

Appendices

Appendix I: Environmental Protection and Public Health—Major International Documents⁴⁷

Brundtland Commission Report

As a matter of fundamental human right, the importance of environmental protection and public health in the context of sustainable development was first clearly enunciated in the 1987 Brundtland Commission Report (“Our Common Future”). It defined the concept of sustainable development as follows: “Humanity has the ability to make development sustainable—to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.”

The Brundtland Commission also included a set of General Principles, Rights and Responsibilities for achieving environmental protection and sustainable development. Its broad first principle of human rights was presented as follows: “All human beings have the fundamental right to an environment adequate for their health and well-being.”

Agenda 21, Rio Declaration and the World Summit on Sustainable Development

Since the initial publication of the Brundtland Commission Report, global population has increased from 5.0 billion in 1987 to over 6.2 billion in mid-2002, with current estimates of 9 billion people living on earth in 2050. This unprecedented population growth has placed an immense strain on human communities and natural ecosystems around the world. This is especially true in developing countries, where many of its inhabitants continue to reside in abject poverty, where they lack life’s basic needs and amenities, such as adequate shelter and food, clean drinking water, unpolluted air, proper sanitation facilities or access to primary health care.

At the United Nations Conference on Environment and Development (UNCED, also known as the “Earth Summit”) held in Rio de Janeiro in June 1992, some 178 countries adopted Agenda 21, the centerpiece report of UNCED, which enunciated a detailed road map for achieving a more ecologically sound and economically sustainable future. In its preamble, Agenda 21 stated that “integration of environment and development concerns and greater attention to them will lead to the fulfillment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future. No nation can achieve this on its own, but together we can—in a global partnership for sustainable development.”

In the Rio Declaration on Environment and Development, which was also adopted at the 1992 UNCED meeting, representatives from developed and developing countries recognized the right to a clean and healthy environment as an overarching human entitlement: “Principle 1: Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.”

In addition, the Rio Declaration explicitly affirmed the rights of indigenous communities in managing their environment in order to preserve their “identity, culture and interests and their effective participation in the achievement of sustainable development” (*Article 22*), and for the protection of the “environment and natural resources of people under oppression, domination and occupation” (*Article 23*).

The UN’s World Summit on Sustainable Development (WSSD) held in Johannesburg, South Africa in August-September, 2002, stated in its Plan of Implementation (in Paragraph 5) that “Peace, security, stability and respect for human rights and fundamental freedoms, including the right to development, as well as respect for cultural diversity, are essential for achieving sustainable development and ensuring that sustainable development benefits all.”

I-B. Environmental Protection and Public Health: Major International Treaties and Conventions

- During the past decade, the international community has adopted a series of agreements and conventions that provide regulatory procedures and guidelines to control the global export and shipment of toxic substances and hazardous wastes. In 1995, the International Code of Conduct on the Distribution and Use of Pesticides was adopted by the Food and Agriculture Organization (FAO),

⁴⁷ Excerpted from: Ahmed, A. Karim. *op. cit.*

followed in 1987 by the enactment of the London Guidelines for the Exchange of Information on Chemicals in International Trade by the United Nations Environment Programme (UNEP).

- In 1989, an international agreement, known as Prior Informed Consent (PIC) (later extended by the Rotterdam Convention in 1998) was adopted to help control the importation of banned or severely restricted products into developing countries. Under PIC, officials in importing countries must be informed by the exporter about the toxicological characteristics and regulatory status of potentially hazardous chemicals before shipment of the product to their region.
- Discarded agricultural chemicals, unused toxic pesticides and hazardous wastes are generally recognized as requiring legal restrictions or regulatory oversight in their international shipments or transfers. Over one hundred countries have banned or severely restricted the import of hazardous materials. However, some developing countries, especially in Asia and Africa, have found an economic niche in importing hazardous wastes from developed nations. The Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal offers a system by which to regulate transport and disposal of such wastes, but also encourages waste minimization and the implementation of sound environmental management policy.
- A class of toxic chemicals, known as persistent organic pollutants (POPs), is made up of long-lasting, non-biodegradable organic compounds that bioconcentrate in the food chain, posing serious health risks to human populations. The international community recently signed a landmark agreement, the Stockholm Convention on Persistent Organic Pollutants (POPs Treaty), which was adopted with considerable worldwide publicity in December 2000 in Johannesburg. Under the POPs Treaty, the following chemicals are to be globally phased out: polychlorinated biphenyls (PCBs), dioxins and furans, aldrin, dieldrin, DDT, endrin, chlordane, hexachlorobenzene, mirex, toxaphene and heptachlor.
- Global climate change exacerbated by anthropogenic activity may bring about severe weather events and drastic changes in land-use patterns in many regions of the world, leading to a number of significant environmental and public health impacts. The impact of global warming on human communities has several short-term and long-term local and regional environmental consequences. Based on these concerns, the international community drafted the Kyoto Protocol to the United Nations Framework Convention on Climate Change in 1998. The Kyoto Protocol calls on ratifying states to reduce atmospheric emissions of greenhouse gases linked to global warming through nationally based emission-reductions program and the creation of international mechanisms for trading emission credits and for providing technical assistance to developing countries.
- In the mid-1980s, the growing worldwide consensus between research scientists and policy makers that earth's protective stratospheric ozone was being depleted led to the adoption of the landmark Montreal Protocol on Substances that Deplete the Ozone Layer in 1987, along with a number of modifying amendments in the 1990s. The Montreal Protocol has led to a worldwide phase out of stratospheric ozone-depleting substances, including chlorofluorocarbons (CFCs) and other halocarbon compounds.
- Global concerns about the rapid rate of loss and extinction of biological species led to the adoption of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in March 1973. The international agreement required the listing of "all species threatened with extinction which are or may be affected by trade. Trade in specimens of these species must be subject to particularly strict regulation in order not to endanger further their survival and must only be authorized in exceptional circumstances."
- To preserve and equitably share the genetic resource base of earth's biological diversity, the international community signed the Convention on Biodiversity at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro. This international agreement on biodiversity describes its main objectives as: ". . . the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies . . ."

