Environmental and Health Impacts of Air Pollution: A Research Article

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ABSTRACT

One of our era's greatest courgesis air pollution, on account not only of its impact on climate change but also its impact on public and individual health due to increasing morbidity and mortality. There are many pollutants that are major factors in disease in humans. Among them, Particulate Matter (PM), particles of variable but very small diameter, penetrate the respiratory system via inhalation, causing respiratory and cardiovascular diseases, reproductive and central nervous system dysfunctions, and cancer. Despite the fact that ozone in the stratosphere plays a protective role against ultraviolet irradiation, it is harmful when in high concentration at ground level, also affecting the respiratory and cardiovascular system. Further more, nitrogen oxide, sulfurdioxide, Volatile Organic Compounds (VOCs), dioxins ,and polycyclic aromatic hydrocarbons (PAHs) are all considered air pollutants that are harmful to humans. Carbon monoxide can even provoke direct poisoning when breathed in at high levels. Heavy metals such as lead, when absorbed into the human body, can lead to direct poisoning or chronic in toxication, depending on exposure. Diseases occurring from the a fore mentioned substances include principally respiratory problems such as Chronic Obstructive Pulmonary Disease (COPD), asthma, bronchiolitis, and also lung cancer, cardiovascular events, central nervous system dysfunctions, and cutaneous diseases. Last but not least, climate change resulting from environmental pollution affects the geographic all distribution of many infectious diseases, as do natural disasters. The only way to tackle this problem is through public awareness coupled with a multi disciplinary approach by scientific experts; national and international organizations must address he emergence of this threat and propose sustainable solutions.

KEYWORDS

air pollution, environment, health, public health, gas emission, policy

1. APPROACH TO THE PROBLEM

The interactions between humans and their physical surroundings have been extensively studied, as multiple human activities influence the environment. The environment is a coupling of the biotic (living organisms and microorganisms) and the abiotic (hydrosphere, lithosphere, and atmosphere). Pollution is defined as the introduction into the environment of substances harmful to humans and other living organisms. Pollutants are harmful solids, liquids, or gases produced in higher than usual concentrations that reduce the quality of our environment.

Human activities have an adverse effect on the environment by polluting the water we drink, the air we breathe, and the soil in which plants grow. Although the industrial revolution was a great success in terms of technology, society, and the provision of multiple services, it also introduced the production of huge quantities of pollutants emitted into the air that are harmful to human health. Without any doubt, the global environmental pollution is considered an international public health issue with multiple facets. Social, economic, and legislative concerns and lifestyle habits are related to this major problem. Clearly, urbanization and industrialization are reaching unprecedented and up setting proportions world wide in our era. Anthropogenic air pollution is one of the biggest public health hazards world wide, given that it accounts for about 9 million deaths per year[1] Without a doubt, all of the aforementioned are closely associated with climate change, and in the event of danger, the consequences can be severe for mankind [2]. Climate changes and the effects of global planetary warming seriously affect multiple ecosystems, causing problems such as food safety issues, ice and iceberg melting, animal extinction, and damage to plants [3, 4]. Air pollution has various health effects. The health of susceptible and sensitive individuals can be impacted even on low air pollution days. Short-term exposure to air pollutants is closely related to COPD (Chronic Obstructive Pulmonary Disease), cough, shortness of breath, wheezing, asthma, respiratory disease, and high rates of hospitalization (a measurement of morbidity).

The long-term effects associated with air pollution are chronic asthma, pulmonary insufficiency, cardiovascular diseases, and cardiovascular mortality. According to a Swedish cohort study, diabetes seems to be induced after long-term air pollution exposure [5]. Moreover, air pollution seems to have various malign health effects in early human life, such as respiratory, cardiovascular, mental, and perinatal disorders [3], leading to infant mortality or chronic disease in adult age [6].

