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Causes and Consequences of Air Pollution and Environmental Injustice as Critical Issues for Science and Environmental Education

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1. Introduction

1.1 Humanity facing complex environmental issues

Modern societies suffer from a diversity of problems involving crucial environmental aspects. These problems concern biodiversity conservation, clean water and clean unpolluted air availability, healthy food, personal and public health and well-being. The causes of these problems lay in the way individuals -as well as entire societies- interact with the natural and form the man-made environment by adopting specific practices and developmental choices. They are also connected with the way people perceive the relationship between human beings, nature and society, in other words the way in which we perceive nature, ourselves and others. For decades -even for centuries- the kind of this relationship has been determined by the conviction of man's dominance over nature and of the more powerful over the weak parts of the population. Thus, in order to face environmental problems and protect the environment it is essential that the relationship between human beings, nature and society is revised. As Einstein aptly put it *"we can't solve problems by using the same kind of thinking we used when we created them"*.

Confronting environmental problems is not an unequivocal process, since they involve multiple dimensions and are determined by a variety of factors. They entail physical, chemical, biological, ecological, social, economic, and political dimensions, intrinsically interrelated and interacting, and often conflicting. Also, environmental problems are usually ideologically 'charged', incorporate different social groups' views and interests, and are connected with decisions taken at economic, political and social level.

Therefore, facing environmental problems is a complex procedure requiring -among others- determining their causes and consequences, their management, the development of alternative solutions and decision-making. It also requires disentangling their components and characteristics and critically determining their inherent interrelations, mechanisms, and conflicts. For this procedure to be effective, an understanding of the environment, its functions and constituent systems -both natural and social- as a whole is imperative. Hence, addressing environmental issues calls for interdisciplinary, systemic and holistic approaches. It also calls for promoting citizens' critical and systemic thinking, in order for them to identify the causes -and not simply the symptoms- of these issues, to understand

the conflicts embedded in their consideration and treatment by different social, political, or interest groups (Dimitriou, 2009; Flogaitis, 2006; Orr, 1992; Scott & Oulton 1998; Sterling, 2004; Tilbury & Ross, 2006).

In this context, the role of science and environmental education is important. These fields of study concentrate on mechanisms and phenomena of the natural and man-made environment and provide students –as future citizens– the knowledge, skills and methodological tools necessary for studying the world around them. Both science and environmental education can contribute to the development of citizens capable of analytical and synthetic thinking, of investigating their position in the world they live in, of understanding the ways in which people change their environment and are affected by it and its changes, and conscious of the relationships between the individual, society, and the environment. Citizens who will be equipped with knowledge and skills essential for appreciating contemporary environmental problems, making relevant decisions and taking actions for their solution in the perspective of a sustainable future. Moreover, students, as future citizens could be supported in perceiving themselves as equivalent in their relationships with other people and natural entities, with a view to counterbalancing the dominating view of man's dominance over nature.

1.2 Sustainability: A key idea to cope with environmental degradation and social injustice

It is widely acknowledged that modern lifestyles and developmental models exceed earth's ability to support human beings and other organisms in terms of providing clean and adequate natural resources. An important concept related to modern lifestyles and the resulting environmental degradation is that of the 'ecological footprint'. Ecological footprint is a measure of people's demand on natural ecosystems. It is a measure of the area of biologically productive¹ land and water an individual, population or activity needs to produce the resources it consumes and absorb the waste it generates using current technology and resource management practices (Global Footprint Network, 2011). In other words, ecological footprint represents the land area an individual, a city or a nation take to support their lifestyles. It is tightly connected with the amounts of waste and pollutants produced by human activities as well as their energy demands. Probably the personal ecological footprint differs from one person to another as well as from one city (or country) to another. More particularly, the ecological footprint of developed countries is much larger than that of developing ones (Global Footprint Network, 2005). This indicates that ecological footprint is related with the notion of environmental injustice.

This has lead societies to recognize the necessity of changing the way of thinking about human activities, focusing on practices that sustain and protect the environment. Adopting sustainable everyday practices and developmental interventions is a crucial challenge for modern societies. Sustainability means the capacity to endure and refers to both physical and man-made systems, living and non-living things. Thus the term "sustainability" is used as determinative for that kind of development that ensures healthy ecosystems and the potential of long-term preservation of humanity.

¹ The land and water area that supports significant photosynthetic activity and biomass accumulation used by humans.

The terms of sustainability and sustainable development have been defined in various ways. The most common definition is given in the report of the World Commission on Environment and Development entitled "Our Common Future", also known as the Brundtland Report, according to which *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987, paragraph 27). In particular, as it is quoted (WCED, 1987, paragraph 27):

"The concept of sustainable development does imply limits -not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth. The Commission believes that widespread poverty is no longer inevitable. Poverty is not only an evil in itself, but sustainable development requires meeting the basic needs of all and extending to all the opportunity to fulfil their aspirations for a better life. A world in which poverty is endemic will always be prone to ecological and other catastrophes".