Appendix II: Atmospheric Pollutants and Air Quality Standards ⁴⁸

Air pollution was recognized as a major public health problem in the 1940s and 1950s when large numbers of individuals in industrial or urban centers in North America and Europe became seriously ill or died from exposure to a variety of toxic air pollutants that were emitted from manufacturing and domestic sources. In 1948, a severe air pollution episode occurred in a small steel mill town of Donora, Pennsylvania (on the outskirts of Pittsburgh), which resulted in acute respiratory illnesses among a large fraction of the population and in the deaths of scores of inhabitants. In 1952, an estimated 4,000 deaths were attributed to the dense “killer fog” that blanketed London, England for several days, most of it caused by emissions from numerous commercial and residential fossil fuel combustion sources within the city.

Since these well-publicized air pollution episodes, many developed countries have adopted stringent air quality standards to safeguard the public from the most commonly occurring and widespread airborne pollutants. These include sulfur dioxide, nitrogen dioxide, particulate matter, carbon monoxide, ground-level ozone (photochemical oxidants) and lead. In the United States, under its air quality regulatory framework, these commonly found airborne gaseous substances and particles are collectively known as “criteria air pollutants”, to distinguish them from other atmospheric pollutants that are found in specific industrial or urban locations. Other non-criteria or “toxic air pollutants”, which are present at high concentration levels in specific regions, consist of heavy metals (cadmium, chromium, mercury, etc) volatile organic compounds (VOCs, such as benzene, methylene chloride, perchloroethylene, etc) and other toxic airborne substances (asbestos, pesticide vapors, etc.).

Criteria Air Pollutants

As mentioned above, the class of air pollutants known as “criteria air pollutants”, which are ubiquitous and commonly found in the atmosphere in almost all regions of the globe, are airborne substances that have adverse acute and/or chronic impacts on human health. The emission sources, physical-chemical characteristics and human health effects of each of the criteria air pollutants are discussed below.

Sulfur Dioxide

As one of the most common and ubiquitous air pollutants that originate from industrial, commercial and residential sources, sulfur dioxide (SO₂) is formed by the combustion of fossil fuels that have high sulfur content, such as certain grades of oil and coal. Sulfur dioxide can be further oxidized to sulfur trioxide (SO₃), which rapidly reacts with atmospheric water vapor to form airborne sulfuric acid (H₂SO₄). The formation of sulfuric acid results in the secondary formation of acid aerosols, which is the main cause of acid precipitation (such as acid rain or acid snow) in certain parts of the industrialized world, especially in northeastern United States and Canada and in northern continental Europe and the Scandinavian countries.

Health effects associated with sulfur dioxide exposure include interference with normal breathing, alteration of pulmonary defense mechanisms and the aggravation of existing cardiovascular diseases. These health effects are more pronounced in young children and the elderly, and in those individuals who suffer from asthma, chronic bronchitis and emphysema. Short term exposure to high levels of sulfur dioxide in a population may lead to increased hospitalization and excess incidence of deaths from a variety of respiratory and cardiovascular diseases. Since sulfur dioxide is often secondarily oxidized to acid aerosols, it is difficult at times to separate its overall health effects from those associated with exposure to fine particulate matter that contain hydrated aerosol particles.

While in recent years the concentration of sulfur dioxide has declined in North America and Western Europe, it still remains high in Eastern Europe and in many urban and industrialized centers of Asia and Latin America. For instance, in a number of industrial centers and major cities of India and China, the ambient (i.e., the surrounding atmosphere's) annual average concentration levels of sulfur dioxide are two- to six-fold above the WHO's SO₂ air quality guidelines of 50 micrograms per cubic meter. The United States Environmental Protection Agency (USEPA) has established a national ambient air quality standard for sulfur dioxide at an annual arithmetic mean of 80 microgram per cubic meter, along with short term air quality standards for 24-hour and 3-hour averages (365 and 1,300 micrograms per cubic meter, respectively.)

⁴⁸ Excerpted from: Ahmed, A. Karim. *op. cit.*

Particulate Matter

Traditionally, particulate matter as a criteria air pollutant was considered as a dispersed mixture of: (a) the heavier, coarse-sized solid or liquid particles that are derived mainly from naturally occurring sources, such as wind-blown dust, sea sprays, plant particles, etc., and (b) the lighter, fine particulate fraction, which is principally a product of human activity, such as industrial processing and fossil fuel combustion. Generally speaking, fine particles have aerodynamic diameters less than 2.5 micrometers in size (approximately, 1/30th the size of a human hair) and remain in the atmosphere for relatively long periods of time and are transported over long distances, while airborne solid matter or liquid droplets above 5 to 10 micrometers in diameter quickly settle out by gravitational sedimentation near the emission source.

Fine particles constitute the most respirable and harmful fraction of atmospheric particulate matter, since they are small enough to evade the respiratory system's clearance mechanism for removing coarser particles, allowing them to penetrate and deposit into the deeper (alveolar) regions of the lung. Fine particles consist of a variety of toxic vapors, liquids and gases that are either absorbed on solid particulate surfaces or are embedded in liquid aerosols. Thus, they contain a mixture of heavy metal ions, hazardous organic vapors and acid aerosols, with the relative proportions of these chemical substances varying from region to region. For instance, in areas that are downwind from electric power generating plants and metallic ore processing operations, atmospheric fine particles generally contains a higher proportion of sulfuric and nitric acids, formed by the secondary oxidation and hydration of sulfur dioxide and nitrogen dioxide.