National reports have mentioned the increased risk of morbidity and mortality [1]. These studies were conducted in many places around the world and show a correlation between daily ranges of particulate matter (PM) concentration and daily mortality. Climate shifts and global planetary warming [3] could aggravate the situation. Besides, increased hospitalization (an index of morbidity) has been registered among the elderly and susceptible individuals for specific reasons. Fine and ultrafine particulate matter seems to be associated with more serious illnesses [6], as it can invade the deepest parts of the air ways and more easily reach the bloodstream.
Technological innovation can only be successful if it is able to meet the needs of society. In this sense, technology must reflect the decision-making practices and procedures of those involved in risk assessment and evaluation and act as a facilitator in providing information and assessments to enable decision makers to make the best decisions possible. Summarizing the a forementioned in order to design an effective air quality control strategy, several aspects must be considered: environmental factors and ambient air quality conditions, engineering factors and air pollutant characteristics, and finally, economic operating costs for technological improvement and

administrative and legal costs. Considering the economic factor, competitiveness through neoliberal concepts is offering a solution to environmental problems [22].

The development of environmental governance, along with technological progress, has initiated the deployment of a dialogue. Environmental politics has created objections and points of opposition between different political parties, scientists, media, and governmental and non-governmental organizations [22]. Radical environmental activism actions and movements have been created [22]. The rise of the new information and communication technologies (ICTs) are many times examined as to whether and in which way they have influenced means of communication and social movements such as activism [28]. Since the 1990s, the term "digital activism" has been used increasingly and in many different disciplines [29]. Nowadays, multiple digital technologies can be used to produce a digital activism outcome on environmental issues. More specifically, devices with online capabilities such as computers or mobile phones are being used as a way to pursue change in political and social affairs [30].
In the present paper, we focus on the sources of environmental pollution in relation to public health and propose some solutions and interventions that may be of interest to environmental legislators and decision makers.

2. SOURCES OF EXPOSURE

It is known that the majority of environmental pollutants are emitted through large-scale human activities such as the useof industrial machinery, power-producing stations, combustion engines, and cars. Because these activities are performed at such a large scale, they are by far the major contributors to air pollution, with cars estimated to be responsible for approximately 80% of today's pollution [31]. Some other human activities are also influencing our environment to a lesser extent, such as field cultivation techniques, gas stations, fuel tanks heaters, and cleaning procedures [32], as well as several natural sources, such as volcanic and soil eruptions and forest fires.

The classification of air pollutants is based mainly on the sources producing pollution. Therefore, it is worth mentioning the four main sources, following the classification system: Major sources, Area sources, Mobile sources, and Natural sources.
Major sources include the emission of pollutants from power stations, refineries, and petrochemicals, the chemical and fertilizer industries, metallurgical and other industrial plants, and, finally, municipal incineration. Indoor area sources include domestic cleaning activities, dry cleaners, printing shops, and petrol stations.

Mobile sources include automobiles, cars, railways, airways, and other types of vehicles. Finally, natural sources include, as stated previously, physical disasters [33] such as forest fire, volcanic erosion, dust storms, and agricultural burning.

However, many classification systems have been proposed. Another type of classification is a grouping according to the recipient of the pollution, as follows:
Air pollution is determined as the presence of pollutants in the air in large quantities for long periods. Air pollutants are dispersed particles, hydrocarbons, CO, CO_2, NO, NO_2, SO_3 etc.
Water pollution is organic and inorganic charge and biological charge (10) at high levels that affect the water quality[34,35].

Soil pollution occurs through the release of chemicals or the disposal of wastes, such as heavy metals, hydrocarbons, and pesticides. Air pollution can influence the quality of soil and water bodies by polluting precipitation, falling into water and soil environments [34,36].

Notably, the chemistry of the soil can be amended due to acid precipitation by affecting plants, cultures, and water quality [37]. Moreover, movement of heavy metals is favored by soil acidity, and metals are so then moving into the watery environment. It is known that heavy metals such as aluminum are noxious to wildlife and fishes. Soil quality seems to be of importance, as soils with low calcium carbonate levels are at increased jeopardy from acid rain. Over and above rain, snow and particulate matter drip into watery bodies [36, 38].

3. CLIMATEANDPOLLUTION

Air pollution and climate change are closely related. Climate is the other side of the same coin that reduces the quality of our Earth [44]. Pollutants such as black carbon, methane, tropospheric ozone, and aerosols affect the amount of incoming sunlight. As a result, the temperature of the Earth is increasing, resulting in the meltingofice, icebergs and glaciers.

