last assignment and he died in 1978.[4]

The bludgeoning of Eugene Smith showed the lengths to which some organisations and individuals were prepared to go

to block awareness of the effects of poisons discharged by their enterprises on the community. Despite such attempts to silence the truth, awareness has slowly spread, more so in some societies than others; more in some social strata than others. But the warning has spread neither far nor fast enough: today, most people still have barely an inkling of the universal chemical deluge to which they are now subject, daily, and of the growing peril that we – and all our descendants – face. If the dawn of that awareness for the educated publics of North America and Europe came with the publication of Rachel Carson's powerful book *Silent Spring* in 1962, where she revealed the impact of certain pesticides used in the food chain on wildlife and humans, then Eugene Smith's searing image of the *Madonna of Minamata*, transcending words and languages, was the shot heard round the world.

The subject matter of this book is plain, unvarnished science, as brutal in its facts as the fists and boots that fell on Eugene Smith. But it is the truth, insofar as any system devised by humans is able to determine and describe such things.

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Earth and all life on it are being saturated with chemicals released by humans, in an event unlike anything that has occurred ever before, in all 4 billion years of our Planet's story. Each moment of our lives, from conception unto death, we are exposed to thousands of substances emitted by our activity, some known to be deadly in even minute doses and most of them unknown in their effects upon our health and wellbeing or upon the natural world. These substances enter our bodies with each breath, with every meal or drink, the things we touch or encounter in our journey through each day. There is no escape from them.

Ours is a poisoned world, its system infused with the substances we deliberately or inadvertently produce in the course of extracting, making, using, burning or discarding the many marvellous products on which modern life depends. Relative to the span of human history, this has all happened quite quickly and

has burgeoned so rapidly that most people are still unaware of the extent or scale of the peril in which it places each of us and our grandchildren. Our present plight has crept up on us unseen, piecemeal, with infinite subtlety and frequent inadvertence, in a social climate of trusting acceptance of authority, over barely the span of a single human lifetime. The impacts are only now starting to emerge into full view – and the forming picture portrays a catastrophic risk to our future as great and as all-pervading as climate change, ecological collapse or weapons of mass destruction. A risk to be urgently understood and overcome using all the creative ingenuity humans have relied on for survival throughout our journey.

Knowledge of the toxicity of industrial chemicals is not new: the ancient Greeks and Romans were both familiar with the diseases caused by lead and mercury among those who worked with them, and with silicosis among miners.[5] In the eighteenth century, scrotal cancers were linked with the occupation of chimney sweep.[6] 'Phossy jaw', a disfiguring ailment among workers in matchstick factories in contact with white phosphorus, was first diagnosed in 1839.[7] Aniline dyes, made industrially from coal tar for fabric dyes, poisoned thousands of workers in the mid-nineteenth century – and still do to this day. Poison gases such as chlorine, phosgene and mustard gas – often made by the same factories and firms that produced the textile dyes – inflicted 1.3 million casualties in World War 1. In the twenty years following the discovery of radium by Marie Curie in 1895, a hundred medical workers died from radiation poisoning. Curie herself died, aged sixty-six, on 4 July 1934, of aplastic anaemia, probably caused by prolonged exposure to radiation: she was known to carry test tubes of radium around in the pocket of her lab coat. Asbestos-related cancers and diseases were first diagnosed in the early part of the twentieth century. Following rapid expansion of the coal and petrochemical industries during World War 2, a spate of large-scale industrial poisonings arose: the Great Smog of London, Minamata, Agent Orange, Seveso, the 'Silent Spring', the Love Canal, Bhopal, Dzershinsk, Tianjin, the Asian Brown Cloud and the

Great Pacific Garbage Pool. However, these were mainly viewed by governments and society as single, largely local, misfortunes, the result of corrupt or careless local companies and officials – not as the heralds of a Planetary pandemic.

In our world, something vast has changed.

Today human-emitted chemicals, their byproducts, mixture products and breakdown products, are everywhere, in all that we do. They are to be found in homes, offices and factories; on farms; in clothing, bedding and furnishings; in electronics and plastics; in cars, aircraft and ships; in the air we breathe and the water we drink; in construction and manufacturing industry; in pest control; and in the many products that we put onto or into our own bodies such as cosmetics, medicines, food, drink, tobacco and drugs, both legal and illegal.

Unlike our great-grandparents and all the generations before them, we are now immersed in these human-generated substances 24/7, no matter where we live: the chemical byproducts of modern industrial life have spread around the Planet and their fingerprints are to be found from the remotest poles to the abyssal oceans, from our living blood, to our grave, to the genes of our grandchildren.

