Chapter 4

Reducing Our Toxic Burden

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In early December 2000, just three weeks after global talks on climate change reached a deadlock at the Hague, delegates ncgotiating a new global toxic chemicals treaty finalized a text that environmentalists and chemical industry representatives alike embraced. The treaty's primary goals are to ban 10 intentionally produced persistent organic pollutants (POPs) worldwide and to reduce emissions of two industrial byproducts, with the aim of eventually eliminating them. POPs are long-lived toxics that cause biological havoc as they bioaccumulate–collect and concentrate–in the food chain. The nine pesticides covered by the treaty had already been banned in at least 60 countries; one value of the treaty is that it sets up the process to expand that list.[1]

Signed in Stockholm in May 2001, the Convention on Persistent Organic Pollutants is one of the main environmental achievements in the decade since the 1992 Earth Summit in Rio. It outlines the key principles for a less toxic world, including the prevention of new toxic, persistent, bioaccumulative chemicals; the reduction of existing ones; substitution with less dangerous materials; and the great care needed with respect to all chemicals. Recent experiences in many industrial sectors and communities have shown that alternatives to toxics are available that not only protect human and environmental health but also improve the economic bottom line. They include unleaded gasoline, organic agriculture, bio-based industrial materials, and an overall reduction in consumption.[2]

Part of what is preventing these and other safer choices from becoming standard practice is the challenge of reframing how we think about toxic chemicals. In effect, we have based our collective well-being on a great deal of scientific ignorance and answers to the wrong questions. Instead of asking if a particular chemical is essential, we currently assume a certain amount of danger. The burden of proof for existing chemicals and many new ones now rests with public authorities and scientists who must prove something is harmful after it has been released and people can be exposed to it, rather than with chemical proponents who must prove a compound is safe over the long term. As structured, our current system puts the focus on which risks are acceptable rather than which are necessary and unavoidable. And what is considered acceptable changes over time, even within a few years, as scientific understanding evolves and society's values change.[3]

Officials at the Earth Summit were mindful of the need to protect people from accidental and routine exposure to thousands of hazardous chemicals. But the chemicals chapter of Agenda 21, the blueprint for change adopted at the conference, failed to address this adequately: it called on nations to promote chemical safety and information sharing, but offered little in the way of specific requirements to rid the planet of the most harmful compounds. The POPs treaty therefore represents an important milestone in international environmental law, not least because it applies to toxic chemicals management the "precautionary principle" – the rule that even in the face of scientific uncertainty, the prudent stance is to restrict or even prohibit an activity that may cause long-term or irreversible harm. (Agenda 21 adopted a less controversial position: the chemicals chapter suggested that countries adopt a precautionary approach to risk reduction where deemed appropriate.)[4]

Since Rio, serious and previously unexpected human health effects have emerged concerning, for example, damage to the body's key communications systems: the nervous system that sends messages through electric pulses and the endocrine system that sends messages chemically, through hormones. Moreover, irreversible health problems have recently been shown to occur at exposure levels below what we normally think of as safe. This new and rapidly changing body of scientific evidence poses a serious challenge to our current way of dealing with toxic chemicals and supports widespread application of the precautionary principle.[5]

But before we can step off the toxics treadmill, we need to understand where these chemicals come from and what they are used for. The distinction between naturally occurring metals and humanmade persistent toxins is an important one. Metals such as lead and mercury are found in Earth's crust combined with other elements, typically sulfur. These toxic metals do not degrade, so if we continue to mine the ore and extract the metals or release them as byproducts, they come back to harm us. "Synthetic" toxins, on the other hand, are not found in nature and are not fundamental to life (although sometimes it may seem like they are because they are found in everything from plastic wrap to computer terminals). Synthetic toxins, such as all the intentionally produced POPs, were created either by trial and error, by deliberate intent, or, in some cases, by accident. By looking at what they are used for, we can begin to determine if they are absolutely necessary or not.[6]

Even when there is widespread agrement on which compounds need to go–toxic heavy metals and POPs, for example–people often find few viable and cost-effective alternatives. The issue is not simply one of banning "the bad guys." It involves developing and then adopting safer materials, processes, and products into our economy. While there is progress in this direction, the challenge remains enormous and the window of opportunity to change the way we use toxic chemicals and to prevent long-term environmental and health damage will not remain open for long.

The Chemical Economy

The chemical economy is one of the largest and most diverse industrial sectors in the world. Each year, tens of thousands of individual chemical compounds are produced and serve as the feedstock for countless industries, as the basic ingredients for virtually every consumer product manufactured today, and as the basis for such products as cleaning agents and pesticides. (See Table 4-1.) By 1998 (the most recent year with data), global sales of all chemicals totaled nearly $1.5 trillion, making the sector about twice as large as the global market for telecommunications equipment and services.[7]

Not surprisingly, the chemicals manufacturing sector has a major influence on the health of the global environment. In 1998, for example, the industry accounted for nearly 10 percent of world water use and 7 percent of world energy use. (Energy inputs, such as oil and natural gas, are used both as a source of fuel and as a feedstock material.) While this is considerably less than agriculture's thirst for water, the global chemicals manufacturing industry consumes 21 percent more water each year than all household water users.[8]

Quantifying the global toxic burden is difficult, given the incomplete picture of the life cycle of thousands of chemicals. Only a few countries measure toxic emissions, and these data are limited in scope. In 1999, for example, the U.S. chemicals manufacturing sector ranked third in terms of toxic emissions, behind metal mining and electric utilities, according to U.S. Toxics Release Inventory (TRI) data. Yet only large manufacturers are required to report, and the current list of 650 chemicals does not cover all toxic chemicals or sources, or emissions during use and disposal. According to the World Bank, the chemicals and plastics manufacturing sectors are among the most intensive in terms of toxic air pollutants. (See Figure 4-1.) (The global ship building and repair industry is the most intensive, emitting about five times more toxics to air than the chemical manufacturing sector.)[9]

Table 4–1. Global Chemical Output by Sector, Value, and Share of Total, 1996

Sector	Value	Share of Total
	(billion dollars)	(percent)
Basic industrial chemicals	360	26
Pharmaceuticals	305	22
Plastics, resins, and synthetic resins	235	17
Soaps and toiletries	160	12
Other chemicals	131	10
Fertilizers and pesticides	90	7
Paints and varnishes	79	6
Total	1,360	100

SOURCE: Organisation for Economic Co-operation and Development, *OECD Environmental Outlook for the Chemicals Industry* (Paris: 2001), p. 112.

Moreover, the quantity of materials produced and used gives no indication of its potency. To bring in this year's agricultural harvest, for example, farmers worldwide will apply something on the order of 2.5 million tons of pesticides, the overwhelming majority of which are synthetic organic chemicals that are orders of magnitude more toxic than 50 years ago. Just as we have no concrete measures of our cumulative environmental burden of toxins, neither do we know the relative safety or danger of most chemicals in use. There are no basic health and environmental data for 71 percent

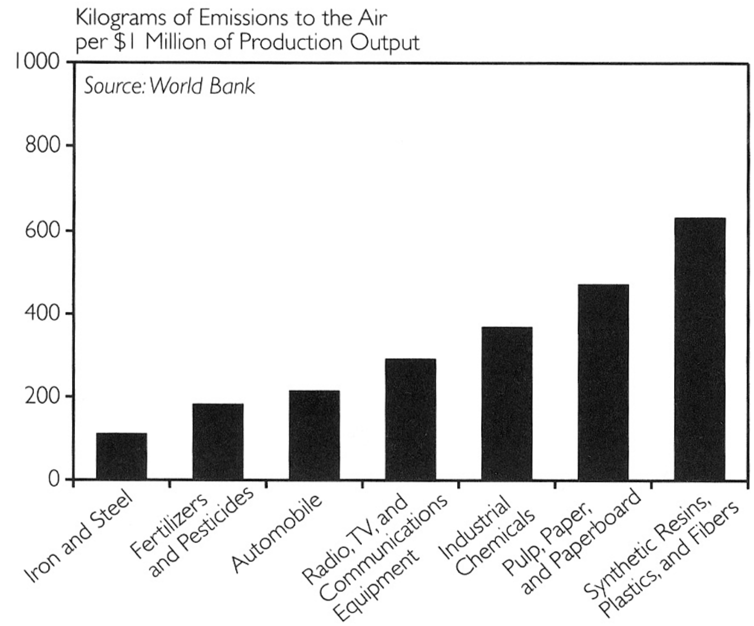


Figure 4–1. Toxic Intensities of Selected U.S. Manufacturing Sectors, Early 1990s

of the most widely used chemicals in the United States today, and less than 10 percent of new chemicals reviewed each year under premarket notifications having adequate test data on health effects. Meanwhile, chemical production keeps growing–it is expected to soon grow faster than the global economy. (See Figure 4–2.)[10]