In this vein, climatic changes will affect the incidence and prevalence of both residual and imported infections in Europe. Climate and weather affect the duration, timing, and intensity of outbreaks strongly and change the map of infectious diseases in the globe [45]. Mosquito-transmitted parasitic or viral diseases are extremely climate-sensitive, as warming firstly shortens the pathogen incubation period and secondly shifts the geographic map of the vector. Similarly, water-warming following climate changes leads to a high incidence of waterborne infections. Recently, in Europe, eradicated diseases seem to be emerging due to the migration of population, for example, cholera, poliomyelitis, tick-borne encephalitis, and malaria [46].

The spread of epidemics is associated with natural climate disasters and storms, which seem to occur more frequently nowadays[47]. Malnutrition and dis equilibration of the immune system are also associated with the emerging infections affecting public health [48].

The Chikungunya virus “took the airplane” from the Indian Oceanto Europe, as outbreaks of the disease were registered in Italy [49] as well as autochthonous cases in France [50].

4. AIRPOLLUTANTS

The World Health Organization (WHO) reports on six major air pollutants, namely particle pollution, ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead. Air pollution can have a disastrous effect on all components of the environment, including ground water, soil, and air. Additionally, it poses a serious threat to living organisms. In this vein, our interest is mainly to focus on these pollutants, as they are related to more extensive and severe problems in human health and environmental impact. Acid rain, global warming, the greenhouse effect, and climate changes have an important ecological impact on air pollution [53].

Particulate Matter (PM) and Health

Studies have shown a relationship between particulate matter (PM) and adverse health effects, focusing on either short-term (acute) or long-term (chronic) PM exposure.

Particulate matter (PM) is usually formed in the atmosphere as a result of chemical reactions between the different pollutants. The penetration of particles is closely dependent on their size [53]. Particulate Matter (PM) was defined as a term for particles by the United States Environmental Protection Agency [54]. Particulate matter (PM) pollution includes particles with diameters of 10 micrometers (μm) or smaller, called PM_{10}, and extremely fine particles with diameters that are generally 2.5 micrometers (μm) and smaller.

Particulate matter contains tiny liquid or solid droplets that can be inhaled and cause serious health effects[55]. Particles <10μmindiameter (PM_{10}) after inhalation can invade the lungs and even reach the bloodstream. Fine particles, $PM_{2.5}$, pose a greater risk to health [6, 56]

(**Table 1**)

Multiple epidemiological studies have been performed on the health effects of PM. A positive relation was shown between

TABLE1|Penetrabilityaccordingtoparticlesize.

Particle size	Penetration degree in human respiratory system
>11μm	Passage into nostrils and upper respiratory tract
7–11μm	Passage into nasal cavity
4.7–7μm	Passage into larynx
3.3–4.7 μm	Passage into trachea-bronchial area
2.1–3.3 μm	Secondary bronchial area passage
1.1–2.1 μm	Terminal bronchial area passage
0.65–1.1μm	Bronchioles penetrability
0.43–0.65μm	Alveolar penetrability

both short-term and long-term exposures of $PM_{2.5}$ and acute nasopharyngitis [56]. In addition, long-term exposure to PM for years was found to be related to cardiovascular diseases and infant mortality.

Those studies depend on $PM_{2.5}$ monitors and are restricted in terms of study area or city area due to a lack of spatially resolved daily $PM_{2.5}$ concentration data and, in this way, are not representative of the entire population. Following a recent epidemiological study by the Department of Environmental Health at Harvard School of Public Health (Boston, MA)(57), it was reported that, as $PM_{2.5}$ concentrations vary spatially, an exposure error (Berkson error) seems to be produced, and the relative magnitudes of the short- and long-term effects are not yetcompletelyelucidated.Theteamdeveloped$PM_{2.5}$ exposure model based on remote sensing data for assessing short- and long-term human exposures [57]. This model permits spatial resolution in short-term effects plus the assessment of long-term effects in the whole population.