A large body of scientific studies has shown the linkage between fine particulate matter exposure and a variety of respiratory diseases, including shortness of breath, bronchitis, asthma and premature deaths. Young children, who breathe 50% more air per body weight than an adult, are especially vulnerable to the environmental impacts of particulate matter. Several acute and chronic respiratory illnesses, including childhood asthma, have been attributed to exposure to fine particles. High levels of atmospheric fine particles also seriously affect the elderly, particularly those with immune system deficiencies or those who have underlying respiratory or cardiovascular diseases.

Until ten or fifteen years ago, most countries only used a total suspended particle (TSP) air quality standard to regulate the levels of atmospheric particulate matter. Unfortunately, the use of TSP to monitor the level of atmospheric fine particles had been demonstrated to be misleading, especially in regions of the world where there were high levels of naturally occurring coarser particles, such as windblown dust or sea sprays. In recent years, a number of regulatory agencies have moved to adopt new health-based air quality standards on particulate matter. For example, the U.S. Environmental Protection Agency in 1987 revoked its TSP standard and enacted instead a PM₁₀ national ambient air quality standard (at an annual arithmetic mean of 50 micrograms per cubic meter), which required specific monitoring of particulate matter below 10 micrometers in diameter.

In 1997, to provide additional protection of the general population, the USEPA proposed a fine particulate matter national ambient air quality standard of PM_{2.5} (at an annual arithmetic mean of 15 micrograms per cubic meter), whereby the air monitoring of fine particles below 2.5 micrometer was required. This is based on recognition by the public health community that current particulate matter standards (TSP or PM₁₀) are not sufficiently protective of human health. Moreover, the USEPA has issued a short-term PM₁₀ air quality standard (at a 24-hour average of 150 micrograms per cubic meter) and proposed a short-term PM_{2.5} air quality standard (at a 24-hour average of 65 micrograms per cubic meter). At present, both WHO and the European Commission are reviewing the replacement of TSP air quality guidelines by establishing a health-based fine particle guideline and recommending a monitoring system of using PM₁₀ and/or PM_{2.5} as appropriate public health yardsticks.

Nitrogen Dioxide

Nitrogen dioxide (NO₂) is a gaseous compound, which is an oxidation by-product of naturally occurring atmospheric nitrogen and oxygen, formed during high temperature combustion processes. Thus, it is a result of a variety of industrial, commercial and residential activities, such as production of steam in electric power generating and manufacturing plants and the use of gasoline products in internal combustion engines of motor vehicles. Since nitrogen dioxide is a dark colored gas, its presence at high levels in the atmosphere is often noted in industrial and urban areas by the familiar brown haze that tends to hover over the region. During the combustion process, nitrogen dioxide is initially formed from its precursor compound, nitrogen oxide (NO), and therefore it is often found in a mixture of various oxidized states of the compound, known collectively as nitrogen oxides (NO_x). Further chemical oxidation and hydration of nitrogen oxide compounds produces atmospheric nitric acid (HNO₃), which is a major

aerosolized component (droplets of air/liquid mixtures) of particulate matter that form acid precipitation in a number of regions of the world.

The environmental impact of nitrogen dioxide on human health may be viewed both directly and indirectly. At relatively high concentrations, nitrogen dioxide causes direct acute effects on respiratory tracts and mucous membranes of both adults and children, such as nose, throat and eye irritations. However, its main long-term health impacts are largely indirect, since it participates in the formation of ground level photochemical smog by reacting with volatile organic compounds, and in the formation of highly corrosive nitric acid, which then becomes part of the fine particulate fraction in the atmosphere. At present, the WHO health-based air quality guideline for nitrogen dioxide is 40 micrograms per cubic meter (annual average), while the USEPA has established an annual (arithmetic mean) average of 100 micrograms per cubic meter as its national ambient air quality standard for nitrogen dioxide.

Ozone (Photochemical Oxidants)

As a gaseous substance, ozone (O₃) contains three atoms of oxygen (arranged in an unstable, ring structure) and is a highly reactive chemical compound found in the atmospheric smog of many regions of the world. In the stratosphere (a region some 10 to 30 miles above the earth's surface), ozone is found as a naturally occurring substance that forms a protective layer against the sun's harmful ultraviolet radiation. However, in the lower atmosphere at the earth's surface, ozone—along with other photochemical oxidants—are a product of a number of anthropogenic activities. They are formed by photochemical oxidation (i.e., atmospheric chemical reactions that are catalyzed by sunlight) of a variety of airborne compounds, such as: (a) hydrocarbon gases that are emitted from power plants, oil refineries, chemical plants, motor vehicles, etc, and (b) nitrogen oxides that are produced from similar industrial and residential sources. While there are many different kinds of reactive chemical substances found in smog, ozone is generally chosen as a surrogate measure of the levels of photochemical oxidants in the lower atmosphere.

At a general rule, atmospheric ozone levels reach their highest concentration during daytime hours and during the summer months when sunlight is at its brightest. High levels of ambient ozone concentration in a community have been correlated with increased incidence of respiratory illnesses and elevated hospital admission rates. Short-term exposure to elevated levels of ozone causes upper respiratory tract irritation and uncomfortable chest distress that may last for several hours. Increased ozone levels may interfere with overall lung function, especially among athletes and those who work outdoors. High levels of ozone may increase the incidence of asthma in a population and may make individuals more susceptible to a variety of allergens, such as exposure to dust mites, cockroaches, pets, fungus, pollen, etc. Other health impacts of ozone include long-term damage to lung linings and the aggravation of other lung diseases, such as chronic bronchitis and emphysema. It is believed that repeated short-term exposure to elevated levels of ozone and other photochemical oxidants may lead to permanent health damage, especially among young children whose lungs are still not fully developed.

At present, the WHO air quality guideline on ozone is 120 micrograms per cubic meter for an 8-hour exposure period. The USEPA has adopted 1-hour average at 235 micrograms per cubic meter (0.12 ppm) as its national ambient air quality standard for ozone. In recent years, the U.S. EPA has also proposed an 8-hour average of 157 micrograms per cubic meter (0.08 ppm) as an additional national ambient air quality standard for ozone.