Sustainability contains within it, at least, three crucial concepts:

- the fulfilment of human needs -and in particular the essential needs of the world's poor- that support improvement of people's lives;
- the fulfilment of the needs of present and future generations that support the value of intergeneration equity;
- the ability of the biosphere to absorb the effects of human activities.

So, sustainability is an evolving concept that contains the key ideas of improving everyone's quality of life (including present and future generations), in the frame of the limits that are posed by the carrying capacity of the ecosystems that support lives. The carrying capacity of an ecosystem is the population size of the species that the ecosystem can support indefinitely, providing the necessities (food, habitat, water, air, and ground) without being damaged (Hui, 2006).

A crucial factor for accomplishing sustainability is the appreciation of social injustice resulting from environmental degradation. Both researchers and international organisations agree that the degree to which the quality of life of individuals and societies is influenced by environmental degradation is different between members of a society as well as between societies (Bard et al 2007; Cifuentes, & Frumkin, 2007; UNICEF, 2008; WHO, 2003a, 2006, 2008a).

These differences create or amplify existing inequalities both between and within countries, related to the quality of basic sanitary infrastructures, food sufficiency, or people's access to clean air and potable water. These commodities constitute fundamental rights for life and health. Nowadays -despite technological and cultural achievements- people suffer from lack of clean, potable water, food insufficiency, polluted air, and deficient sanitary infrastructure. Conditions intensifying environmental injustice threaten fundamental human rights. Klaus Toepfer, Executive Director of the United Nations Environment Programme appositely described this reality at the 57th Human Rights Commission meeting in Geneva in 2001 (Shelton, 2002):

"Environmental conditions clearly help to determine the extent to which people enjoy their basic rights to life, health, adequate food and housing, and traditional livelihood and culture. It is time to recognize that those who pollute or destroy the natural environment are not just committing a crime against nature, but are violating human rights as well. Human rights cannot be secured in a degraded or polluted environment. The fundamental right to life is threatened by soil degradation and deforestation and by exposures to toxic chemicals, hazardous wastes, and contaminated drinking water".

The study of environmental quality in relation to social inequalities produced by environmental degradation is supported and promoted by various researchers. Some underline the role of environmental science in this direction and focus on the development of scientific methods to estimate pollution of environmental recipients, i.e. air, ground, and water (Stephens, 2007). Others emphasise the relation of environmental quality with quality of life and particularly with human health (Donohoe, 2003; Heynen, 2003; Mitchell & Dorling, 2003).

In this chapter we aim at elaborating on the idea of environmental justice as central in organising and implementing relevant educational interventions in the context of science and environmental education at school, as a means to cope with environmental and social injustice and promote sustainability. In the following sections of this chapter we discuss the problem of air pollution and further develop the issues of environmental justice and injustice. More particularly, air pollution, its causes and consequences are discussed, with an emphasis on human health and quality of life. Data demonstrating environmental injustice caused by air pollution are presented and the idea of environmental justice is introduced as a means to counterbalance it. The discussion then focuses on the contribution of science and environmental education to facilitate students' and (future) citizens' understanding of the causes and consequences of air pollution as critical dimensions of environmental injustice. Suggestions and implications for developing relevant educational programs at school are also provided, aiming at enhancing students' scientific knowledge and skills necessary to understand air pollution and determine actions for resolving it in view of sustainability and environmental justice.

2. Air pollution and environmental injustice

Air pollution is one of the most pressing environmental problems and is among the critical challenges facing modern societies. Air pollution is responsible for major harmful effects on human health, animal lives, natural ecosystems and the man-made environment. It is also responsible for climate change due to the enhanced greenhouse effect, acid rain, and the depletion of the ozone layer that constitute important global environmental problems. Air pollution occurs both outdoors and indoors and is caused by human activities and natural mechanisms. Although air quality degradation because of air pollution is a global problem that threatens humanity's wellbeing overall, it is largely associated with environmental injustice.

2.1 Outdoor air pollution

Outdoor air pollution is defined as the release of several substances -called air pollutants- into the atmosphere, in concentrations that threaten the wellbeing of living organisms or disrupt the function of the environment as a system leading to human health damages in various ways. Air pollutants can be gaseous, solid particles, or liquid droplets. They can be products of either natural processes or human activities. Natural sources of air pollutants include volcanic activity, forest fires, organic decay or soil dispersion into the air by the wind. The main anthropogenic sources of pollutants released in the atmosphere are human activities such as transportation (motor vehicles, aircrafts), burning coal or other fossil fuels for energy demands, industrial processes, or use of chemicals in agriculture, and facilities like power plants, incinerators, landfills for waste deposition (EEA, 2006a; 2006b; EPA, 2007; Valent et al., 2004).