More over, respiratory diseases and affection of the immune system are registered as long-term chronic effects [58]. It is worth noting that people with asthma, pneumonia, diabetes, and respiratory and cardiovascular diseases are especially susceptible and vulnerable to the effects of PM. $PM_{2.5}$, followed by PM_{10}, are strongly associated with diverse respiratory system diseases [59], as their size permits them to pierce interior spaces [60]. The particles produce toxic effects according to their chemical andphysicalproperties.ThecomponentsofPM_{10} and$PM_{2.5}$ can be organic(polycyclic aromatic hydrocarbons, dioxins, benzene, 1-3butadiene) or inorganic (carbon, chlorides, nitrates, sulfates, metals) in nature [55]. Particulate Matter (PM) is divided into four main categories according to type and size [61]

(**Table 2**)

TABLE2|Types and sizes of particulate Matter (PM)

Type		PM diameter [μm]
Particulate contaminants	Smog	0.01–1
	Soot	0.01–0.8
	Tobacco smoke	0.01–1
	Fly ash	1–100
	Cement Dust	8–100
Biological Contaminants	Bacteria and bacterial spores	0.7–10
	Viruses	0.01–1
	Fungi and molds	2–12
	Allergens(dogs, cats, pollen, house hold dust)	0.1–100
Types of Dust	Atmospheric dust	0.01–1
	Heavy dust	100–1000
	Settling dust	1–100
Gases	Different gaseous contaminants	0.0001–0.01

Ozone Impact in the Atmosphere

Ozone (O_3) is a gas formed from oxygen under high voltage electric discharge [62]. It is a strong oxidant, 52% stronger than chlorine. It arises in the stratosphere, but it could also arise following chain reactions of photochemical smog in the troposphere [63].

Ozone can travel to distant areas from its initial source, moving with air masses [64]. It is surprising that ozone levels over cities are low in contrast to the increased amounts occuring in urban areas, which could become harmful for cultures, forests, and vegetation [65] as it is reducing carbon assimilation[66].Ozone reduces growth and yield[47,48] and affects the plant micro flora due to its antimicrobial capacity [67, 68]. In this regard, ozone acts upon other natural ecosystems, with micro flora [69,70] and animal species changing their species composition [71]. Ozone increases DNA damage in epidermal keratinocytes and leads to impaired cellular function [72].

Carbon Monoxide (CO)

Carbon monoxide is produced by fossil fuel when combustion is incomplete. The symptoms of poisoning due to inhaling carbon monoxide include headache, dizziness, weakness, nausea, vomiting, and, finally, loss of consciousness.

The affinity of carbon monoxide to hemoglobin is much greater than that of oxygen. In this vein, serious poisoning may occur in people exposed to high levels of carbon monoxide for a long period of time. Due to the loss of oxygen as a result of the competitive binding of carbon monoxide, hypoxia, ischemia, and cardiovascular disease are observed.

Carbon monoxide affects the greenhouses gases that are tightly connected to global warming and climate. This should lead to an increase in soil and water temperatures, and extreme weather conditions or storms may occur [68]. However, in laboratory and field experiments, it has been seen to produce increased plant growth [78].

Nitrogen Oxide(NO_2).

Nitrogen oxide is a traffic-related pollutant, as it is emitted from auto mobile motorengines [79,80].It is an irritant of the respiratory system as it penetrates deep in the lung, inducing respiratory diseases, coughing, wheezing, dyspnea, broncho spasm, and even pulmonary edema when in haled at high levels. It seems that concentration sover 0.2ppm produce these adverse effects in humans, while concentration shigher than 2.0 ppm affect T-lymphocytes,particularly the CD8+ cells and NKCells that produce our immune response [81]. It is reported that long-term exposure to high levels of nitrogen dioxide can be responsible for chronic lung disease. Long-term exposure to NO_2 can impair the sense of smell [81]. However, systems other than respiratory ones can be involved, as symptoms such as eye, throat, and nose irritation have been registered (81).

Sulfur Dioxide(SO_2)

Sulfur dioxide is a harmful gas that is emitted mainly from fossil fuel consumption or industrial activities. The annual standard for SO_2 is 0.03 ppm [82]. It affects human, animal, and plant life. Susceptible people as those with lung disease, old people, and children, who present a higher risk of damage. The major health problems associated with sulfur dioxide emissions in industrialized areas are respiratory irritation, bronchitis, mucus production, and broncho spasm, as it is a sensory irritant and penetrates deep into the lung converted into bisulfite and interacting with sensory receptors, causing broncho constriction.