In modern society the world over, synthetic chemicals are integral to our daily lives. There is no industry or activity of advanced civilisation where they are not used in some form or other, with the aim of improving our quality of life. They solve problems, protect, adorn, kill pests, save lives, improve efficiency and enhance convenience. An advanced society without such chemicals is almost unimaginable. They are a part of who we are – but in far more ways than most of us suspect. Figure 1.1 summarises the risks associated with common, everyday chemical-based products and services.

In 2018 the United Nations Environment Programme (UNEP) estimated the number of industrial chemicals in general commerce globally was between 40,000 and 60,000.[8] However, the United States Environmental Protection Agency (US EPA) listed more than 86,000 different chemical substances manufactured, used or being researched in the USA alone.[9] (The US chemical

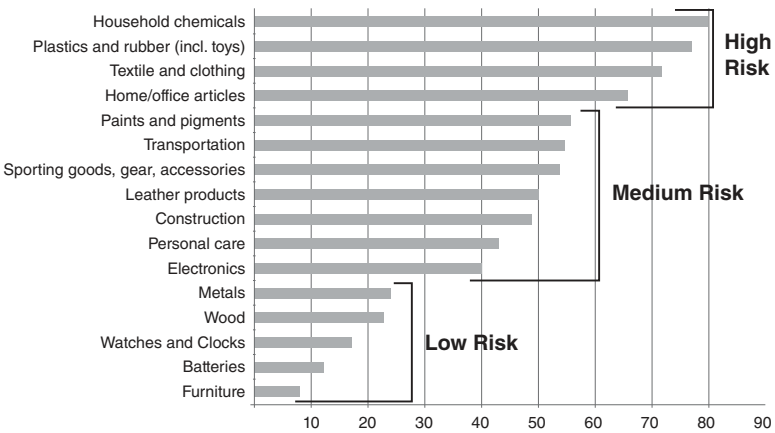

Figure 1.1. Risks associated with common chemical-based products in our daily lives. Source: UNEP.

industry denied this, claiming only 8707 chemicals were used in America.[10]) The US Agency for Toxic Substances and Disease Registry (ATSDR) estimated that 'more than 100,000 chemicals are used by Americans'.[11] The European Union (EU) stated that more than 106,000 chemical substances were used within in its member countries.[12] Furthermore, the EU assessed that almost two-thirds of the chemicals used pose a known health hazard. In China, the Chemical Inspection and Regulation Service (CIRS) listed 49,000 different substances used in the People's Republic, which has become the fastest growing and largest chemical producer in the world.[13] UNEP stated 'The exact number of chemicals on the global market is not known but under the pre-registration requirement of the EU's chemicals regulation, REACH, 143,835 chemical substances have been pre-registered. This is a reasonable guide to the approximate number of chemicals in commerce globally.'[14]

It turns out that all these well-intentioned efforts to quantify the scale of global chemical production were woeful underestimates. In 2020, an international scientific team, led by Zhanyun Wang of Switzerland's Institute of Environmental Engineering,

examined the chemical inventories of nineteen countries in Europe, North America, Oceania and part of Asia and concluded:

> *Over 350 000 chemicals and mixtures of chemicals have been registered for production and use, up to three times as many as previously estimated and with substantial differences across countries/regions. A noteworthy finding is that the identities of many chemicals remain publicly unknown because they are claimed as confidential (over 50 000) or ambiguously described (up to 70 000). Coordinated efforts by all stakeholders including scientists from different disciplines are urgently needed . . .*[15]

The total included 157,000 identifiable chemicals, 75,000 mixtures, polymers and substances of unknown composition, and 120,000 other substances that could not be conclusively identified. Besides revealing that manufactured chemicals far outnumber previous estimates, the world's first-ever attempt to compile a global chemical inventory also pointed to widespread secrecy, mis-identification and obfuscation.

However, even these formal registers cover only chemicals purposefully manufactured by industry. They do not include the far, far larger volumes of substances released directly or as unintended consequences of human activity in the form of construction, land development, farming, mining, mineral refining, energy generation, the use of machinery, deforestation, combustion, transport and other acts that put chemicals in places and concentrations where they would not otherwise naturally occur. And these do not include the millions of breakdown products derived from man-made chemicals, nor the daughter products they give rise to when interacting with other substances in our environment.

Together, these substances – purpose-made and unintentional, simple and evolved – have been entering our lives, our bodies and our living spaces largely unmonitored and, in many cases, undetected, in a rising global flood since the mid-twentieth century, when they first became commonplace. Purpose-made chemicals are thus the mere tip of the iceberg of

humanity's total chemical exposure resulting from our own activity.

Without being conscious of it, we poison ourselves every day, every moment of our lives.