The major outdoor air pollutants produced by human activities include, among others (EEA, 2006a; 2006b; EPA, 2007):

- Carbon oxides, especially carbon monoxide (CO) and carbon dioxide (CO₂) produced by the transportation sector (motor vehicle exhaust) and combustion of fossil fuels;
- Nitrogen oxides (NO_x), especially nitrogen dioxide (NO₂) emitted from high temperature fossil fuel combustion and electricity production;
- Sulphur oxides (SO_x), produced in various industrial processes such the smelting of sulphur-bearing ores for extracting metals and electricity production;
- Volatile organic compounds (hydrocarbons, VOCs) that include a variety of substances released from power plants and from industries producing numerous products such as painting colours, cleaning products, pesticides, building materials, and furniture;
- Particulate matter (PM), that is solid or liquid air pollutants mainly emitted by power plants and the transportation sector (aircrafts, motor vehicles), mining, and incinerators;
- Ground level ozone (O₃), an air pollutant that results from photochemical reactions between nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight;
- Toxic metals particularly lead (Pb), cadmium (Cd) and copper (Cu) that are emitted from the transportation sector (motor vehicle exhaust), as well as from industrial procedures (production of painting colours, mining processes).

Outdoor air pollution is a major problem mainly in urban areas because of overpopulation. Increasing population² in urban areas results in increasing demands in transportation, industrial production and energy, which constitute the main sources of outdoor air pollution (UN, 2004). Moreover, this problem is intensified due to inadequate green open spaces in towns and cities and their restricted possibility to improve air quality and reduce air pollution (Givoni, 1991).

2.2 Indoor air pollution

Indoor air pollution refers to the amount of chemical, biological and physical contaminants in the air inside a building. Indoor air pollution can often be worse than outdoor air pollution. There is a wide range of indoor air pollutant sources in houses including building materials, pressed wood products and furniture, central heating and cooling systems, several personal care or household cleaning products, painting colours, solvents, heating or cooking appliances (stoves, wood and gas burning fireplaces, gas heaters), tobacco smoke, office machines and a variety of other products used in daily activities (EPA, 2007, 2008, 2009). In addition, outdoor pollutants are also traced in indoor spaces, such as radon (a natural trace component of soil and ground). The major source of indoor air pollution is household combustion of coal or biomass for cooking and heating. It is estimated that more than half of the world's population relies on animal dung, wood, crop waste, or coal to meet their most basic energy needs (WHO, 2005).

The major indoor pollutants that can practically be traced in any home are -among others- formaldehyde, asbestos, carbon monoxide, nitrogen oxides, sulphur oxides, benzene, polyaromatic compounds, particulate matter, toxic metals (lead, mercury, cadmium, and chromium), and volatile organic compounds (EPA, 2007, 2008, 2009; WHO, 2005).

² It is estimated that in 2010, 50.5 per cent or 3.5 billion of the people on Earth were living in cities (UN, 2004).

Several factors affect indoor air quality and are related to the type and maintenance of their sources, the level of hazard of the emitted pollutants, the quality of house ventilation and the quality of the building as well. For example, an old air pollutant source (a stove, a gas heating system, etc.) that is not properly maintained can emit significantly larger amounts of air pollutants than a source that is properly maintained (EPA, 2009). Indoors air temperature and humidity, biological contaminants (bacteria, mold, pollen, and viruses) as well as overcrowding are also important factors determining the quality of indoors air. In particular, high air temperature and humidity can affect the rate of indoors pollutant emissions. Moreover, these factors combined with inadequate building ventilation can further degrade air quality since indoors pollutants cannot be removed. Indoor air degradation in buildings may result in several health problems such as headaches, tiredness, hypersensitivity, coughing, eye, nose, and throat irritation, skin and mucosal dryness, dizziness, nausea, lethargy, inability to concentrate and mental fatigue. The occurrence of these symptoms is defined as the “sick building syndrome” (Burge, 2004; Stolwijk, 1991).

The “sick building syndrome”, is also related to workplaces. In order to ensure healthy conditions at workplaces international organizations have defined upper limits of both environmental and chemical factors that could cause serious problems or disturbances to human health. Among these factors thermal conditions (air temperature and humidity) as well as the levels of dust and chemicals concentration in the air are recognized as important factors affecting health and safety conditions at workplace (ILO, 1993; OSHA, 2009).

2.3 Air pollution, health and environmental injustice

Numerous outdoor and indoor air pollutants affect human health and pose significant threats to individuals worldwide, such as cardiovascular or respiratory disorders, asthma and lung cancer, which can be fatal (WHO, 2002, 2003a, 2006, 2009). Given that an individual inhales more than 14.000 litres of air per day, it becomes obvious that air pollutants pose significant dangers for human health. According to the World Health Organization (WHO, 2006, 2009) more than two million premature deaths each year can be attributed to the effects of urban outdoor and indoor air pollution. In particular, every year indoor air pollution is responsible for the death of 1.6 million people while 800.000 deaths from lung cancer, cardiovascular and respiratory diseases worldwide are attributed to outdoor air pollution (Valent et al., 2004; WHO, 2005). It is estimated that currently air pollution reduces average life expectancy of Europeans by 9 to 24 months (CEC, 2006).

Do urban populations equally enjoy environmental quality? Intense social injustice is often located within cities and is related to the way in which the man-made environment is formulated, functions and develops in time and space. This evolution is a result of various social, cultural, economic, and political processes, along with environmental components and their interrelations, which combine to shape space consumption in an urban environment determining its residential quality from an environmental perspective. These processes are typically regulated by individuals belonging in higher socio-economic strata, having access to decision-making and economic activity centres, which allows them to act in favour of financial profit and against lower socio-economic status populations (Bard et al., 2007; FOE, 2001; Harner, Warner, Pierce & Huber, 2002).