Lead

Lead is a heavy metal used in different industrial plants and emitted from some petrol motor engines, batteries, radiators, waste incinerators, and waste waters [84]. Moreover, major sources of lead pollution in the air are metals, ore, and piston-engine aircraft. Lead poisoning is a threat to public health due to its deleterious effects upon humans, animals, and the environment, especially in the developing countries.

Exposure to lead can occur through in halation, ingestion, and dermal absorption. Trans-placental transport of lead was also reported, as lead passes through the placenta unencumbered[85]. The younger the fetus is, the more harmful the toxic effects. Lead toxicity affects the fetal nervous system; edema or swelling of the brain is observed [86]. Lead, when inhaled, accumulates in the blood, soft tissue, liver, lung, bones, and cardiovascular, nervous, and reproductive systems. Moreover, loss of concentration and memory, as well as muscle and joint pain, were observed in adults [85, 86].

Polycyclic Aromatic Hydrocarbons (PAHs)

The distribution of PAHs is ubiquitous in the environment, as the atmosphere is the most important means of their dispersal. They are found in coal and intarsediments. Moreover, they are generated through incomplete combustion of organic matter as in the cases of forest fires, incineration, and engines [89]. PAH compounds, such as benzopyrene, acenaphthylene, anthracene, and fluoran the near erecognizedastoxic, mutagenic, and carcinogenic substances. They are an important risk factor for lung cancer [89].

Volatile Organic Compounds(VOCs)

Volatile organic compounds (VOCs), such as toluene, benzene, ethylbenzene, and xylene(90),have been found to be associated with cancer in humans (91). The use of new products and materials has actually resulted in increased concentrations of VOCs. VOCs pollute indoor air (90) and may have adverse effects on human health(91).Short-term and long-term adverse effects on human health are observed. VOCs are responsible for indoor air smells. Short-term exposure is found to cause irritation of eyes, nose, throat, and mucosal membranes, while those of long duration exposure include toxic reactions [92]. Predictable assessment of the toxic

effects of complex VOC mixtures is difficult to estimate, as these pollutants can have synergic, antagonistic, or indifferent effects [91, 93].

Dioxins

Dioxins originate from industrial processes but also come from natural processes, such as forest fires and volcanic eruptions. They accumulate in foods such as meat and dairy products, fish and shellfish, and especially in the fatty tissue of animals ([94]. Short-period exhibition to high dioxin concentrations may result in dark spots and lesions on the skin [94].Long- term exposure to dioxins can cause developmental problems, impairment of the immune, endocrine and nervous systems, reproductive infertility, and cancer [94].

Without any doubt, fossil fuel consumption is responsible for a sizeable part of air contamination. This contamination may be anthropogenic, as in agricultural and industrial processes or transportation, while contamination from natural sources is also possible. Interestingly, it is of note that the air quality standards established through the European Air Quality Directive are some what looser than the WHO guidelines, which are stricter [95].