Much of the expansion in chemicals production and use is now occurring in developing countries, in part because companies in traditional producing nations (primarily industrial countries) are shiftting away from commodity chemicals, which are a mature market, toward speciality chemicals, which is a less cyclical business and has a higher profit margin. But several changes within developing regions are also contributing to the global realignment of the industry from North to South, including the growth in domestic demand, low labor costs, and expanding chemical-dependent sectors.[11]

Polyvinyl chloride (PVC) plastic provides a telling example. Every stage of its life cycle–from manufacture to disposal–creates dangerous chemicals, including some POPs, while toxic additives are used to stabilize the matrial and add flexibility. Nearly 25 million tons of PVC were produced in 1999. This material now has a constant presence in every channel of the global economy. Overall, production is accelerating, with much of the growth expected in Asia, where rapidly expanding cities are built with PVC building materials and filled with consumer goods made from PVC and other plastics.[12] Similar trends are evident in the chemically intense pulp and paper sector. Some 40 percent of the world's pulp supply is bleached with chlorine compounds. A large share of these are based on elemental chlorine, a process that creates up to 35 tons of chlorinated byproducts a day per industrial scale facility, as opposed to almost none for chlorine-free bleach methods based on hydrogen or oxygen. In 1998, the world volume of paper production was 294 million tons, more than a sixfold increase since 1950. It is expected to increase by another one third by 2010. Countries in Asia and Latin America are rapidly boosting their pulp production, eager to tap into lucrative

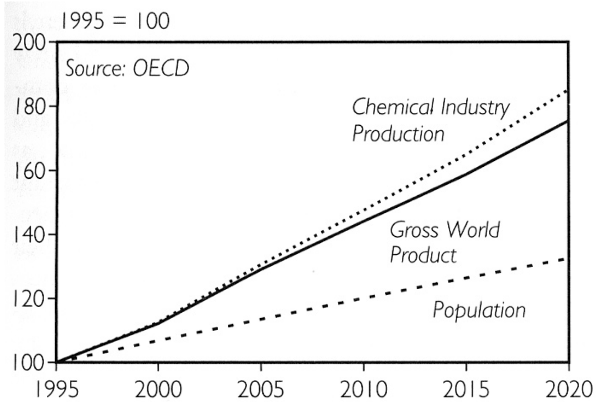


Figure 4–2. Projected Growth in World Economy, Population, and Chemical Production, 1995–2020

trade markets. In the next few years, Asia's paper and pulp output will likely surpass that of North America, making that region the world's top producer."

Growth in these and other chemically intense industries promises to bring not only desperately needed jobs and export earnings, but also significant environmental liabilities. And as these activities expand in developing countries and economies in transition, which often have minimal capacity to monitor toxic contamination from persistent and mobile pollutants–let alone contain and reduce it effectively–global contamination could become much worse in the years ahead.[14]

In addition to releasing toxic compounds, industries producing PVC plastics and pulp and paper consume chemicals, and thus help propel the growing demand for existing and new chemicals. Part of the reason that these industries use so many chemicals is simply that all modern industrial production follows this pattern. But the demand of these industries for chemical inputs also results from deliberate–and successful–efforts by others to create markets for unwanted synthetic chemicals. Producers of materials such as petroleum have intentionally created markets for byproduct chemicals to reduce waste and make money. Each year, petroleum refineries create literally tons of highly toxic byproducts including benzene, ethylene, and propylene. Over time, these were developed as chemical sources for secondary processing and manufacturing industries, most notably plastics manufacturing.[15]

Of course, recycling materials and closing the production loop are basic concepts in "industrial ecology," a new discipline that tries to model industrial processes on the efficiencies found in nature, in order to minimize waste and pollution. But in some cases, these principles have been applied to their extreme, essentially creating a justification for the continued production of toxic materials.[16]

Chlorine is the classic example of a chemical byproduct that was marketed as the basis for entirely new branches of industrial production. Because it is highly reactive, chlorine has a strong affinity for organic (carbon-based) compounds. (In nature, chlorine is almost never found alone in its elemental state-it normally binds with sodium or carbon.) Combined with an organic molecule, chlorine often imparts stability and persistence, making the resulting compound likely to bioaccumulate. Because of its versatility, chlorine is the basis for thousands of synthetic chemicals. About 60 percent of the final products in the chemical industry involve chlorinated chemicals at some stage of production. Initially generated as an unwanted byproduct of caustic soda (which is used in manufacturing pulp, paper, and soaps, among other things), chlorine has been hailed by W. Joseph Stearns of Dow

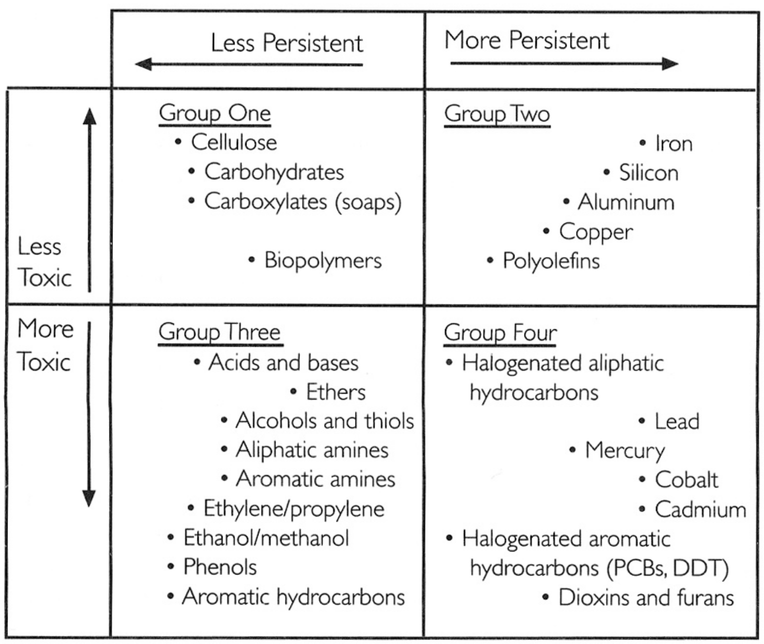
Chemical as "the single most important ingredient in modern [industrial] chemistry."[17]

Many compounds–including the thousands that contain chlorine–are both innocuous and valuable for commerce and medicine. The challenge is to identify and regulate the most dangerous ones. At the moment, scientists do not even know how many dangerous ones exist. Estimates vary from dozens to hundreds. Despite the ubiquity of synthetic chemicals, many compounds have never been tested for basic health impacts, such as toxicity, let alone for bioaccumulative or persistent properties.[18]

There are, however, some clear choices for elimination among the thousands of chemicals on the market today. (See Figure 4-3.) Based on the degree of persistence and toxicity, high-priority chemicals include dioxins and furans (both POPs), chlorinated pesticides, and polychlorinated biphenyls (PCBs), along with mercury, lead, and a few other heavy metals. Other toxic compounds–including organic solvents and organophosphate pesticides–are not as harmful as POPs, but they are important from public health and ecological perspectives because of the harm they pose on their own or in reaction with other substances and because the lessons they offer for phasing out toxics.[19]

Old Metals, New Threats: Lead and Mercury

Metals are different from other toxic substances because they are naturally occurring, albeit trace elements in Earth's crust. They cannot be created or destroyed. Once emitted, they can reside in the environment for hundreds of years. Natural forces such as volcanoes, forest fires, and ocean tides cycle metals through the environment. But humans also play an important role and, in many cases, a larger role than nature. By influencing the rate of release and transport of metals through the environment and by altering their biochemical state, humanity has increased by several orders of magnitude the emissions of and its own exposure to toxic heavy metals. In particular, the stories of lead and mercury–two



Source: Geiser

Figure 4–3. Industrial Materials Groups

potent neurotoxins (compounds that harm the nervous system)–demonstrate the scale of contamination, the resulting human and environmental health problems, the difficulties of addressing such releases, and, especially in the case of lead, the enormous health and economic benefits of reducing usage.[20]

Emissions of lead date back at least 8,000 years, to the first lead-smelting furnace. During the nineteenth century, large-scale coal combustion released significant quantities of mercury (a common contaminant in coal) into the atmosphere, while the use of large quantities of mercury to amalgamate gold and silver dates back at least to the sixteenth century in Latin America. Despite our long history with these two elements, the twentieth century brought enormous change to the relationships. Metals consumption in the United States jumped sixteenfold between 1900 and 1998, compared with a tripling in the use of wood products. At their peak in the mid-1980s, global atmospheric releases from human activities exceeded natural sources by a factor of 28 to 1 for lead and 1.4 to 1 for mercury.[21]