Some dimensions of environmental quality of an urban area entailing social injustice include the spatial distribution of functions and activities, the distribution of outdoor and green spaces and the quality of residential and natural environments. Distribution of functions and activities in urban spaces frequently involves environmental injustice, creating

environmentally degraded areas. Noisy facilities (industries, landfills, biological treatment facilities, highways) serving large urban populations are usually located in degraded residential areas. These facilities are responsible for pollutant emissions, noise, and also entail other dangers (e.g. explosions, fires) threatening nearby residents' physical and mental health. Air quality in these regions is typically low due to toxic gaseous substances emitted (Bard et al., 2007). According to international epidemiological studies, the populations living in the vicinity of large-scale urban facilities like industrialized regions exhibit higher frequencies of respiratory and cardiovascular incidents compared to inhabitants of other regions of the same cities. These incidents are related with pollutants traced in the air of these regions (Bard et al., 2007; Harner, Warner, Pierce & Huber, 2002; WHO, 2003a, 2003b).

As far as green and free open spaces are concerned, apart from being generally inadequate, they are not evenly distributed in all city districts; lack of public open spaces is more intense in densely inhabited and degraded quarters. Green space development requires free open spaces that are not always available, mainly because of the density of an urban area. Nevertheless, density is differentiated from one district to another within the same city, which results in further degradation of unprivileged neighbourhoods compared to privileged ones. As Heynen (2003, p. 980) points out: *"Social production of urban environments explicitly leads to uneven urban environments and environmental injustice. Environmental inequalities clearly exist within cities"*.

Furthermore, air pollution occurs in both rural and urban areas because of transportation, industrial emissions and energy use. What is common between highly polluted rural and urban areas is that they are both correlated with low income residential quarters, which indicates another facet of social and environmental injustice (FOE, 2001; Mitchell & Dorling, 2003). In other words, higher socio-economic status social groups' actions influence life quality of lower socio-economic status groups within countries. In a study implemented in London respiratory problems have been found to concentrate in the poorest areas and to correlate with high traffic levels even though the responsibility for the causes of these problems is unequal -car ownership was lower in areas with worse traffic levels (Stevenson et al., 1999).

Environmental differences and inequalities related to air pollution also appear between countries. In developing countries the issue of air quality is mainly related with indoor air pollution. In most of these countries organic fuel, such as wood and coal are the most common energy resources available for domestic use -e.g. for heating and cooking. Their combustion releases harmful pollutants inside houses, especially solid particles (WHO, 2005). Chronic exposure to solid particles is considered to contribute to the development of cardiovascular and respiratory diseases, as well as of lung cancer, while it is related with mortality mostly among children (WHO, 2006). Actually, 20%³ of child mortality for children under 5 years is attributed to indoor pollution (WHO, 2008a). Also, it is estimated that indoor air pollution associated with using biomass fuels (such as wood and grasses) causes an average of 871,500 deaths annually from childhood pneumonia (Valent et al., 2004).

As already indicated, dangers of air pollution are particularly increased in the case of children, who -in proportion to their body weight and surface- inhale larger quantities of air than adults, thus taking in larger amounts of the dangerous substances they are being exposed to. Moreover, their body systems are not mature, but are still evolving during

³ This percentage corresponds to two million children under five years of age annually.

childhood. This implies that children are more vulnerable to incoming toxic substances than adults. Their tissues directly absorb these substances, and -due to their immaturity- they are not able to restore the damages caused. So, if their brain, immune, or endocrine system are affected by toxic substances, the damage caused can be permanent and irreversible (Landrigan et al., 1998).

Data relate the development of leukemia in children living in areas with high concentrations of suspended particles. Also, children suffering from asthma living in areas with increased air pollution-especially pollution from nitrogen oxides, acid vapours and particulate matter- exhibit a higher probability of deterioration (e.g. development of bronchitis symptoms). These data are further supported by research indicating that when children suffering from respiratory disorders leave areas with high particulate air pollution, their lung function improves, while this is not the case for those who remain in polluted areas (WHO, 2002, 2003a).

In addition, epidemiological studies in European countries indicate that morbidity and mortality are higher in low socio-economic status populations⁴ suffering unhealthy environmental conditions. This especially concerns populations living in industrialised regions and nearby power plants (Bard et al., 2007; Cifuentes & Frumkin, 2007; UNICEF, 2008; WHO, 2003a, 2006, 2008a, 2009). Usually these regions are inhabited by low socio-economic status populations intensively experiencing the consequences of environmental degradation without being responsible for its emergence. On the contrary, they suffer from choices made by individuals of higher socio-economic status, pursuing economic growth. These choices concern investments entailing excessive use or degradation of natural resources. As a result, those who produce environmental degradation enjoy profits, while others suffer from its consequences. In this frame air pollution poses a threat to the fundamental right of life in a healthy environment and creates environmental injustice.