5. EFFECT OF AIR POLLUTION ON HEALTH

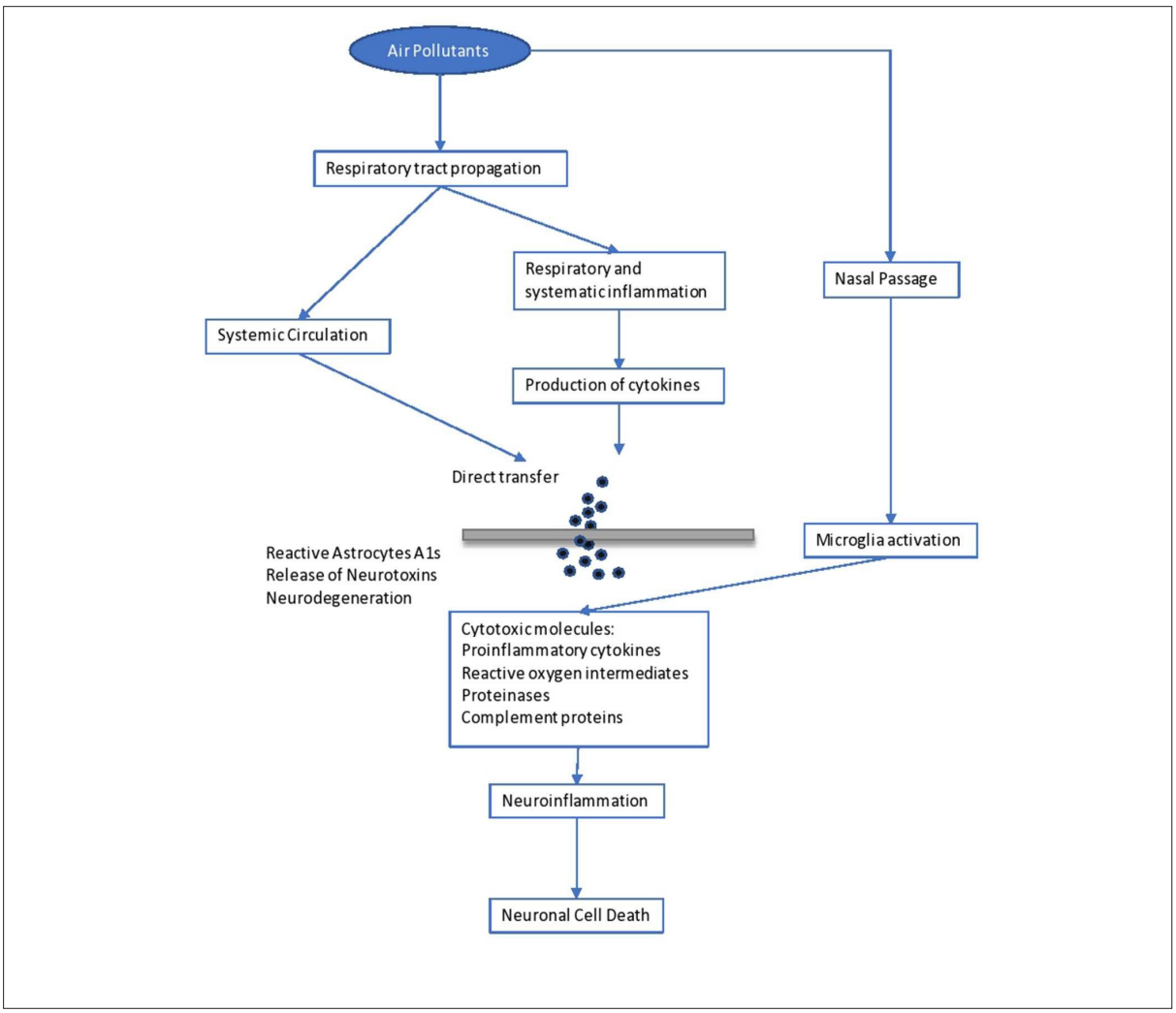
The most common air pollutants are ground-level ozone and Particulates Matter(PM). Air pollution is distinguished into two main types:

Outdoor pollution is the ambient air pollution.
Indoor pollution is the pollution generated by household combustion of fuels.

People exposed to high concentrations of air pollutants experience disease symptoms and states of greater and lesser seriousness. These effects are grouped into short- and long-term effects affecting health.

Susceptible populations that need to be aware of health protection measures include old people, children, and people with diabetes and predisposing heart or lung disease, especially asthma.

As extensively stated previously, according to a recent epidemiological study from Harvard School of Public Health, the relative magnitudes of the short- and long-term effects have not been completely clarified [57] due to the different epidemiological methodologies and to the exposure errors. New models are proposed for assessing short-and long-term human exposure data more successfully [57]. Thus, in the present section, were port them or common short-and long-term health effects but also general concerns for both types of effects, as these effects are often dependent on environmental conditions, dose, and individual susceptibility.



6. ENVIRONMENTAL IMPACT OF AIR POLLUTION

Air pollution is harming not only human health but also the environment in which we live. The most important environmental effects are as follows.