The use of leaded gasoline throughout much of the last century boosted global lead levels to unprecedented heights. In 1924, three U.S. companies – General Motors Corporation, Du Pont Chemical, and Standard Oil – formed a separate company known as Ethyl Corporation solely for the purposes of producing and selling tetraethyl lead (TEL), a compound that reduced the audible "knocking" sound in cars during fuel combustion and was supposed to improve overall engine performance. Well before the additive was marketed, company and government officials knew of its dangers but assumed they could control its release in factories and protect workers. Moreover, because TEL dissipates easily, many assumed it would never cause any significant environmental or public health problems.[22]

Despite several initial setbacks, including a challenge by the U.S. Surgeon General in 1925, the Ethyl Corporation aggressively pushed TEL onto U.S. and eventually world gasoline markets. The company favored TEL because it could patent the compound–as opposed to ethanol, a more effective and less polluting compound, but one that anyone could make. Leaded gasoline went on to become the global standard for decades. Between 1926 and 1977, U.S production of TEL increased from 1,000 tons to 266,000 tons per year. With widespread use of leaded gas came a parallel rise in global contamination. In Japan, airborne lead emissions increased about a thousandfold from 1949 to 1970. Today, TEL is responsible for some 90 percent of airborne lead emissions in developing countries .[23] ,

Quite literally, the legacy of the Ethyl Corporation and other manufacturers that deal with lead is written in human blood: the average person today carries levels of lead that are 500-1,000 times higher than our preindustrial ancestors. Lead is now found in all living things and throughout the environment. (Unlike copper or iron, free lead was virtually nonexistent in the precivilization biosphere, which meant that humans and other species had no opportunity to evolve a natural defense to it.)[24]

But the story of TEL does not end at the tailpipe. In the process of solving a noise problem, burning TEL created a corrosive byproduct that ruins the engine. So in order to get the lead out of the engine and into the atmosphere as quickly as possible, scientists added another toxic compound, ethylene dibromide (EDB), to leaded gas. When EDB is burned it produces methyl bromide, a developmental toxin and potent ozone–depleting substance. Indeed, the World Meteorological Organization has identified automobile exhaust from leaded gasoline as one of the top three sources of methyl bromide.[25]

By the 1970s, countries as varied as Brazil, the Soviet Union, Thailand, and the United States began to phase out leaded gas, although often for reasons unrelated to the health effects of TEL and EDB. Brazil, for example, switched from gas to ethanol in an effort to reduce its dependence on foreign oil and save the national currency from collapse. The Soviet Union diverted high-octane, leaded fuel to the military during the cold war, leaving little choice for Russian consumers. And beginning in 1975, the United States required automobiles to have catalytic converters to reduce carbon monoxide and other hazardous air pollutants from vehicular emissions. As with older engines, leaded gas was incompatible with this new technology.[26]

The list of countries that have banned leaded gasoline continues to grow.

The list of countries that have banned leaded gasoline continues to grow. And although 100 or so countries still use leaded gas today, some have reduced the lead content and others have begun to introduce unleaded gasoline as an alternative. All told, some 80 percent of the gasoline sold today in the world is unleaded. [27]

As the markets for leaded gasoline declined, the Ethyl Corporation and other manufacturers faced significant profit losses. As early as the 1970s, the industry turned its attention to a manganese-based compound (MMT) that also had antiknock properties and enhanced gasoline octane. Although the U.S. Environmental Protection Agency (EPA) argued against its use until basic health tests were done, and although the American Automobile Association warned that its use would damage catalytic converters, in 1995 a U.S. federal court allowed Ethyl Corporation to introduce MMT, claiming it was not in EPA's jurisdiction to ban MMT on health grounds. (At high doses, manganese is extremely toxic and causes nervous disorders and symptoms of Parkinson's disease; at low, airborne doses, its effects are unknown.) Since 1977, MMT has been widely added to gas sold in Canada. Most U.S. companies now avoid it, however, because of public health concerns. As the story of tetraethyl lead in gasoline and the related bromide and manganese-based compounds illustrates, novel applications of chemicals can create new, unforeseeable problems, which then prompt chemical producers to offer "solutions" that in turn create their own problems.[28]

People have been exposed to and poisoned by lead in many other sources in addition to gasoline. Lead has been added to ceramic glazes, paints, electronics, batteries, and other products that emit it to varying degrees when they are burned or otherwise disposed of Some applications are problematic during routine use: Lead in pipes leaches into water supplies, which happened as long ago as during Roman times, whereas lead-based paint can peel off walls, doors, and window frames and become a deadly meal of dust for curious children. Children are at special risk from mercury, lead, and other toxins because they "eat, drink and breathe three to four times as much per pound of body weight as adults do," according to Richard Jackson, Director of the U.S. Centers for Disease Control and Prevention's National Center for Environmental Health. [29]

These other uses are not insignificant. Worldwide, for example, tens of thousands of tons of lead (as well as other toxic metals) are added to PVC each year to stabilize it at high temperatures. In North America, lead is now only added to PVC wire and cables, but in Europe it is still used in rigid applications, such as pipes, where it can leach into water.[30]

While turning to unleaded gasoline, many countries have also improved waste incineration and wastewater treatment technologies and reduced the use of lead in paint, batteries, and other sources. Consequently, global lead emissions dropped two thirds from the mid-1980s to the mid-1990s. (See Table 4-2.) Although annual emissions have dropped, a huge reservoir of dispersed lead must still be dealt with. Global mercury emissions have followed a similar path in recent years, but the situation in developing countries is worsening.[31]

The primary human-based sources of mercury today are coal burning and solid waste disposal, both of which are increasing in many regions. (Another main source, the mercury cell method of industrial chlorine production, has been declining for many years.) Asia now accounts for about half of the world's annual mercury emissions from human activities, in large part because China and India burn about one third of the world's coal. Between 1990 and 1995, mercury emissions in Asia jumped 26 percent. Several hundred million Chinese regularly heat their homes and cook in unvented stoves, exposing family members to high doses of mercury as well as arsenic, fluorine, and other contaminants. Exposure to mercury and other toxics comes from polluted air and water, but in fact we absorb most persistent bioaccumulative toxics in our food. Mercury illustrates this point.[12]

In its inorganic state, mercury is a common but poorly absorbed compound. In its organic form, however, methyl mercury is both very toxic and easily absorbed by fish, birds, and humans. By unfortunate coincidence, bacteria commonly found in polluted waters readily convert inorganic mercury to its more dangerous organic state, bringing it directly into the aquatic food chain. What are often dismissed as inconsequential environmental discharges of inorganic mercury are easily transformed into methyl mercury and carried up the food chain, where the mercury is concentrated hundreds and thousands of times over. Some 2,200 tons of mercury are emitted

Table 4–2. Global Atmospheric Emissions of Lead and Mercury by Major Industrial Source, Mid–1990s, with Decline Since 1983

Source	Lead	Mercury
	(tons per year)	
Vehicular traffic	88,739	-
Stationary fossil fuel combustion	11,690	1,475
Nonferrous metal production	14,815	164
Iron and steel production	2,926	29
Cement production	268	133
Waste disposal	821	109
Other		325
Total emissions, mid-1990s	119,259	2,235
Change since 1983	- 64 percent	- 37 percent

SOURCE: Jozef M. Pacyna and Elisabeth G. Pacyna, "An Assessment of Global and Regional Emissions of Trace Metals to the Atmosphere from Anthropogenic Sources Worldwide," Environmental Reviews (in press).

from human activities each year, while as little as one seventieth of a teaspoon is enough to contaminate a 25-acre lake for a year.[31]

One indicator of the growing environmental burden of methyl mercury is the number of fish consumption advisories issued by governments. (An advisory is issued when officials find concentrations of a contaminant in local fish at a level that may pose a risk to the public or to groups at high risk, such as young children, the elderly, or the fetuses of pregnant women.) In the United States, the number of mercury advisories for noncommercial fish increased more than one and a half times between 1993 and 2000. Almost 80 percent of fish advisories issued by state officials now appear at least in part because of high levels of mercury. In February 2001, the U.S. Food and Drug Administration warned pregnant women not to eat any top marine predators, including swordfish and shark, because of mercury. Based on studies from the Faroe Islands and New Zealand, people who rely on fish for a large share of protein in their diets are especially at risk of mercury contamination. And in communities near gold mines, high mercury levels in the food chain have become a fact of life. (See Box 4-1.)[34]