Another issue related with air quality degradation which entails social injustice involves air quality in working environments. These constitute local environments frequently containing harmful indoor air components, which may directly influence employees' health. They include various physical, chemical and biological components⁵ released during the production process and degrade the quality of the air inhaled causing severe problems (ILO, 1993). It is estimated that in the US approximately 135 employees die every day from diseases caused by long-term exposure to toxic⁶ substances at work (Faber & McCarthy, 2002). According to data available by European and World organisations high rates of morbidity and mortality are recorded among employees due to their exposure to environmental dangers in their workplaces. Obviously, low income employees -typically in lower ranking occupations- are those who suffer indoor air pollution in their workplaces the

⁴ In Western Europe danger of disease caused by degraded environmental quality is 1.5-2.5 times higher in low socio-economic status populations.

⁵ Physical environmental components include light, noise, radiation (ionizing or non-ionizing), dust, temperature, and humidity of indoor air. Chemical components are substances belonging in the production process and may be dangerous gaseous, toxic, erosive, or explosive substances. Biological components involve pathogens, bacteria, or viruses that may be traced in the air of a working environment.

⁶ Toxicity is the degree to which a substance is able to externally or internally damage an exposed organism. Toxicity danger is the probability of harmful effects caused by the use of a chemical compound.

most compared to those in highly ranked occupations –i.e. close to management (FACTS 29, 2002; WHO, 2003b, 2004).

2.4 Environmental justice

The issues raised in the previous paragraphs suggest that air pollution is directly related with social injustice. People are exposed to polluted air and their health and wellbeing are affected in socially unjust ways. Mitigating and overcoming this injustice does not mean equal exposure to environmental danger; it means elimination of every kind of pollution endangering the environment and living organisms. The challenge here lies in ensuring air quality, health and wellbeing for everyone. Health is not simplistically meant as absence of illness, but as a broader concept involving prevention as well as promoting physical, mental, and social wellbeing. It is a basic human value and a fundamental right of every individual regardless of race, religion, political beliefs, social, or economic status. It is the foundation of modern citizens', and accordingly our societies' and civilization's development and progress (WHO, 1992).

Environmental justice can thus bridge the gap between environmental quality and social injustice. Environmental justice is the fair treatment and meaningful involvement of all people with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. It will be achieved when everyone enjoys the same degree of protection from environmental and health hazards and equal access to decision-making processes to have a healthy environment in which to live, learn, and work (EPA, 2001).

The demand for environmental justice is expressed by organised social groups in the frame of the 'environmental justice movement'⁷ which has been increasingly established and reinforced in people's consciousness. It originates from human rights movements and is organised on the basis of three central principles: equality in environmental danger distribution, recognition of otherness and diversity between individuals, and active participation in political processes designing and applying environmental policies (Faber, & McCarthy, 2002; Harner, Warner, Pierce & Tuber, 2002; Scholosberg, 2004).

Environmental justice thus encompasses a variety of environmental, social and political dimensions and components. It involves issues such as natural resources management and distribution, social justice, development for all citizens, the right to participation in co-constructing an environment of quality. It is therefore apparent that environmental justice and the relevant issues are considered as directly connected to human rights. The UN Declaration of Human Rights and the Environment recognized the strong relationship between human rights and environmental quality that is reflected in the following principles (UN, 1994, pp. 3-4):

1. Human rights, an ecologically sound environment, sustainable development and peace are interdependent and indivisible.
2. All persons have the right to a secure, healthy and ecologically sound environment. This right and other human rights, including civil, cultural, economic, political, and social rights, are universal, interdependent and indivisible.
3. All persons shall be free from any form of discrimination in regard to actions and decisions that affect the environment.

⁷ The Environmental Justice Movement started in the United States in the early '80s and has since spread in European and other countries.

4. All persons have the right to an environment adequate to meet equitably the needs of present generations and that does not impair the rights of future generations to equitably meet their needs.
5. All persons have the right to freedom from pollution, environmental degradation and activities that adversely affect the environment, threaten life, health, livelihood, well-being or sustainable development within, across or outside national boundaries.

3. Environmental quality in the context of science and environmental education for the promotion of environmental justice

3.1 Environmental education and environmental quality

Environmental education has long been established as a premise for the development and promotion of education about the environment. In the beginning -during the '70s- it focused on improving environmental quality in view of the urgent and unprecedented environmental problems. During that period the environment was identified with 'nature' and its protection was a moral imperative. In this context, environmental education concentrated on the development of knowledge about nature and its functions; on the development of the skills necessary to face environmental problems on the basis of identifying their causes; and on encouraging appropriate behaviours for resolving them. In other words, environmental education focused on causal relationships and suggested that a change in behaviour (the cause) could amend the effect for the benefit of the environment (UN, 1973; UNESCO, 1976, 1978).