Chemical Flood

Chemicals are a burgeoning enterprise – expanding at rates faster, indeed, than economic growth or the human population itself. UNEP anticipates the value of chemical production worldwide to grow from $5 trillion in 2017 to $10 trillion in 2030 and triple again in value by 2050 – a sixfold increase in barely thirty years.[16] The US ATSDR estimates that 'about 1,000 new chemicals are introduced each year'.[17]

The chemical industry is the second largest manufacturing activity in the world. Between 2000 and 2017, its output nearly doubled, from about 1.2 to 2.3 billion tonnes.[18]

Consequently, the UN commented: 'Trends ... suggest that the doubling of the global chemicals market between 2017 and 2030 will increase global chemical releases, exposures, concentrations and adverse health and environmental impacts unless the sound management of chemicals and waste is achieved worldwide.'[19]

Another way to see the issue is that humanity is being exposed to nearly 3 billion *additional* tonnes of man-made substances – including toxins, carcinogens, nerve poisons and hormone disruptors – every year. That's a third of a tonne of man-made chemicals for every child, woman and man on the Planet. This release is effectively cumulative, year on year, and is on track to triple to *one tonne per person* by the mid-century.

To give some idea of the overwhelming scale of this release, during the 'Agent Orange' defoliant campaign (1961–71) in the Vietnam War the total amount of herbicides released for every member of the exposed rural Vietnamese population per year was about 2.5 kilograms; this was subsequently linked to 400,000 dead or maimed and half a million birth deformities.[20] In contrast, citizens globally are now exposed to combined

annual emissions of around 325 kilograms of manufactured chemicals *each*.

These numbers are presented purely to give a sense of the scale of the chemical exposure of modern society. No comparison in toxicity is intended, since the overall toxicity of the chemical avalanche is unknown, so many substances never having been properly tested – and almost none of them tested in mixtures. However, while many of these chemicals are deemed harmless in single, small doses – it takes only a tiny quantity of a carcinogen to unleash a cancer – even harmless substances can recombine or break down to form toxic ones. Once used, chemicals never simply vanish. They or their constituents hang around and form new compounds or mixtures, both safe and deadly, in the living environment almost *ad infinitum* – an issue that has become horrifyingly apparent in the particular case of plastics.[21]

Nutrient Cascade

In addition to the 2.5 billion tonnes of manufactured chemicals produced and released each year, humanity also emits vast quantities of nutrients, soil particles, dust, gases and other substances unintentionally, through global agriculture, transport, energy production and manufacturing.

By far the largest part of this category of emissions consists of eroded topsoil, which is released chiefly by agriculture – especially mechanised cropping – forest removal and land clearing for development. Recent estimates of global soil loss range from 36 billion tonnes a year[22] to as high as 75 billion tonnes.[23] Thus, it requires the loss of from 4.5 to 10 tonnes of topsoil every year to feed each of us.

By eating we are now, effectively, devouring our Planet.

While soil is not usually regarded as a 'chemical', nevertheless its release on such a scale has vast biogeochemical impacts on the Earth, on waters and all life, including us. Soil consists of many chemical compounds, some of which are toxic – such as heavy metals or excessively acidic or alkaline minerals which

can foul water. Most of these can react with other substances they encounter in the environment, in both the short and long term, creating new products and causing local pollution hotspots or diffuse contamination. Soil loss also leads to dust storms, sedimentation and the silting of rivers, lakes and dams. It is linked with lung disease, allergies, infectious agents such as anthrax and TB and the pollution of drinking water. Above all it causes malnutrition, which leads to many forms of disease and death. On average, human activity is causing the world to lose its precious topsoil at rates from ten to forty times faster than it is naturally replenished.[24] This places the modern industrial food system on a path of no return.

Soil also contains vast quantities of nutrients, both natural and man-made – nitrogen, phosphorus, potash, essential minerals and micronutrients. For example, only 22 per cent of the world's 250 million tonnes of fertiliser made each year actually ends up being consumed as human food;[25] the rest becomes an environmental contaminant that either feeds weeds and algal blooms or pollutes waterways. The staggering volume of nutrients emitted in lost soil ultimately ends up fouling rivers, lakes, groundwater and the sea, where it has created more than 700 'dead zones' in the world's oceans, places stripped of their oxygen and so, largely devoid of life.[26]

Released on such a scale by humans, nutrients have become a dangerous contaminant of the Earth system and now greatly exceed the volumes that circulate naturally in it. Indeed, nitrogen pollution of the Earth's biosphere is now considered to have breached a boundary more perilous, even, than our release of carbon into the atmosphere.[27] A boundary which, in the opinion of the scientists, humanity ought never to transgress for our own safety.[28]

At the same time food production uses around 5 million tonnes a year of specialised poisons designed to control weeds, insects, rodents and moulds in the farming and food chain. Use of pesticides has thus grown tenfold since Rachel Carson warned the world about them in *Silent Spring* in the early 1960s. However, it is estimated that up to 98 per cent of these