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Mercury's impact on human health is well documented, unfortunately, because so many people have become ill after being exposed to it. As early as the eighteenth century, workers who used mercury to make felt hats from beaver pelts suffered from tremors, hallucinations, delirium, and other signs of mercury poisoning, which gained a reputation as "mad-hatter's disease." In the 1950s, large industrial discharges of mercury into Japan's Minimata Bay killed hundreds of people and left epidemiologists with a tragic record of the workings of this powerful neurotoxin. Children born after the initial incident suffered from cerebral palsy, mental retardation, and severe brain defects, and some adults became afflicted with a wide range of neurological disorders, including tremors, paralysis, blindness, and deafness. More recently, researchers have found that when low levels of methyl mercury strike at key points in fetal and childhood development – as opposed to repeated occupational exposure or large industrial releases– they can slow brain development significantly, prompting loss of cognitive skills and other effects.[35]

Demonstrating the links between the trends in the production of these toxins and the trends in human illness is difficult, but one thing is clear: efforts to reduce exposure to lead, a powerful neurotoxin, have paid off. Since 1976, blood lead levels of American adults have dropped, on average, more than 75 percent and those of children, more than 85 percent. This means that, on average, each American child born today has gained five IQ points over children born a generation ago, a gain that is quantified as being worth about $45,000 over the course of a lifetime (measured in terms of cognitive ability, memory, and educational achievement).[36]

But this good news is tempered by the reality that averages do not translate into equal gains for everyone. Research from places as varied as Mexico City, the Cape Province of South Africa, and Rhode Island shows that socioeconomic factors are important indicators of high blood lead levels, especially among children. Approximately one out of three inner-city

BOX 4–1. GOLD MINING'S TOXIC TRAIL

Since the early 1980s, when the price of gold reached its all-time high, hundreds of thousands of small-scale miners or *garimpeiros* have flocked to the rainforests of Brazil, Venezuela, Guyana, and neighboring countries in search of this precious metal. In the Amazon, as in southern Africa, the Philippines, and other gold mining regions, small-scale miners use the same age-old formula to extract gold from earth and rock They pour mercury over crushed ore that they have dredged from riverbeds or mountainsides, believing the sediments may contain gold. They press out the excess mercury with their hands, and then burn the mixture in order to evaporate the rest of the heavy metal. The lucky few are left with a few grains of gold; almost all will have inhaled or absorbed some mercury in the process.

Not surprisingly, many miners and their families have extremely high levels of mercury in their bodies. Tests conducted on the Wayana Indians in French Guiana revealed that 57 percent of subjects had mercury concentrations two to three times higher than World Health Organization (WHO) standards. Studies from Venezuela and the Brazilian Amazon show similar results. Other residents of the region may be exposed to mercury by eating fish-an important part of the diet of most native peoples in the Amazon-containing mercury in its highly toxic form, methyl mercury.

It is believed that since the 1980s, Amazon garimpeiros have produced between 80 and 100 tons of gold annually. Mining this gold sends roughly 100 tons of mercury into the Amazon and another 100 tons into the atmosphere each year-accounting for about 8 percent of annual emissions of mercury from human activities. Metals mining is a leading polluter globally. In the United States, for example, it is responsible for nearly half of the toxins released by industry. In 1999, U.S. mines sent nearly 4 billion pounds of toxic pollutants such as mercury, lead, cadmium, and cyanide into the environment

– Payal Sampat

SOURCE: See endnote 34.

African-American children today has elevated blood lead levels that are, on average, 80 percent higher than the U.S. figure for all children. (Lead poisoning persists in poor communities in part because the houses tend to be older and in disrepair, and frequently still have lead-based paint.)[37]

Other factors, such as proximity to highways and nutritional status, also contribute to the gross inequities in lead exposure and poisoning. Children living in rapidly expanding urban areas of China, for instance, have blood lead levels up to four times as high as the average level for American children in the 1970s, when it was at its peak. One in five children in Beijing carry more lead in their blood than is considered safe by the World Health Organization. In one district of the Chinese capital, 80 percent of children had readings above the unsafe level. Almost universally, lead exposure is worse in developing countries. People who live in Dhaka, Bangladesh, for example, breathe air that has the highest atmospheric lead levels in the world. And in Africa, much of the gasoline sold today contains among the highest levels of lead in the world."

Although it has been 10 years since WHO described gasoline-based lead poisoning as "one of the world's worst environmental problems," this assessment remains true today. Given current rates of industrialization, the continuing use of leaded gasoline in some countries, rapid growth in vehicle production and road-building, and the persistence of lead in the environment, childhood lead poisoning and exposure among adults will continue to be an enormous global public health problem for many years to come. Almost universally, the urban poor will continue to bear the brunt of this health crisis.[39]

While most health professionals recognize the need for a global phaseout of leaded gas to improve public health, we have only begun to think in global terms with respect to mercury. The Governing Council of the U.N. Environment Programme (UNEP) recently called for an assessment of mercury to be completed by 2003. At the same time that we are gathering information, scientists are finding that the effects of mercury–like lead–will be with us for a long time. Gold mines operating in Nova Scotia from 1860 until 1945 produced some 3 million tons of tailings (mine waste), which include mercury as well as arsenic, cadmium, copper, iron, and thallium. Scientists recently tested lake sediments downstream of the mine and found that there is still "no evidence of [a] downturn" in contamination levels, despite the 50 years that have passed since the mines were closed.[40]

POPs and Precaution

Most chemicals are now tightly regulated under environmental laws, usually in terms of exposure limits for air, water, or soil. In contrast, regulatory approval to introduce chemicals is less stringent. "Like the science that informs it, the process of regulation has taken a reductionist approach; seeking chemical by chemical solutions; focusing on too few [biological] outcomes; neglecting additive, cumulative, and synergistic effects; and allowing balkanization of regulatory authority," according to Sheldon Krimsky, a professor of urban and environmental policy at Tufts University. It is no wonder that we are only beginning to discover how everyday chemicals, assumed to be relatively harmless–indeed, safe–are in fact jeopardizing our health and quite possibly that of generations to come. (See Table 4-3.)[41]

Consider PVC plastic: in addition to the problems associated with stabilizers such as lead, a majority of the additives that give this material its range of flexibilities belong to a group of compounds called phthalates. Because they are not chemically bonded to the resin (raw plastic), they can migrate to the surface and leak into the surrounding environment. Under particular conditions, some commonly used ones persist and bioaccumulate. In wildlife and laboratory animals, phthalates have been linked to a range of reproductive health problems, including reduced fertility rates, miscarriages, birth defects, abnormal sperm counts, and testicular damage, as well as liver and kidney cancer.[42]

Hospital patients receiving blood infusions have been shown to be at risk of exposure to a commonly used phthalate known as DEHP, which can leach directly out of intravenous tubes and into a patient's bloodstream. Adults who receive one or two transfusions are not believed to be in danger, but critically ill patients, such as premature babies, who require life-saving procedures are exposed to "very, very high doses," according to a researcher at Boston's Children's Hospital Medical Center. The U.S.-based National Toxicology Panel recently concluded, "there may be no margin of safety" with respect to DEHP.[43]

Recently, scientists at the U.S. Centers for Disease Control and Prevention detected

Table 4-3. Chemicals by Health Effects

Health Effects	Main Chemicals
Cancer	arsenic, benzene chromium, vinyl chloride *probable:* acrylonitrile, ethylene oxide, formaldehyde, nickel, perchloroethylene, PCBs, PAHs, metals, other endocrine disrupters
Cardiovascular diseases	arsenic, cadmium, cobalt, lead
Endocrine disruption	aldrin, aluminum, atrazine, cadmium, clichlorvos, dieldrin, dioxins, DDT, enclosuffan, furans, lead, linclane, mercury, nonylpherols, plithalates (including DEHP), PCBs, styrene, tributyltin, vinyl acetate
Nervous system disorders/ cognitive impairment	aluminum, arsenic, benzene, ethylene oxide, lead, manganese, mercury, many organic solvents
Osteoporosis	aluminum, cadmium, lead, selenium
Reproductive effects (such as birth defects and miscarriages)	arsenic, benzene, benzidine, cadmium, chlorine, chloroform, chromium, DDT, ethylene oxide, formaldehyde, lead, mercury, nickel, perchloroethylene, PCBs, PAHs, phthalates, styrene, trichloroethylene, vinyl chloride