During the '80's and '90's environmental education was associated with developmental issues, since environmental problems were considered as instigated by developmental choices made by modern societies. Environmental education was enriched with concepts related with development, economy, and society, and aimed at supporting learners' capacity to investigate further from the physicochemical components of environmental problems, the socio-economic dimensions inherent in their creation in the framework of the relationships between individuals, society and the environment. The role of human activities and choices in environmental quality was acknowledged as critical in the formation and resolution of environmental problems (UNEP, 1992; UNESCO, 1988; UNESCO-EPD, 1997). At the same time the notion of sustainability -involving social processes, individual and collective values- was dynamically adopted as central in organising and achieving environmental education objectives. As indicated in the Declaration of Thessaloniki (UNESCO-EPD, 1997): *"The concept of sustainability encompasses not only environment but also poverty, population, health, food security, democracy, human rights and peace. Sustainability is, in the final analysis, a moral and ethical imperative in which cultural diversity and traditional knowledge need to be respected"* (article 10).

Since the early '00's the idea of sustainability has been further promoted as a crucial organising principle redefining the scope of environmental education. In the context of sustainability, development is not merely conceptualised as economic growth, or economic profit, but also takes into account environmental quality and social cohesion. Therefore, sustainable development encompasses populations, animal and plant species, ecosystems, natural resources (water, air, energy, agriculture, biodiversity), climate change, rural development, urbanization, and integrates concerns such as poverty reduction, human rights, health, human security, culture diversity and intercultural understanding (UNESCO, 2005, 2007).

In order to accomplish sustainable development environmental education aims at preparing individuals for being capable of co-constructing their future in terms of environmental and social sustainability by integrating values, activities and principles inherently linked to sustainable development and encourage a change in attitudes, behaviours and values to ensure a more sustainable future in social, environmental and economic terms (UNESCO, 2007). For this general aim to be accomplished particular objectives are considered as crucial for each of the following domains (UNESCO, 2005, p. 6):

- Society: an understanding of social institutions and their role in change and development, as well as the democratic and participatory systems which give opportunity for the expression of opinion, the selection of governments, the forging of consensus and the resolution of differences.
- Environment: awareness of the resources and fragility of the physical environment and the effects on it of human activity and decisions, with a commitment to factoring environmental concerns into social and economic policy development.
- Economy: a sensitivity to the limits and potential of economic growth and their impact on society and on the environment, with a commitment to assess personal and societal levels of consumption out of concern for the environment and for social justice.

Finally, sustainability is organised with reference to the notions of ecological limits, social justice, environmental justice, and individual participation in environmental actions. The formation of developmental processes based on environmental quality, balance of ecological processes, and quality of socio-political structures is imperative for ensuring a sustainable future aiming at the improvement of life quality of citizens (Huckle, 2006; Jacobs, 2004; Orr, 1992; Scott, & Gough, 2004). In this framework, both individuals and society should respect the boundaries set by ecological processes within and between natural systems. This requires an appropriate understanding of the concepts of carrying capacity and ecological footprint (see subsection 1.2) that determine the sustainable function of ecosystems and the degree to which human societies exert pressure on them in order to fulfill their diverse needs.

Therefore, environmental education can play an important role in supporting individuals to critically consider environmental decisions of contemporary societies and enabling them to investigate and challenge the social structures and political decisions that preserve or reinforce social and environmental injustice. At the same time, it can strengthen students' roles as future citizens by encouraging participation in the design and implementation of actions to resolve environmental problems, training them in democratic processes, and involving them in issues concerning their local communities. Such orientations build up citizens' confidence, mutual help and solidarity for the improvement of life quality. These values are the foundations of a democratic society with social and environmental justice.

3.2 Science education and environmental quality

Science has developed tools and knowledge for understanding the complex physicochemical mechanisms underlying environmental problems, the ways in which human interventions and everyday habits affect natural ecosystems and the ways in which ecosystems react to these interventions. Ecological footprint, ecosystems' carrying capacity, atmospheric and hydrosphere mechanisms are among these important tools for studying environmental problems, and estimating the degree to which human activities, practices and developmental interventions create or enhance them (AAAS, 1989; Hodson, 2003). Science teaching can address these issues to support students in constructing the environmental

knowledge necessary for understanding environmental problems and undertaking appropriate actions for their resolution. Scientific knowledge and methodological tools can therefore enhance students' ecological literacy, which involves understanding natural phenomena and their interrelations, the interdependence between society, economy, the natural environment and the ways in which human activities affect the environment and are affected by it (Orr, 1992). In this framework natural systems are considered as constituents of the environment (also including the social, man-made, and economic environment). Therefore, science teaching can enhance students' ability to connect scientific knowledge with everyday issues, such as environmental problems which nowadays –more than ever before– are part of individuals' and society's daily life.

Besides, such an integration of scientific knowledge with the multiple components of environmental problems is expected to stimulate students' involvement in science, since these problems require an interdisciplinary connection of science teaching with education for the environment; on the one hand integrated scientific knowledge provides the means for understanding environmental issues by means of a holistic and systemic approach; on the other it provides insight to the human-environment interaction that enables environmental sustainability. From this perspective science teaching may become more meaningful for students, since it also incorporates a strong affective dimension and provides possibilities to develop evaluative judgments and take up environmentally appropriate actions in real life situations (AAAS, 1989; Brody, 1991; Bybee, 1993; Gough, 2002; Hodson, 2003; Iozzi, 1989; Schneider et al., 2002).