Carbon Monoxide

Carbon monoxide (CO) is a highly toxic, colorless and odorless gas. It is principally formed as an incomplete combustion product of carbon-based sources (gasoline and diesel fuels) used in motor vehicles. In many urban environments, as much as 95% of carbon monoxide present in the atmosphere comes from motor vehicle exhausts. Thus, its atmospheric concentration levels are especially high in heavily used roadways and during morning and evening rush hours. Other significant emission sources of carbon monoxide are the boilers and incinerators employed in industrial and fuel combustion processes.

Over the years, the health impacts of carbon monoxide have been well characterized. Carbon monoxide enters the bloodstream through inhalation and reduces the amount of oxygen that is delivered to organs and tissues of the body. Physiologically, carbon monoxide binds to hemoglobin (Hb), an oxygen-binding protein found in the bloodstream, by displacing oxygen to form carboxyhemoglobin (Hb-CO). Thus, carbon monoxide decreases the ability of hemoglobin to carry fresh, inhaled oxygen to other parts of the body. Exposure to elevated levels of carbon monoxide may therefore affect capacity to work, impair manual dexterity, reduce learning ability and cause visual impairment.

In addition, acute health effects of carbon monoxide exposure at even moderate amounts may be serious to individuals with underlying cardiovascular diseases.

WHO has recommended several health-based short-term air quality guidelines for carbon monoxide – at 10, 30, 60 and 100 milligrams per cubic meter for 8-hour, 1-hour, 30-minute and 15 minute averages, respectively. On the other hand, the U.S.EPA has only two short term national ambient air quality standards for carbon monoxide: 10 and 40 milligrams per cubic meter for 8-hour and 1-hour averages.

Lead

Lead is a naturally occurring metallic substance that has been incorporated into a variety of handicrafts, water pipings, ceramic glazes, household paints and other manufactured products over two or three thousand years. However, its toxic effects on human populations have only been recognized fully in the past 50 to 100 years. Today, lead is present in many old housing structures and contaminated industrial sites, and it continues to be used in many consumer products, such as paints and ceramic glazes. The main source of lead in the atmosphere is exhaust from motor vehicles that employ lead compounds as an antiknock additive in gasoline products. While in recent years lead additives in gasoline have been phased out in many developed countries in North America and Western Europe, it is still being used in many Eastern European countries and in most developing regions of the world.

The health effect of lead has been well documented in both adults and children. Its impacts are especially severe on young children, since it is a neuro-toxic agent that impairs the normal development of the central nervous system. At relatively low exposure levels, lead has been shown to affect the cognitive skills of children – a 10 micrograms per deciliter increase in blood lead level caused a decline of about 2.5 IQ points in lead-exposed children. Chronic lead exposure may also result in decreased growth, hyperactivity and impaired hearing in children. Short-term high levels of lead exposure may cause permanent brain damage in children and on occasion result in death. At present, in many regions of the developing world, blood lead levels in children below five years old continue to exceed 10 micrograms per deciliter, which is the health advisory guideline established by the U.S. Centers for Disease Control and Prevention (USCDC) for safeguarding children from long-term ill effects of lead exposure.

The current WHO health-based air quality guideline for lead is an annual average of 0.5 microgram per cubic meter. The USEPA has adopted a national ambient air quality standard for lead of 1.5 microgram per cubic meter averaged quarterly each year.

Toxic Air Pollutants

Toxic air pollutants are a large and diverse class of hazardous airborne substances that range from heavy metals, volatile organic compounds, and other atmospheric suspended substances, including a number of insecticide and herbicide vapors, inorganic mineral fibers and radionuclides.

Heavy Metals

While a number of toxic heavy metals are found in the atmosphere, their airborne concentration levels vary markedly from region to region. Airborne heavy metals consist of arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium and zinc. Heavy metals are emitted into the atmosphere ore smelters, ferrous and non-ferrous industries, coal-fired power plants, metal foundries and a variety of manufacturing facilities. Each heavy metal—and their various compounds—has different physical and chemical properties and thus possesses diverse toxicological characteristics. For instance, both mercury and lead are well known neurotoxic agents, while arsenic, beryllium and chromium VI are potent carcinogens. Exposure to airborne cadmium has been associated with kidney disorders, chronic bronchitis, emphysema and lung cancer. Nickel fumes cause eye and skin irritation and can lead to pneumonia-like symptoms, while chronic exposure to nickel is associated with nasal, throat and lung cancer. On the other hand, low concentration levels of copper, selenium and zinc have important nutritional value to animals and humans, but at higher exposure levels they can exhibit quite toxic effects. Therefore, it is not possible to generalize about the health effects of heavy metals as a group, since their risk profiles are assessed on an individual basis in order to determine their specific toxic impact on human populations.

Volatile Organic Compounds

This group of toxic air pollutants constitutes a vast number of organic chemical substances that range from highly volatile solvents (such as benzene, methylene chloride, perchloroethylene, etc.) to complex polyaromatic compounds (multiple-cyclic organic chemicals, such as dioxins and furans). The chief emission sources of these volatile organic compounds (VOCs) are petroleum refineries, coke ovens, chemical manufacturing and processing plants, motor vehicle exhausts, municipal and hazardous waste incinerators and a number of industrial facilities and commercial outlets, such as tanning factories, dry cleaning establishments and gasoline stations. Short-term exposure to high levels of VOCs may cause headaches, dizziness, nausea and abdominal distress, while long-term chronic exposure may lead to an array of neurological diseases, reproductive failures, developmental abnormalities, genetic damage and cancers.