SOURCE: European Environment Agency, Europe's Environment 1998 (Copenhagen: 1998), p. 122; Kenneth Geiser, Materials Matter: Toward a Sustainable Materials Policy (Cambridge, MA: The MIT Press, 200 1), p. 130; Francoise Brucker-Davis, "Effects of Environmental Synthetic Chemicals on Thyroid Function," Thyroid, vol. 8, no. 9 (1998), pp. 829-3 1; "Agency Attacked Over Endocrine Disruptors Strategy," ENDS Report March 2000, p. 39.

plithalate metabolites (breakdowm products) in the urine of women of childbearing age. DBP, a plithalate used in perfumes, cosmetics, and other health care products marketed almost exclusively to women, was most commonly reported. Although this compound is not known to cause reproductive problems, others that are known offenders were also found in the general U.S. population, proving that exposure is far more common than previously suspected.[44]

The clearest and most undisputed body of evidence showing the ability of synthetic chemicals to disrupt the glands and hormones that make up the endocrine system comes from more than 100 species of mollusks (mussels, oysters, snails, and other shellfish), which have suffered worldwide population declines and, in some cases, complete disappearances because of the reproductive and hormone-disrupting effects of tributyltin (TBT). TBT, a form of organic tin, was first introduced in the mid 1960s as an additive in marine paint that was 10-100 times better than copper at fending off algae, barnacles, and other "fouling" organisms that cause structural damages to ships and slow them down in the water.[45]

Within a few years of the first use of these anti-fouling paints, shellfish in northern European waters began to develop an irreversible condition known as imposex, which leaves the species unable to breed normally. By 1981, scientists had established the link between reproductive toxicity and TBT paints, based on tests in and around marinas and harbors. Residues of TBT have been found in bottlenose dolphins and bluefin tuna, animals that are high on the aquatic food chain, showing that TBT is a bioaccumulative compound.[46]

Several countries have since banned TBT paints from vessels, particularly smaller, recreational boats that tend to spend more time in harbors and close to coastal areas. But this paint is still used on larger, oceangoing vessels. In October 2001, the International Maritime Organization adopted an international convention that will ban TBT and related compounds in marine paints.[47]

As this example suggests, endocrine disruption is potentially "a far more serious health problem than cancer," according to Dr. Terry Collins, a professor of chemistry and an expert in "green chemistry" (the scientific field that focuses on detoxification) at Carnegie Mellon University. There are at least four reasons for this. First, the animal or person often looks and appears healthy even while suffering the effects of reproductive, neurological, or immunological toxicity, so simple identification of the problem is difficult. Second, frequently there is a long time lag between exposure and effects, so it is difficult to predict–and prevent-such effects until it is often too late. Third, the effects of some chemicals, like TBT, cannot be predicted on the basis of the compound's chemical structure alone, making it difficult to screen chemicals and identify which ones may be endocrine disrupters. Fourth, many of our current regulatory limits are based on screening for cancer and other health effects from high doses. But because endocrine disruption can occur at low exposure levels, these compounds can slip below the regulatory radar screen and often are perfectly acceptable under our current regulatory definition of what is deemed safe for human health.[48]

Despite extensive counter-studies from industry-supported groups in the United States and Japan, a panel of scientific experts recently concluded that "estrogenic chemicals can cause biological effects at levels below those normally found safe," according to a report in Science. Lab tests even found damages to the reproductive organs and the neurological and immune systems that were absent at higher doses. Given mounting evidence of human reproductive and developmental problems-including declining sperm counts, rising rates of testicular cancer and other male reproductive disorders, increasing incidence of breast cancer, earlier ages of puberty among young girls-these findings regarding low doses in lab animals suggest that environmental factors, including exposure to endocrine-disrupting chemicals, may be to blame in causing such problems in people.[49]

As evidence of toxic and environmental damage mounts, the list of suspected PON will grow and make the initial "dirty dozen"-10 pesticides plus dioxins and furans, the unintentional byproducts of combustion and other industrial and natural practices-look like easy targets. The challenge of pinpointing which compounds might be persistent organic pollutants and then proving they need to be banned is a task that quickly becomes complicated and costly. Adding to the challenge is the fact that long-term risks are not created solely by metals and POPs. Depending on the circumstances of their production and use, other chemicals may create long-term problems, even if they are not called POPs.

Chlorinated solvents, for example, are generally not persistent enough to qualify as POPs, yet many of them are quite toxic: they have been linked to miscarriages, infertility, kidney and liver cancer, and various immune system disorders. A recent study showed that women who regularly worked with organic solvents (such as factory workers, lab technicians, and graphic designers) had a thirteenfold higher chance of having a child with a major birth defect than did mothers in other occupations. Some chlorinated solvents are now effectively considered POPs by certain regional agreements, notably the 1992 OSPAR Convention for the Protection of the Marine Environment of the Northeast Atlantic. (While they may not be persistent, they may degrade into other toxic substances that are much more stable.)[50]

Another complication in identifying chemical culprits is that people are routinely exposed to mixtures of compounds that can react in unexpected ways. Researchers from the University of Wisconsin looked at the combined effects on mice of two pesticides and one fertilizer commonly used on U.S. farms-aldicarb, atrazine, and nitrate. Although one of these compounds alone did not trigger a significant change in the level of thyroid hormones, a similar concentration of a mixture of the three contaminants altered thyroid levels enough to trigger behavioral, endocrine, and immune changes.[51]

In formulating so-called safety thresholds, we invariably focus on–and get bogged down in a debate over–how much of a toxic material to use and release according to a highly politicized process of setting such Limits. While the debates are usually based on the best available science, the science itself-because it is highly uncertainbecomes politicized and subject to delay as interested stakeholders question its methods, assumptions, and motives rather than weighing what is best for the economic bottom line of certain companies against what is needed to protect human and ecological health. Designing better regulations, while important, is an inadequate long-term response to persistent, bioaccumulative toxins. Because of the high stakes involved, these compounds require a new way of thinking about and producing materials, which is nothing short of a chemical revolution. Instead of asking ourselves how much harm we should allow, we should focus on preventing as much harm as possible .[52]

The Changing International Field

Prompted by rapidly emerging scientific evidence and heightened public awareness, the global community has moved far beyond the goals laid out in Rio for chemical safety. Indeed, we have begun to question–and, in some cases, reject–the long-held presumption of innocence for toxic chemicals and called for a higher standard of proof, a standard based on necessity and informed consent rather than convenience. With the Stockholm Convention on POPs now open for ratification and funding available on an interim basis, politicians, business leaders, health officials, environmentalists, and concerned citizens have an enormous opportunity to embrace the precautionary principle and rewrite the human relationship with toxic chemicals. While treaties alone will not get rid of toxic chemicals, they can help create a level playing field and spur the technical and financial transition that is needed to move the world away from these chemicals.[53]

The Stockholm Convention has many notable features, including provisions to "turn off the tap" on new and existing POPs; the option for countries to require–not simply promote-substitute materials, products, or processes; and a broad commitment to the precautionary principle. Parties to the treaty will examine any new pesticides and industrial chemicals "with the aim of preventing" additional persistent organic pollutants. Governments are also obligated to screen existing chemicals and reduce the use and release of those with the characteristics of a POP. Perhaps more profoundly, they must promote "the best available technology" and "best environmental practices" with respect to a number of major industrial sources, including oil refineries, paper and pulp mills, metal processing plants, and all types of waste incinerators. Although such technologies and practices have not yet been specified by the Conference of the Parties, these features will help change social behavior "down to the level of how municipalities deal with their trash," according to the treaty Chair, John Buccini.[54]

Richer countries have a special responsibility not to externalize their pollution costs via exports.