In this context science teaching enhances students' critical thinking, essential for understanding the complexity of environmental problems. Critical thinking requires that an individual is both mentally and emotionally engaged when facing a problem in order to end up with rational conclusions, judgments, and choices. It is a process of data collection, processing, analysis and synthesis with existing knowledge to explain concepts and phenomena, to understand personal conceptions and evaluate them against the ideas of others, and to question prejudices (Jones, Merritt & Palmer, 1999; Tilbury & Ross, 2006). Furthermore, data analysis and interpretation to extract conclusions are basic components of critical thinking, and are also considered as central in science education (Facione, 2007).

As already mentioned, systemic thinking is crucial for understanding environmental problems. Understanding the environment –as a 'system' interacting with other systems – involves conceptualising its organisation in time, its influxes, the decisions and measures taken by individuals and organisations about its management, and the way in which it reacts to the actions it is imposed to (Ragou & Souchon, 2000). Thus, a systemic approach of environmental problems requires systemic thinking, which is substantiated by means of the complementary processes of analytical and synthetic thinking (Bartlett, 2001; Espejo, 1994; Sterman 1994; Richardson, 1994; Richmond, 1993, 1994). The first process is essential in understanding the parts of a problem; the second enables comprehension of the way in which these parts interact within a system, as well as with surrounding systems. According to Richmond (1994) systemic thinking is a dynamic way of reasoning and learning, the 'art' and science of creating reliable conclusions about a system's behaviour by deeply understanding the structures regulating it. It is therefore evident that science education can provide essential knowledge and tools of thinking for studying natural systems and their interrelations with other –natural or man-made– systems.

Moreover, the study of environmental problems through the prism of environmental justice can emphasise the social role of science education in improving life quality and ensuring

individual and public health. More particularly, an environmental perspective in science education allows for

- Application of scientific tools and knowledge in estimating environmental degradation and its consequences on health, and in revealing pertinent social injustice;
- Development of instruments to consider alternative ways of environmental management that ensure everyone's right to security and health;
- Application of scientific knowledge in considering the environment as a system comprising other natural and social systems and in understanding their interrelations as well as the relations producing social injustice;
- Development of scientific method skills to support critical and systemic thinking and promote the idea of the social role of science and technology in dealing with environmental injustice.

3.3 Connecting environmental and science education to promote environmental justice

The preceding analysis indicates that the connection of science with environmental education can elucidate environmental and social injustice inherent in environmental problems. This connection can serve basic objectives regarded as preconditions for students' engagement in understanding environmental problems and dealing with environmental injustice. These objectives include (Brody, 1991; Bybee, 1993; Orr, 1992; Peloso, 2007; Scott, 2007):

1. Supporting students in developing thinking skills (e.g. systematic observation and investigation, problem solving, critical synthesis of different parameters in decision making) to allow them satisfy basic personal needs and use natural resources rationally aiming at achieving environmental justice;
2. Supporting students in developing communication and collaboration skills so that they are capable of formulating and comparing different views, of constructing new, synthetic and consensual ideas ensuring environmental quality for all citizens;
3. Enhancing students' interest in science by revealing its relevance to real and important issues concerning life quality;
4. Developing learning processes that support students in constructing more adequate explanatory models about the natural world and the environment;
5. Revealing interrelations between science, technology, the environment, and society, and promoting positive attitudes towards the environment, aiming at improving its quality to the benefit of all people;
6. Presenting science and technology as useful means for the adaptation of humanity to the environment, since they provide rationally structured explanations of reality –as interpreted in every period and developmental phase- to ensure environmental quality for all;
7. Making clear that science and technology entail –apart from the necessary information and knowledge- value and ethical issues.
8. Supporting students' understanding of the importance of concepts like interdependence, sustainable development, conservation of natural resources, population control. Awareness of the sensitive environmental equilibrium could support the development of a 'universal ethos' to counteract social injustice and adopt sustainable actions for protecting, conserving and improving environmental quality.

4. Air pollution in the framework of science and environmental education to promote environmental justice

As already mentioned air pollution is related with environmental injustice inherent in its causes as well as its consequences. On the one hand, the causes of air pollution lie in people's lifestyles, which are differentiated according to their socio-economic possibilities. On the other, they are related to developmental choices and financial investments made by higher socio-economic strata, and to political decisions forming their institutional context. At the same time air pollution is associated with the way in which cities are organised, with their infrastructures and green spaces available determining the quality of urban environment and producing inequalities between residents. Thus, air quality is recognised as one of the priorities for healthy and sustainable cities.