Acid rain is wet (rain, fog, snow) or dry (particulates and gas) precipitation containing toxic amounts of nitric and sulfuric acids. They are able to acidify the water and soil environments, damage trees and plantations, and even damage buildings and outdoor sculptures, constructions, and statues.

Haze is produced when fine particles are dispersed in the air and reduce the transparency of the atmosphere. It is caused by gas emissions in the air coming from industrial facilities, power plants, automobiles, and trucks.

Ozone, as discussed previously, occurs both at ground level and in the upper level (stratosphere) of the Earth's atmosphere. Stratospheric ozone is protecting us from the Sun's harmful ultraviolet (UV) rays. In contrast, ground-level ozone is harmful to human health and is a pollutant. Unfortunately, stratospheric ozone is gradually damaged by ozone-depleting substances(i.e., chemicals, pesticides, and aerosols). If this protecting stratospheric ozone layer is thinned, then UV radiation can reach our Earth, with harmful effects for human life(skin cancer)(116) and crops(117).In plants, ozone penetrates through the stomata, inducing them to close, which blocks CO_2 transfer and induces a reduction in photosynthesis .

Global climate change is an important issue that concerns mankind. As is known, the "greenhouse effect" keeps the Earth's temperature stable. Unhappily, anthropogenic activities have destroyed this protecting temperature effect by producing large amounts of greenhouse gases, and global warming is mounting, with harmful effects on human health, animals, forests, wildlife, agriculture, and the water environment. Are port states that global warming is adding to the health risks of poor people .

7. DISCUSSION

In 2018, during the first WHO Global Conference on Air Pollution and Health, the WHO's General Director, Dr. Tedros AdhanomGhebreyesus, called air pollution "silent public health emergency" and "the new tobacco".

Undoubtedly, children are particularly vulnerable to air pollution, especially during their development. Air pollution as adverse effects on our lives in many different respects.
Diseases associated with air pollution have not only an important economic impact but also a societal impact due to absences from productive work and school.

Despite the difficulty of eradicating the problem of anthropogenic environmental pollution, a successful solution could be envisaged as a tight collaboration of authorities, bodies, and doctors to regularize the situation. Governments should spread sufficient information and educate people and should involve professionals in these issues so as to control the emergence of the problem successfully.

Technologies to reduce air pollution at the source must be established and should be used in all industries and power plants. The Kyoto Protocol of 1997 set as a major target the reduction ofGHGemissionstobelow5%by2012(123).This was followed by the Copenhagen summit, 2009 , and then the Durban summitof2011(125),where it was decided to keep to the same line of action. The Kyoto protocol and the subsequent ones were ratified by many countries. Among the pioneers who adopted this important protocol for the world's environmental and climate "health" was China [(3).] As is known, China is a fast-developing economy and its GDP (Gross Domestic

Product) is expected to be very high by 2050,which is defined as the year of dissolution of the protocol for the decrease in gas emissions.

A more recent international agreement of crucial importance for climate change is the Paris Agreement of 2015, issued by the UNFCCC(United Nations Climate Change Committee). This latest agreement was ratified by a plethora of UN (United Nations) countries as well as the countries of the European Union . In this vein, parties should promote actions and measures to enhance numerous aspects around the subject. Boosting education, training, public awareness, and public participation are some of the relevant actions for maximizing the opportunities to achieve the targets and goals on the crucial matter of climate change and environmental pollution (126). Without any doubt, technological improvements makes our world easier and it seems difficult to reduce the harmful impact caused by gas emissions, we could limit its use by seeking reliable approaches.

Synopsizing, a global prevention policy should be designed in order to combat anthropogenic air pollution as a complement to the correct handling of the adverse health effects associated with air pollution. Sustainable development practices should be applied, together with information coming from research in order to handle the problem effectively.

At this point, international cooperation in terms of research, development, administration policy, monitoring, and politics is vital for effective pollution control. Legislation concerning air pollution must be aligned and updated, and policy makers should propose the design of a powerful tool of environmental and health protection. As a result, the main proposal of this essay is that we should focus on fostering local structures to promote experience and practice and extrapolate these to the international level through developing effective policies for sustainable management of ecosystems.

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