Other Air Toxics

A number of insecticides and herbicides used in agriculture, forests and domestic settings can remain airborne for considerable periods of time and thus adversely affect animal and human populations that live in proximity to commercial and residential spraying. At present, in many developed countries, a number of non-biological degradable pesticides (such as DDT, aldrin, dieldrin, chlordane, etc) have been phased out for their long-term chronic impact on human populations, while under a new international treaty (the recently signed Persistent Organic Pollutants (POPs) Treaty) a worldwide campaign has been launched to discard the remaining stockpiles of POPs and rapidly phase out the commercial and residential use of these toxic substances.

Another common hazardous airborne substance is asbestos fiber, whose microscopically small aerodynamic diameter allows it to penetrate deeply into the alveolar region of human lungs. In the past, asbestos was used extensively in many commercial and residential applications, mainly as an acoustical and thermal insulator (in floor and ceiling tiles, cement pipes, etc.) and as a fire proofing material in building structures. Over time, asbestos fibers in these buildings became frayed and loose, thus allowing them to become airborne in both the interior and exterior of human dwellings. Chronic exposure to airborne asbestos fibers has been conclusively linked in many occupational health studies to a variety of diseases, including asbestosis (a debilitating respiratory disease), mesothelioma (abdominal carcinoma) and lung cancer .

Finally, certain biologically harmful radionuclides (such as Iodine-131, Cesium-137, Polonium-210, Strontium-90, etc) are released into the atmosphere in trace amounts from nuclear power plants and uranium processing facilities, and in considerably higher amounts during above ground nuclear weapons testing. On the other hand, the radionuclide gas, radon (which is a potential carcinogen) is present in the interior air of buildings and residences in certain geographical regions where it occurs naturally at high concentrations in the underlying soil substratum.

Indoor Air Pollution

Developing Regions

In recent years, there has been a growing recognition that in addition to deteriorating outdoor air quality in many parts of the world, indoor air pollution is a major public health problem, especially in rural populated areas of developing regions. A significant factor here is the almost exclusive reliance of rural populations on traditional forms of energy sources, such as biomass fuels that produce high levels of harmful air pollutants in indoor environments, e.g., gaseous fumes, smoke and fine particulate matter emitted from cooking stoves and other heat producing devices. It is estimated that currently 2 billion people around the world use biomass fuels (such as firewood, dung and crop residues), and other fossil fuel products (such as low grade coal and charcoal), to cook their meals and heat their homes. Recent studies have shown that in developing countries such as India and China, indoor air pollution poses a major risk factor on their national burden of disease. For example, using conservative assumptions of use patterns in the rural sector of India, it was determined that between 400,000 and 550,000 premature deaths annually may be attributed to the use of biomass fuels. Employing the World Bank's disability-adjusted lost life-year (DALY) approach, between 4 and 6 percent of India's burden of disease is linked to the use of biomass fuels in the country. Earlier studies had shown that particulate matter concentration levels (monitored as PM10) of over 2,000 micrograms per cubic meter (averaged over a 24-hour period) were measured in indoor dwellings among the rural population, with short-term PM10 levels rising considerably higher during cooking periods. This should be compared to the annual average atmospheric concentration levels of PM10 ranging between 90 and 600 micrograms

per cubic meter (with a population mean of 200 micrograms per cubic meter) in the outdoor air of many Indian cities and urban areas.

In addition to the use of traditional biomass fuels, coal is still widely used in many regions of Eastern Europe, China and South Africa. While coal products are easier to obtain, transport and store, they are a considerably less clean source of fuel than firewood. For the past twenty years, a number of national and international programs have been initiated to introduce clean fuels and cooking stoves around the world. Since the early 1980s, China has embarked on a major national effort to introduce improved cooking stoves to over 175 million rural households. A similar effort in India, under the aegis of National Programme on Improved Chulhas (cooking stoves), has led to distribution of 30 million improved stoves. Unfortunately, in a follow-up survey, it was found that less than one-third of such stoves were still in use in India. It now appears that many former recipients in rural areas remained unconvinced of the stove's overall energy efficiency and its ability to produce less smoke. The greater success of this approach in China may be attributed to superior program design and implementation, such as better education and training, less bureaucratic interference, with more user involvement in the construction of stoves for convenience, attractiveness and longevity.

Developed Regions

Indoor air pollution has also been recognized as an environmental health problem in many developed countries. Myriad air pollution sources reside in the interiors of buildings and residential homes, including gas-, coal-, wood- and kerosene-based stoves (buildup of carbon monoxide and nitrogen dioxide), building materials (asbestos floor and ceiling tiles), furnishings (volatile chemicals used in carpeting, drapes, upholstery), furniture and paneling (urea-formaldehyde resins used in pressed wood), household products (toxic chemicals used in cleaners, paints, solvents, insect sprays), household allergens (dust mites, molds, mildew, pet and insect residues), humidifiers (use of ultrasonic and impeller units), central heating and cooling systems, second-hand tobacco smoke, and radon gas seepage in residential basements. With buildings and homes now being built with more tightly sealed interiors, acute and chronic exposure to these indoor air pollutants has increased in recent years. This factor coupled with inadequate ventilating systems in the workplace and residential homes has enhanced the potential for serious respiratory illness for adults and children. Practical solutions to these problems include eliminating (where possible) the sources of indoor air pollutants, increasing the dwelling's air exchange rate with the outdoors (opening windows, unblocking air supply vents), cleaning humidifiers and ventilation systems, and installing air-cleaning devices.

A number of physical symptoms and diseases have been associated with indoor air pollution in the working environment of office buildings in developed countries. These include serious illnesses such as asthma, hypersensitivity pneumonitis, humidifier fever and Legionnaire's disease. More often, individuals working or residing in poorly maintained or inadequately ventilated buildings may not manifest any specific pattern of disease, but suffer from a variety of physical symptoms, collectively labeled as the "sick building syndrome". Such persons may experience a variety of different symptoms: headaches; dizziness; nausea; dryness or burning sensation in their eyes, nose or throat; a general sense of lethargy or fatigue; frequent sneezing; stuffy or runny nose; irritability; and forgetfulness. Frequently, these symptoms may affect workers when they enter a building and then dissipates when they leave the premises. WHO has estimated that as many as 30% of new or remodeled buildings today may have occupants who suffer from physical symptoms associated with poor indoor air quality.