In an important compromise, the treaty allows countries to continue using DDT, one of the "dirty dozen" chemicals it addresses, in programs to control malaria-carrying mosquitoes or other disease vectors if a country files a request with the Secretariat, closely monitors such use, and reports regularly to a publicly available DDT registry. This is a notable improvement over the situation today, in which no one is responsible for tracking DDT. Twenty-six countries had requested such exemptions as of May 2001, but all parties to the treaty "must promote the research and development for alternatives to DDT," a significant obligation to ensure universal support for alternative methods of mosquito control. The Stockholm Convention also includes specific steps for implementing treaty requirements, including detailed mechanisms to ensure transparency and accountability as well as requirements for new and additional funding from industrial countries to help developing nations pay for required changes.[55]

Two other treaties–the 1998 Rotterdam Convention on the Prior Informed Consent Procedure (PIC) for Certain Hazardous Chemicals and Pesticides in International Trade and the 1989 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal together with its 1995 amendment that bans the export of hazardous waste from rich to poorer countries-also have a big role to play in limiting the flow of toxic pesticides and wastes. In addition, they provide an opportunity for public access to information and greater transparency in the handling of hazardous materials, which too often occurs behind the scenes and is becoming a more pressing issue as disposal sites fill up and waste piles grow.[56]

On the surface, the PIC procedure pales in comparison to the far-reaching Stockholm Convention. Essentially, it is a reporting requirement that helps establish a global information exchange system on pesticides. It is intended to be an early warning system to prevent the proliferation of pesticides and encourage the adoption of alternatives. PIC was initiated on a voluntary basis at the global level in the 1989 revision of the International Code of Conduct on the Distribution and Use of Pesticides. At the 1992 Earth Summit, governments agreed that PIC should have the status of an international convention. And by 1998, prior informed consent had made the transition from voluntary tool to global legal instrument. Although it is not yet in force, most countries already abide by it.[57]

The PIC procedure requires exporting parties to share information globally on chemicals and pesticides each country has banned or restricted nationally. The

Convention's Chemical Review Committee considers such products and decides whether to place them on a list that will be subject to the PIC procedure. Listed chemicals cannot be traded until recipient countries have been informed and have consented to the import. The sender is obligated to comply with that country's decision, and the decisions are made public so that other countries can track them and see how they were made. PIC gives potential destination countries the power to choose what they will or will not accept, along with a growing basis of information in order to make that decision.[58]

The 1995 amendment to the Basel Convention takes the PIC policy to another level. As with PIC, the amendment is not yet in force but countries have agreed voluntarily to abide by its prohibition on shipments of hazardous wastes from industrial to developing countries. A blanket ban such as this will not only make it easier to detect illegal shipments, it will, at least in theory, force industrial nations–typically the source of hazardous waste–to deal with treatment and disposal themselves rather than dumping their wastes on poorer countries. Worldwide, some 300-500 million tons of hazardous wastes are generated each year, according to UNEP estimates, with industrial countries accounting for 80-90 percent of the total. With the Basel Ban, the Basel Convention recognized that free trade in hazardous waste was not acceptable, and that richer countries have a special responsibility not to externalize their pollution costs via exports.[59]

Although the ban was passed by consensus and is supported almost universally in developing countries, a few industrial nations still oppose ratification. In August 2001, U.S. State Department officials argued that the Basel ban may prevent some legitimate recycling activities and could inhibit trade. (The United States signed the Basel Convention in 1989 but has not yet ratified it.)[60]

Like the Basel Convention itself, a central point of disagreement on the hazardous waste trade ban concerns the term "recyclable." Some argue that recycling wastes is preferable to using virgin materials, and may help encourage proper disposal, and therefore that developing countries should be allowed to accept hazardous wastes for recycling. Environmentalists argue that the recycling of hazardous waste via export is usually a polluting enterprise, as there are inevitably quantities of the material that remain as pollution and expose workers in the recipient country to health threats. Further, they argue that such export provides a major disincentive to preventing hazardous waste and avoiding the use of toxics in the first place. One of the fundamental goals of the Basel Convention is to minimize the generation of hazardous waste and therefore its trade. The Basel Ban is seen as a way of implementing the convention, starting first with the industrial countries that produce the most waste and have the most resources to reduce toxicity and quantities of waste dramatically. [61]

Behind the trade in hazardous wastes is a larger story involving the economics of unused materials and stockpiles. Like illegal drug trafficking, illegal movements of hazardous wastes are hard to detect, thought to be underreported, and difficult to control. Tracking hazardous wastes from "'cradle-to-grave' when the cradle is in one country and the grave in another is nearly impossible," according to a recent study on hazardous waste flows under the North American Free Trade Agreement.[62]

Noting these difficulties, global networks of activists, such as the Basel Action Net work, have sprung up to work on these issues. In January 2001, for example, a 20 ton shipment of obsolete mercury left the now defunct HoltraChern facility in coastal Maine, bound for India. With an alert sent out from U.S. activists to colleagues in India, the union of port workers there successfully blocked the ship from unloading its cargo there. The ship was last seen in Port Said, Egypt, but activists are unsure where the mercury finally ended up. The remaining 110 tons of mercury from this facility are still sitting in Maine, awaiting their fate.[63]

While banning chemicals is increasingly an accepted tool for reducing toxic burden, dealing with toxic wastes in ways that do not exacerbate the problem is harder to do. Incineration and burning can create dioxins and furans and other harmful pollutants. Similarly, disposal of hazardous wastes on land and at sea has backfired, leaking toxic compounds into the environment, dispersing the problem to larger areas, and allowing toxics to interact in unpredictable ways to form new compounds. Recycling of hazardous wastes is also a serious problem. Recycling mercury, for example, reintroduces this toxic metal into products that almost always have safer substitutes.

The scale of the waste problem is enormous. Nearly every nation in Africa now shares the legacy of some 50 years of international development aid: more than 200,000 tons of abandoned pesticides, about one third of which are thought to be POPs. Such stockpiles are continually creating problems of their own-from water degradation to acute human exposures-through improper storage and misuse and subsequent exposure. The situation is equally grave in the former Soviet Union. The reality is that much of the world's unwanted pesticides are housed in places that are least able to deal with their disposal. Most of the 53 nations in Africa, for example, lack the institutional capacity to remedy the situation, much less the labs to do the testing and site analysis or the medical personnel to treat victims of exposure. Expensive hightech waste disposal methods are not an option in countries that rely on waste imports for quick cash.[64]

While the waste problem is not new, it is becoming more pressing. The global toxic waste pile is growing rapidly: plastics waste, such as PVC from short-lived items, continues to pile up, and we are near the end of the useful life span of "long-lived" (20-30 years) PVC materials such as pipes, siding, and other construction materials. Electronic waste is also mounting due to rapid obsolescence of computers and other electronic equipment and the manufacturers' lack of attempts to reduce toxic inputs in their products. The present toxic waste challenge could take on the dimensions of a crisis during the next two decades as thousands of tons of PCBs and other POPs are phased out, as called for in the Stockholm Convention.[65]

Even though the yearly emissions of many toxic compounds are now declining and well below peak levels, what has accumulated over the last several decades in the environment is what ultimately matters in terms of public health. Persistent toxins in soil, water, and even bedrock can be reactivated by human or natural causes (as happened with arsenic poisoning from wells in Bangladesh), essentially keeping the threat alive. Further, many new compounds are invented and put on the market each year without proper testing as to their long-term impacts on the environment. Minimizing the generation of new toxic wastes and finding ways to detoxify or store current wastes are essential to protecting health.

In combination with the POPs treaty, PIC and the Basel Ban will help stimulate more responsible chemicals management and a better informed public. But having individual companies and countries report their activities to designated national authorities and banning particular activities still may not be enough to reduce the use and generation of toxics and to dispose of toxic wastes safely. What is needed is a market-driven impetus to refocus our efforts upstream toward prevention rather than the ultimately hopeless efforts at an end-of-pipe cure. With more accurate information about the chemicals available, nongovernmental organizations (NGOs) and the general public can help force this change through innovative market-based programs, community based monitoring systems, and other tools.[66]

Environmental Democracy and Markets

In October 2001, the Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to justice came into effect, thanks to wide support from a number of economics in transition. (This regional agreement applies to 28 countries in Western and Eastern Europe but is open to other governments.) It encourages more citizen participation in environmental issues and greater public access to information previously limited to government authorities. U.N. Secretary General Kofi Annan has called the Convention the "most ambitious venture in the area of 'environmental democracy'" since Rio.[67]

Establishing the public's legal right to know what they are being exposed to dates back at least to 1986, when following the 1984 Bhopal disaster the U.S. Congress passed the world's first community right-to-know law, over strong protests from industry officials. The Emergency Planning and Community Right-to-Know Act created a national database of toxic emissions and releases by manufacturing plants. Known as the Toxics Release Inventory, the data allow citizens, companies, and the media to publicize the worst polluters and to bring public attention to the issues of toxic waste management. This helped drive down releases of an original core group of 300 chemicals by 45 percent between 1988 and 1999. Despite some notable limitations, the TRI system is continually being improved. In April 2001, for instance, the U.S. EPA drastically lowered the reporting threshold for lead, from 25,000 pounds to 100 pounds. Accordingly, information on hundreds of thousands of pounds of lead emissions that were never previously reported will become public beginning in 2002.[68]