Appendix III: Bacterial and Chemical Contaminants in Water— Drinking Water Standards ⁴⁹

Infectious and Vector-Borne Diseases

Microbial Diseases in Developing Regions

According to WHO and the US Centers for Disease Control and Prevention (CDC), over 2 billion people, mostly living in developing countries, are at elevated risk to water-related bacterial diseases. While there are many illnesses in this category, the major water-borne diseases include acute dehydrating diarrhea (cholera), abdominal illness (typhoid fever), bacterial enteritis (salmonellosis), acute diarrhea (dysentery) and chronic diarrhea (Brainerd diarrhea). One of the main modes of transmission of these diseases is from drinking bacterially infested water from poorly maintained municipal distribution systems. This happens either as a result of lack of chlorination at the drinking water source or through cross-contamination of the disinfectant-treated piped water by underground sewage wastes. Another mode of microbial infections from water sources occurs through occasional phytoplankton blooms. Such a bloom episode, in which pathogenic bacteria survive and spread widely, was associated with a major cholera outbreak in Bangladesh in 1994.

Proper means to address these water-related environmental health problems in developing regions requires simple point-of-use disinfection methods and availability of clean storage vessels. At present this may be achieved relatively inexpensively in many rural areas by the use sodium hypochlorite as a disinfectant, which is produced from salt water by means of simple electrolytic devices. However, the widespread use of sanitary latrines in rural areas, along with the introduction of sewage treatment systems in urban areas of developing regions, is necessary if long-term solutions to water pollution problems are to be achieved.

Cryptosporidiosis and Giardiasis

In many regions of the world, including the United States, a common water-related diarrheal disease that has been recognized as a major public health problem is cryptosporidiosis, which is caused by a microscopic parasite (*Cryptosporidium*). This parasite is generally found in drinking water, swimming pools and recreational streams that are contaminated by human fecal wastes. Since *Cryptosporidium* has a strong protective outer shell, it survives outside the human body for long periods of time, thus making it difficult to destroy by using conventional disinfectants such as chlorine. Additionally, this highly contagious disease can be transmitted by raw, uncooked food or by oral contact of bacterially contaminated objects by young children. For these reasons, thorough washing of hands with soap and water after using the toilet (or changing diapers) and before eating a meal is highly recommended. Furthermore, the importance of restricting the use of inside recreational waters (pools, jacuzzis, hot tubs) and outdoor streams by individuals who have been recently been infected with this bacterial disease needs to be widely communicated to the general public.

Another increasingly common water related diarrheal disease around the world, including the United States, is giardiasis, which is caused by a one-celled microscopic parasite (*Giardia*). Similar to the spread of cryptosporidium in the environment, giardia is transmitted by discharges of fecal wastes into water, food, soil and other surfaces. Therefore the preventative hygienic measures that are recommended to lower the overall incidence of cryptosporidiosis apply to giardiasis as well.

Malaria

One of the most serious vector-borne diseases in the world today is malaria. It occurs in many warm, tropical regions of the world, such as Central and South America, Hispaniola, the sub-Saharan region of Africa (where the largest annual incidences are reported), the Indian subcontinent, Southeast Asia, the Middle East and Oceania. Malaria is a water-related disease, since it is caused by four subspecies of microscopic parasites (*Plasmodium*) carried by female *Anopheles* mosquitoes that breed their larvae in stagnant pools and water storage reservoirs in warm climates. Each year, 300 to 500 million people contract malaria worldwide, of which some 1.5 to 2.7 million people die from the disease. The overwhelming majority (90%) of fatal cases are children below the age of 5 years. Since the 1970s,

⁴⁹ Excerpted from: Ahmed, A. Karim. *ob. cit.*

there has been a resurgence of malaria in many regions of the world, partially due to the rapid formation of parasites that are resistant to malaria preventing drugs, such as chloroquine and other quinoline products. In addition, significant increases in the incidence of malaria in recent years have been caused by the construction of dams, intensified irrigation systems and other water-related projects, accounting for a large number of new mosquito breeding sites in many developing regions.

In general, prevention and control of malarial diseases is quite complex and multifaceted. Though relatively expensive, the use of wire screens in houses and other buildings is an effective way to keep infectious mosquitoes out of indoor premises. The use of mosquito fish in small ponds and water tanks for reducing larval populations has met with success in some communities. Insect repellent treatments of home walls, bednets, mats and coils are also recommended in severely affected areas. It should be noted, however, that in many regions of the world, some strains of mosquitoes have become highly resistant to frequently used insecticides, such as DDT and pyrethroids. For travelers who plan to visit areas of the world where malarial diseases are endemic, it is important to take antimalarial prescription drug (whose non-resistant properties have been well established) in advance (generally 4–6 weeks before traveling) and to maintain a strict dosage regimen. Moreover, use of insect repellents is advisable, along with wearing clothing that covers the body and sleeping under mosquito bednets treated with insecticides.

Schistosomiasis and Trachoma

It is estimated that 200 million people worldwide are infected with schistosomiasis, with another 2 billion people in some 74 countries at elevated risk from this debilitating water-borne disease. Schistosomiasis (sometimes known as bilharzia) is caused by parasitic worms (*Schistosoma*) when human beings come into contact with certain types of snails that harbor these parasites in contaminated fresh water. The main factor in the proliferation of this disease is dumping human fecal wastes to fresh water sources. While 20 million people suffer from severe consequences of this disease, the World Health Organization states that better latrines and sanitation facilities could significantly reduce the incidence of schistosomiasis by as much as 77%. Prevention of schistosomiasis can be achieved by avoiding swimming or wading in contaminated streams and lakes, by drinking properly boiled water, and bathing or showering in water heated to 66 degrees C (150 degrees F) for 5 minutes.

Improved water sanitation and hygienic conditions could also reduce the worldwide incidence of trachoma, a serious chronic eye disease, which is caused by an infectious bacterial agent (*Chlamydia trachomatis*). This disease is spread by person-to-person contacts and by insect vectors such as houseflies. The infection begins by irritation of the cornea (trichiasis), which increases the risk of ulceration of the cornea, resulting in reduced vision and blindness. At present, it is estimated that 500 million people are at risk to this disease, while 146 million people are threatened with irreversible blindness. The World Health Organization estimates that trachoma results in 6 million cases of blindness each year, and that the prevalence of this disease in children is 10–40% in some African countries. Recently, WHO initiated a global campaign to eliminate trachoma, which consists of a combined strategy of: (1) monitoring and conducting surveillance for the disease, (2) improving community water supplies and introducing sanitation facilities, (3) encouraging individual hygiene programs, (4) prescribing the use of antimicrobial drugs, and (5) eye surgery to correct the onset of trichiasis.

Naturally Occurring Water Contaminants

Arsenic

An environmental health problem of enormous proportion has arisen in a number of regions of the world where naturally occurring arsenic found in subsoil layers has contaminated underground drinking water sources. The most severe cases of arsenic poisoning have occurred in Bangladesh, where it is estimated that between 35 and 77 million people (in a country of 125 million people) were exposed to this toxic chemical substance by ingesting drinking water from underground aquifers. Today, 97% of the population in Bangladesh drinks water drawn from underground aquifers. These underground drinking water sources were tapped through installation of tube wells under an extensive World Bank assisted program during the 1980s when it was recognized by local authorities that surface water sources in the country had become too contaminated for human consumption. At present, in many rural areas of the country arsenic is found in drinking water above WHO's recommended level of 10 parts per billion (ppb). To confront this public health crisis, a combination of remediation, clinical and educational programs have been undertaken by the national government and by a number of international agencies. Three types of action programs have been identified to address this problem: (1) enabling people in the community to have access to

arsenic-free drinking water, (2) providing financial assistance and medical treatment to those suffering from arsenic poisoning, and (3) conducting an extensive study of underground water sources to understand the overall hydro-geological nature of the problem.

Toxicological studies show that ingestion of arsenic may lead to thickening of the skin, nervous system disorders, digestive problems, diabetes, liver disease, and cancer. Treatment for arsenic poisoning range from changes in dietary habits (e.g., eating more high sulfur-containing foods, such as eggs, onions and garlic, and those food products with high fiber content) to medical treatments (oral ingestion of charcoal tablets or intravenous injection of metal binding agents). Other countries of the world where arsenic in drinking water from underground sources (and in some cases from surface mine tailings and agricultural runoffs) has also been identified as an environmental health risk include Argentina, Chile, China, India, Mexico, Thailand and the United States.

Fluoride

In several regions of the world, unsafe levels of naturally occurring fluoride, which is present abundantly in the earth's crust, are found in drinking water. Excessive level of fluoride ingestion causes a chronic disease known as fluorosis, which is a serious bone disease that discolors teeth (dental fluorosis), and causes stiffness of joints and other skeletal deformations. According to UNICEF, fluorosis is endemic in at least 25 countries across the globe, whereas WHO estimates that in China alone some 30 million people suffer from chronic fluorosis. In 1993, fluorosis was reported to be endemic in 15 out of 32 states in India and an estimated 5 million people in Mexico were affected by high levels of fluoride from exposure to underground drinking water. In areas of the world where high levels of fluoride occur in groundwater, surface water sources need to be developed that are free of bacterial and chemical contaminants. Another approach is to remove fluoride from groundwater sources by employing either flocculation (solid precipitation) or adsorption (chemical binding) treatment procedures. Currently, in many developed countries, fluoride is added intentionally in drinking water—at a presumed safe concentration level of around 1 part per million (ppm)—as a preventative measure against dental decay. However, WHO has recommended that in warmer climates, fluoride in drinking water be kept below the 1 ppm concentration level, since individuals in hot weather ingests greater quantities of water daily than those living in more temperature regions.

Water-Related Toxic Substances and Hazardous Wastes

Increasingly, many surface and underground drinking water sources around the world have become severely polluted by a variety of toxic chemical substances and hazardous wastes. These sources of water contamination include manufacturing, refinery and municipal effluent discharges, leachates from landfills and hazardous waste sites, agricultural runoffs, mining operations, and other commercial and recreational activities. Among the more common toxic substances found in drinking water are (i) heavy metals, (ii) toxic organic compounds, (iii) pesticides and fertilizers, and (iv) disinfection by-products.⁵⁰

The major identifiable or “point” sources of heavy metal contamination of waterways are from the mining, metal smelting, electroplating and chemical manufacturing industries, whereas “non-point” sources of heavy metals are mainly from agricultural runoffs (containing mineral fertilizers, sewage sludge and certain types of pesticides) and from urban/suburban runoffs, along with atmospheric fallout linked to road traffic and emissions from power plants and waste incinerators. Major sources of toxic organic compounds in surface and ground water are from chemical, pharmaceutical, synthetic polymer (plastic/rubber) and fossil fuel refining industries, while most pesticide contamination of drinking water originates from agricultural and domestic uses.

Disinfectant by-products are formed in waterways and reservoirs when chlorine—used as a bactericidal agent in many water treatment plants—chemically reacts with naturally occurring organic compounds (e.g., soil-bearing humic acids) to form a number of halogenated organic compounds, such as chloroform and bromoform. In addition, agricultural runoff of nitrogen fertilizers in many rural areas of the world contaminates rivers, lakes and underground aquifers leading to excessive levels of dissolved nitrates in drinking water that may cause “blue baby syndrome”, an acute and serious life-threatening disease among infants and young children.