Such systems of tracking chemicals and emissions by industry are catching on elsewhere. Since Rio, eight industrial countries and two developing nations-Mexico and the Slovak Republic-have implemented systems like the U.S. right-to-know laws. Several others – including Argentina, the Czech Republic, Egypt, and five former Soviet bloc nations – are expected to adopt similar systems soon. Public right-to-know also extends to product labeling systems, which are now used in a variety of settings from PVC-free toys and mercury-free thermometers to organically grown cotton T-shirts and chlorine-free bleached paper. Simply by telling consumers what is in a product and how it was made, these systems give the public the power to refuse to buy particular toxics. In addition to monitoring emissions, registers and labeling systems will help develop national POPs inventories, as called for in the Stockholm Convention. And they help remove the wall of corporate secrecy, encourage greater public participation, and provide a check against government and corporate abuses.[69]

The vibrant and vocal NGO network that sprung up during the U.N. POPs treaty negotiations provides ample evidence that greater public access to information does set the stage for greater citizen involvement. The more than 250 NGOs represented in the International POPs Elimination Network outnumbered the number of countries participating in the U.N. treaty by almost two to one .[70]

Increased citizen awareness and participation, whether in international negotiations or our own backyards, often translate into growing political support for change. In Mozambique, for example, local activists and political leaders successfully blocked the construction of a Danish-fiinded incinerator. The country has since banned incineration as a method to get rid of stockpiled pesticides. For an alternative, the government can look to demonstration projects now under way in Slovenia and the Philippines to treat PCB wastes with non-burn technologies that do not emit additional toxic byproducts in the process .[71]

Chemical bans have also prompted proactive responses from the regulated industry. In late 2000, for example, the Swedish Parliament called for a national ban on all persistent and bioaccumulative chemicals by 2020. The law puts the onus on industry to prove that a chemical is safe (an important aspect of the precautionary principle) rather than on government to show it is dangerous. While this may seem to discourage innovation, it has in fact spurred new research as manufacturers whose livelihoods appear to depend on toxic substances like lead have moved in a new direction. Orrefors Kosta Bod, a world-famous Swedish crystal glass company that dates back several generations, is exploring the use of barium instead of lead to give its crystal a similar luster but a lighter feel and a much safer product. As a company spokesperson says, "We will have to educate our customers not to choose their glass by weight but only by its beauty."[72]

Similar sentiments concerning the importance of corporate education and public awareness-raising are heard elsewhere. In anticipation of a global ban on TBT (the antifouling marine paint), for example, the World Wide Fund for Nature is now working with a number of shipping and paint companies to organize a buyers' group for TBT-free paint. Several companies have already agreed to use safer paints by the end of 2002. Likewise, many toy manufacturers have pledged to phase out phthalate-softeners from toys and other items that children use in response to a ban in the European Union, growing public concern in the United States and elsewhere, and the fear of losing business worldwide.[73]

Taxes and fiscal policies can further support the progress made in parliaments and boardrooms. Since 1970, for example, the Netherlands has had great success in toxics reduction by charging households and companies for discharges of heavy metals. Originally intended to raise revenues, levies based on the quantities of toxics released-combined with a permitting system-proved to be effective incentives for companies to treat their own discharges or switch to cleaner processes. (See Figure 4-4.)[74]

Similar efforts have been undertaken with pesticides and gasoline. Sweden, for instance, has a pesticide tax that adds a 7.5 percent surcharge for every kilogram of active ingredient purchased. This was one of a set of government initiatives that helped Swedish farmers cut their pesticide use by 65 percent from 1986 to 1993. Many countries have reduced their consumption of leaded gas by taxing it at a higher rate than unleaded gas. Malaysia, for example, made unleaded gas 2.7 percent cheaper than leaded, which increased the share of unleaded to 60 percent of the total. Unleaded fuel was first available in 1991 in Singapore; by 1997, it accounted for 75 percent of the gas used there, thanks to differential gas taxes. Twenty industrial countries introduced differential taxes at the same time they implemented other policies, such as stricter emissions controls, thereby accelerating the shift from leaded to unleaded gas.[75]

Combining the influence of financial markets with the power of the news media has helped reduce pollution in a number of communities around the world. It is an especially powerful incentive in countries where monitoring is lax and enforcement is weak, so that polluters typically have little incentive to change their ways. In an experiment in Indonesia, for instance, government officials publicly graded factories using a color-coded system: black for those that made no attempt to manage wastes, red for significant violators, blue for those that met national standards, and green for those that went beyond what was required.

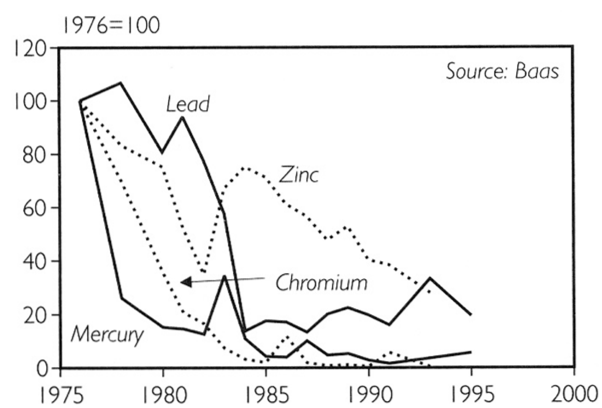

Figure 4–4. Industrial Discharges of Chromium and Zinc, 1976–93, and of Lead and Mercury, 1976–95, into Regional Surface Waters, Netherlands

Shortly after a highly publicized awards ceremony, companies that had regularly ignored regulators started asking how they could improve their grade. Within 18 months, water pollution from the 187 pilot plants fell by 40 percent.[76]

While we clearly need to scale up these and other efforts, an important step in the transition away from toxics–defining what tools should be used–has largely been achieved. This frees up intellectual capital to focus on the more fundamental and challenging task of developing safer materials, products, and processes.

Technological Changes and Opportunities

"We have invested heavily in addressing the effects of the materials in our economy while mostly ignoring the materials themselves," writes Ken Geiser, Director of the Massachusetts Toxics Reduction Institute and author of a new book on materials. In terms of toxicity, Geiser argues that we have barely begun to scratch the surface of opportunities for reduction. Indeed, few sectors of the global economy have been scrutinized in terms of their use of toxic chemicals, let alone subject to actual change. One notable exception is agriculture, where much work has gone into adopting and improving farming methods that are safer for farm workers, consumers, and the environment. But for much of the rest of our economy, opportunities to reduce our use of toxics abound. As an official at the New Jersey Department of Environmental Protection recently stated in an interview on toxics and pollution prevention, not only is "low hanging fruit" going unpicked, some is "rotting on the ground."[77]

In response to human and ecological health concerns, increasing numbers of farmers are abandoning the pesticide treadmill that makes farmers reliant on expensive synthetic chemicals in favor of farming techniques that use pesticides only as a last resort or that avoid them entirely. (See Chapter 3.) Recently, for instance, thousands of rice farmers in China demonstrated that growing multiple varieties of rice in the same paddies could double yields without the use of any synthetic chemicals. In the U.S. Midwest, farmers who produce grain and soybean organically are finding that their net profits equal or surpass those from conventional production, even when they do not charge the premium prices that organic crops generally command.[78]

Many players in the solvents industry have begun to search for—and implement—safer alternatives.

Lucrative global markets-more than $25 billion produced a year in at least 130 countries-combined with growing consumer preferences and labeling have helped make organic food a major influence in world food markets. Currently, between 3 and 5 percent of European food is grown organically. (With 25 percent of the world's pesticides used in household settings and on commercial properties, and with pesticide use in this sector rising, the next step is to apply nonchemical methods of pest control in schools, hospitals, public parks, and private homes and yards.)[79]

The use of pesticides to protect public health is also coming under increasing scrutiny by environmentalists and health professionals. Under the Stockholm Convention, some two dozen tropical countries that need DDT to fight malaria-carrying mosquitoes will be allowed to continue spraying. Indeed, malaria's lethal grip on humanity is the reason DDT is still in use at all: some 950 people become infected every minute by this modern-day plague.[80]

But alternatives are increasingly available here too. Researchers in sub-Saharan Africa have demonstrated that bednets with small amounts of humanmade pyrethroids, which are natural insecticides found in plants, can reduce the transmission of malaria by preventing mosquitoes from biting people who are asleep. Combined with other prevention and treatment strategies, these bednets can prevent half of all childhood deaths from malaria. In addition, they are easily introduced at the local level and relatively cost-effective: $10 for a bednet plus $1 for a year's supply of insecticide. Over the next five years, the Roll Back Malaria program, which involves WHO, the World Bank, and numerous bilateral agencies, is planning a thirtyfold increase in the use of bednets in Africa. Uganda and Tanzania have already reduced taxes on nets to make them more affordable.[81]

By using the least toxic option first, and knowing the ecology of *Anopheles*, the malarial parasite's mosquito host, health officials are beating back this deadly disease in some areas. Although reducing the use of DDT is a primary goal of the POPs treaty, this pesticide will remain in the arsenal of public health protection–and rightly so–until all areas at high risk of malaria have suitable alternatives in place. South Africa's recent experience–a rapid and deadly comeback of malaria following the emergence in 1996 of mosquito resistance to alternative insecticides–has meant the reintroduction of controlled DDT spraying in homes until the outbreak is brought under control.[82]

The same principles at work in organic agriculture and public health campaigns use the least toxic option first and know your enemy–are equally applicable to the vast range of chemical-intensive processes in our economy. Chlorinated solvents, for example, are "one of the largest and most easily phased out" compounds, according to Joe Thornton, author of a recent book on chlorine. The key phrase is "phase out," since these highly volatile substances are so difficult to contain. Many players in the solvents industry have begun to search for and implement-safer alternatives. The classic case involves chlorofluorocarbons (CFCs), a group of compounds with a wide range of uses, from aerosol propellants to refrigerants, whose output dropped 87 percent between 1988 and 1997–prompted by the Montreal Protocol that targeted CFCs because they deplete the ozone layer that protects Earth from harmful ultraviolet radiation. Technical ingenuity and innovation on the part of manufacturers played a big role in this international success story.[83]

Because solvents–indeed all chemicals–cost money to use and dispose of properly, phasing them out with safer substitutes makes good economic sense. A 1994 Massachusetts study reported that buying chemicals and disposing of contaminated waste accounted for up to 85 percent of operating costs in companies that regularly used solvents. Moreover, these same companies found that replacing chlorinated solvents with safer alternatives yielded considerable health and environmental benefits as well as economic savings. Most companies in the study reaped enormous benefits by replacing solvents with safer, often water-based alkaline solutions: all but one saved at least 75 percent in net operating costs. The benefits demonstrated in this survey and through the Montreal Protocol have been replicated by numerous multinational companies.[84]

Supplementing these achievements, researchers have made promising advances in "green chemistry." Such efforts have typically focused on finding environmentally benign feedstocks, reagents, catalysts, and chemical products. A variety of traditional industrial materials are now commercially available in bio-based form, and their production is growing steadily. (See Table 4-4.) One company has developed plates, bowls, and other food containers from a mix of potato starch, limestone, and post-consumer recycled fiber. The packaging has been used by several hundred McDonald's restaurants and is being tested in the cafeteria at the U.S. Department of Interior. It is biodegradable and consumes significantly less energy throughout its existence than either polystyrene plastic or paper, which are typically used.[85]

While recent and ongoing research in plant-based industrial materials is gradally gaining a toehold in the market, much of the work remains behind the scenes of commercial markets, off in laboratories. But those involved in such efforts predict that a major breakthrough is closer than it might appear. In the next few years, companies will be building plants that use bio-based materials, predicts Pat Gruber, Vice-President for Technology at Cargill Dow. Her company has invested $300 million to build the world's first facility to produce plastic from corn sugar, known as polylactide polymers, which is an alternative to traditional petroleum-based plastics. Although the processing methods for these and other polymers are still in their infancy, notable technical improvements are expected. Combined with the use of agricultural wastes (rather than high-grade sugars) as the feedstock material and the entrance of several large research companies, plant-based chemical manufacturers and plastics producers could be competitive with high

Table 4-4. U.S. Industrial Materials Derived from Plant Matter, by Production Volume and Share of Total, 1992 and 1996

Product	Production, 1996	Share of Total 1992	Share of Total 1996
	(million tons per year)	(percent)	(percent)
Wall paints	7.8	3.5	9.0
Specialty paints	2.4	2.0	4.5
Pigments	15.0	6.0	9.0
Dyes	4.5	6.0	15.0
Inks	3.5	7.0	16.0
Detergents	12.6	11.0	18.0
Surface cleaning agents	3.5	35.0	50.0
Adhesives	5.0	40.0	48.0
Plastics	30.0	1.8	4.3
Plasticizers	0.8	15.0	32.0
Acetic Acid	2.3	17.5	28.0

SOURCE: Kenneth Geiser, Materiais Matter: Toward a Sustainable Materials Policy (Cambridge, MA: The MIT Press, 2001), p. 262.

volume petroleum-based ones in the next decade or so, if not earlier.[86]

Another promising avenue is the use of plants to absorb and break down toxic metals and pollution, a field known as phytoremediation. University of Florida chemists have found ferns that can accumulate up to 200 times as much arsenic as in highly contaminated soil. In some tests, as much as 2.3 percent of the plant was composed of this toxic metal. Currently, phytoremediation accounts for just I percent of the $8 billion environmental remediation market in the United States. But a number of plants, including sunflower, poplar, clover, mustard, and some herbs, can serve as the botanical equivalent of detox centers for polluted soil and water, often working in conjunction with the fungi and bacteria that thrive in the plants' roots and soil.[87]

Although several hundred plant species worldwide have been identified as potential 11 pollution sponges" for toxic compounds, they do, however, come with a number of cautions: the plants can become so toxic that they must be treated as hazardous waste and kept away from animals, insects, and people; some chemicals may evaporate from the leaves; and although some compounds may break down in plants, this is not true for elements. While they should not be used to justify greater waste generation, these living sponges are already proving useful to contain and concentrate the problem of toxic wastes.[88]

Progress in other cutting edge fields is falling short. To date, advanced and engineered materials that offer significant potential to reduce total materials use have not been adequately tested for toxicity. These include composites and super alloys that are synthesized from byproducts of conventional materials, nanotechnology that requires less materials because equipment is so tiny, and so-called smart materials that change their properties in response to environmental conditions. "For all that is impressive and intriguing about these materials, it is disappointing to consider how little attention has been paid to their effects on human health or the environment .... Seldom are even the most obvious health or environmental effects of production or disposal considered," writes Ken Geiser of the Massachusetts Toxics Reduction Institute. In *Materials Matter*, he makes a strong case for materials sciences to integrate the issues of human and environmental health effects as primary design factors along with the traditional concerns for performance, processing efficiency, and cost.[89]

Even before such a fundamental shift can take place in the scientific underpinnings of our economy, consumers can take the lead and demand safer products. This consumer mobilization will not only help spur the transition away from toxic materials in the near term, but also begin to build the political support for lawmakers to make the deeper reforms in our economic and scientific systems that will let us reach far beyond the "low hanging fruit."

Moving Forward

In early 2001, the U.N. Commission on Human Rights declared that living free of pollution is a basic human right. With a number of treaties, programs, and community efforts under way to reduce toxics use and waste, and with the Stockholm Convention expected to be fully ratified as early as 2003, the next decade marks an era of enormous opportunity to give life to this declaration and make the planet a safer and healthier place.[90]

Although toxic chemicals are a unique part of the materials economy, production and consumption of chemicals are just as much a reflection of overconsumption as the volume of material used is. When people think of overconsumption, they typically envision denuded forests, polluted inland and coastal waters, and extinct animals. But the visible stockpiles of chemical substances in our landfills and abandoned industrial sites, as well as those that collect unseen in our bodies, are no less a reflection of global overconsumption of materials. In many ways, it is a more pernicious form of overconsumption. Much of it is undetected and will remain a threat for generations to come, owing to its persistent nature. Moreover, these compounds interfere with normal biological functioning of species in ways we have only begun to identify, let alone fully comprehend.

The key to addressing the challenge of toxics use and wastes rests on a fairly straightforward principle: harness the innovation and technical ingenuity that has characterized the chemicals industry from its beginning and channel these qualities in a new direction that seeks to detoxify our economy. Chemicals and materials researchers will need to make concerted efforts to find nontoxic alternatives. The primary purpose of research should be to find safer substitute materials, products, and processes for those that now contribute to our global toxic burden. Proving the necessity of toxic chemicals should also be foremost in the minds of producers, consumers, and policy makers alike. Only by realigning our uses of chemicals closer to those found in nature will we build an economy that is more accountable to the environment and ourselves.

WORLD SUMMIT PRIORITIES ON CHEMICALS

Short-term

- Phase out leaded gasoline globally.
- Ratify the three major global toxics treaties (Stockholm, Basel, and Rotterdam).
- Secure funding for research on alternative materials and environmentally sound methods of waste disposal.

Long-term

- Adopt a uniform and mandatory system of reporting toxics use and releases.
- Tax commercial and residential pesticide use.
- Eliminate persistent compounds in dissipative uses, such as agricultural pesticide spraying and cleaning agents.
- Minimize the release of mercury, lead, and other toxins as byproducts from the mining of metallic ores and other industrial sources.
- Reduce and eventually phase out coal-based power generation.