The presence of toxic chemical substances and hazardous waste materials in drinking water pose a large spectrum of human health risks to the general population. They range from simple ailments such as short-term skin rashes, nose and eye irritation, gastrointestinal distress, numbness in fingers and toes, to a variety of serious acute and

⁵⁰ Examples of heavy metals in water resources consist of such chemical substances as beryllium, cadmium, chromium, lead, mercury, nickel; toxic organic compounds such as benzene, dichloroethylene, dioxin, ethylene dibromide, MTBE, phthalates, PCBs, toluene, xylenes; pesticides such as alachlor, atrazine, DDT, dalapron, hexachlorobenzene, lindane, permethrin, 2,4-D; and disinfection by-products such as bromates, chlorophenols, chloroform, bromoform, halogenated acetic acids and acetonitriles (For more explanatory information on these chemical substances, see Section III-B).

chronic diseases. For instance, a number of heavy metals cause long-term liver and kidney damage, nervous system disorders, loss of fingernails and hair, blood pressure changes and circulatory problems. Many persistent organic pollutants (POPs) found in drinking water, such as aromatic and halogenated hydrocarbons, cause developmental and nervous system disorders, reproductive difficulties, liver and kidney problems, several types of cardiovascular disorders, increased risks of childhood and adult cancer and potential genetic damage to future generations. The chief characteristic of POPs is their long-lasting presence in the environment, where they can exert their adverse toxicological effects on human and animal populations for many years or even decades.

The human health risks associated with ingesting heavy metal and toxic organic substances in drinking water over a prolonged period of time often occurs at relatively low concentration levels, generally in the range of parts per million (ppm) or below. For these reasons, prevention and/or removal of trace amounts of these water-borne contaminants in drinking water sources is considered a matter of high priority by regulatory agencies in many industrialized and rapidly developing countries. In addition to prohibiting or severely restricting the discharge of toxic effluents and hazardous wastes into surface and ground water sources, a number of technological solutions may be employed to remove chemical contaminants in drinking water. These include the use of activated charcoal filters (and other chemical adsorption devices) at the water tap to remove persistent organic pollutants and disinfectant by-products in homes and office buildings.

In some areas of developed countries, such as the United States and Canada, where ground water has been severely polluted with heavy metals or toxic organic compounds, an entire aquifer that serves a community may have to undergo extensive remediation, such as by pumping out and treating the underground contaminated drinking water source. At present, the treatment technologies to remove drinking water contaminants employ a variety of approaches, including chemical adsorption technique, biological degradation, air stripping of volatile compounds and metallic precipitation. However, such a remediation procedure would be prohibitively expensive and difficult to carry out in less developed regions of the world, and is not recommended as the method of first choice in most cases.

Water Resources and Drinking Water Standards

At present, drinking water is not available at sufficient amounts needed for daily human consumption in many regions of the world for the simple reason that the global supply of freshwater is unevenly distributed. For instance, some arid and semi-arid regions on the earth's surface receive only about 2% of the global flow of fresh water, while they account for 40% of the total landmass of the world. On the other hand, some major river basins may carry enormous quantities of fresh water, such as the Amazon River (accounting for 16% of the global water run-off) or the Congo River basin, which accounts for one-third of all fresh water flow on the African continent. For these reasons, in many regions of the world more than half the population, especially those living in rural areas, obtain their drinking water supplies from shallow well waters and underground aquifers.

In addition to providing drinking water that is free from pathogenic microbial contaminants that cause water-borne infectious diseases, special steps must be taken to keep toxic substances (such as industrial chemicals, urban/suburban storm water effluents and agricultural runoffs) from polluting downstream water resources. These measures include protecting watersheds and aquatic recharge areas from a variety of human activities, such as dumping of human wastes, mining operations, manufacturing discharges and excessive use of agricultural fertilizers and pesticides. Groundwater sources of drinking water must be protected from surface drainage and flooding, with rainwater recharge areas kept free of garbage and toxic waste disposals, agricultural husbandry and land clearance activities.

An important factor in achieving clean water supplies for the community is the development of health-based water quality standards and indicators that should be accompanied by frequent monitoring to ensure compliance with safe drinking water guidelines and regulations. WHO has issued Guidelines for Drinking Water Quality, a set of recommendations whose primary goal is to safeguard human health and which were intended for the development of national water quality standards. Its health-based guidelines for chemical substances are divided as follows: (i) inorganic compounds (including heavy metals and anions), (ii) organic compounds, (iii) pesticides, and (iv) disinfectants/disinfectant by-products. The WHO guidelines provide recommended maximum acceptable concentration levels for each water-borne contaminant in order to ensure the safety of drinking water sources. However, these guidelines are not envisioned to be a mandatory limit, since the water quality guidelines are to be viewed "in the context of local or national environmental, social, economic and cultural conditions."

Under the U. S. Safe Drinking Water Act, the United States Environmental Protection Agency (USEPA) has issued legally enforceable drinking water standards known as National Primary Drinking Water Regulations (NPDWRs), which are divided into the following broad categories: (i) microorganisms (including bacteria and viruses), (ii)

disinfectants/disinfectant by-products, (iii) inorganic chemicals (including heavy metals and anions), (iv) organic chemicals (including pesticides), and (v) radionuclides (including alpha and beta particles). In addition, the USEPA has published non-enforceable guidelines—the National Secondary Drinking Water Regulations (NSDWRs)—on a number of physical/chemical factors and chemical substances that cause cosmetic or aesthetic effects in drinking water. These include items such as corrosivity, odor, color, foaming agents, pH (acidity), total dissolved solids and the non-health impacts of a number of metal cations and anions (aluminum, chloride, copper, fluoride, iron, manganese, silver, sulfate and zinc). However, each state in the U. S. has the regulatory discretion to adopt the federal NSDWRs as enforceable drinking water standards.

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