Apart from knowledge about scientific concepts and the complexity of environmental phenomena, the development of educational programs related to environmental issues – such as air pollution- also requires that students' ideas and ways of thinking are taken into account. An analysis of learners' thinking and conceptions can provide valuable insight into the way in which individuals or social groups come to organise their reasoning and concern about the environment and the relevant problems. For instance, if one attributes environmental problems to the development of industry and believes that they can be faced through technological applications, s/he adopts a technocratic approach. On the other hand, those who attribute environmental problems to human activities embrace a more politicised stance (Wals, 1992). In the first case an individual may not develop further interest or an intention to act to protect the environment, given that technology can solve any problem. Therefore, students' thinking about environmental problems can guide the development of teaching material and activities that depart from their conceptions.

Students' ideas about air pollution have been recorded by a number of studies. Their main findings can be summarised as follows:

- Pupils conceptualise air pollution as presence of harmful substances into the atmosphere (Ali, 1991). From 10-11 years on they appreciate that air is polluted with 'extra gas(es)', 'fumes', or 'smoke', some of them identifying specific pollutants such as CFCs, carbon monoxide and dioxide, sulphur dioxide, and nitrogen oxides (Batterham et al., 1996; Boyes and Stanisstreet, 1997; Thornber et al., 1999).
- Students describe cars and transportation, industry, waste, fires and sprays as the primary anthropogenic pollution sources (Boyes and Stanisstreet, 1997; Thornber et al., 1999). They regard air pollution as exclusively man-made (Ali, 1991; Boyes and Stanisstreet, 1994; Brody, 1991; Brody, 1994; Dove, 1996; Thornber et al., 1999), adopt a restricted and local view of the issue, being unable to appreciate its global dimension (Brody, 1994), and perceive air pollutants as inert, i.e. not participating in physical or chemical processes in the atmosphere (Marinopoulos and Stavridou, 2002).
- Air pollution is considered to cause plant and animal diseases and/or death, as well as respiratory problems to humans (Ali, 1991; Batterham et al., 1996; Brody, 1994; Thornber et al., 1999). Some students attribute other global environmental problems to air pollution (Batterham et al., 1996). In this case, they often hold a generalised idea of global environmental issues, confusing them at the levels of causes, mechanisms and consequences (Boyes and Stanisstreet, 1997; Christidou & Koulaidis, 1996; Francis et al., 1993; Hillman et al., 1996; Koulaidis & Christidou, 1999; Plunkett and Skamp, 1994; Rye

et al., 1994). They often consider air pollutants in general as enhancing the greenhouse effect and ozone depletion.

- Research outcomes from a Greek study (Dimitriou & Crhistidou, 2007) exploring students' understanding of air pollution indicate that they have a generalised understanding of the problem. They are familiar with a variety of its components - such as sources of pollution, pollutant types, consequences on living things and on the environment- but they do not seem to comprehend the relationships between these components. At the same time they do not have an adequate understanding of the degree to which individual and social decisions and practices influence the intensity of air pollution. On the other hand, they seem to have a more appropriate understanding of the effects of air pollution on human health and explicitly express their concern about them.

The preceding analysis reveals that students are not aware of all the dimensions of air pollution and therefore cannot fully understand the interrelations and interactions between its components. Understanding the framework of relations between natural and human dimensions composing an environmental phenomenon such as air pollution is –in our view- a prerequisite for developing critical reasoning about it and should constitute a key educational objective for supporting future citizens in thinking about the world. Therefore, students should become competent in recognising and interpreting the framework of physical, ecological, social, economic and political relations underlying environmental issues, the contradictions inherent in those components, as well as possible alternative explanations and solutions to these issues. They should also become capable of sincerely examining their personal views, practices, prejudices and stereotypes, make appropriate decisions and implement changes at individual and collective level. In other words, students should be equipped with knowledge, skills and thinking tools necessary for interpreting the world around them in order to change it, since the world cannot change unless it is adequately explained (Huckle, 2004).

In this context, educational programs on air pollution should ultimately aim at determining all relevant components, indicating their interrelations and the ways in which these interrelations enhance or reduce the problem and its consequences. In other words, educational programs need to be designed in the framework of a systemic approach for air pollution, considering all the systems with which it interacts. Such a systemic approach would also contribute to understanding and resolving environmental injustice inherent in air pollution and related with people's rights, lifestyles, financial activities, along with state and governmental decisions. These systems reflect the social, political, and financial dimensions of air pollution and are tightly connected with the way individuals and organised societies (institutions, legislation, etc.) decide and act. The functions of these systems correspond to influxes to the air pollution 'system' and in turn influence the way it functions (at the level of physicochemical and biological mechanisms), the way it reacts to these influxes and its effects on the natural and man-made environment.

This approach provides the possibility of a holistic study of air pollution in order to understand natural and human components causing it and their interrelations. At the same time it provides an opportunity for understanding the temporal evolution of this issue due to human interventions –be it in terms of managerial practices or protection practices for its resolution.

The previous discussion allows for developing educational programs about air quality degradation and the relevant social injustice by studying indoor and outdoor local

environments. Such programs would enhance students' critical understanding of environmental quality in the context of individual and social activities, practises and political actions. Within this context, environmental justice in the perspective of sustainability is a crucial component for maintaining a healthy environment for all, and for creating sustainable places to live and work, now and in the future. By integrating scientific knowledge with life experiences students would be encouraged to make personal decisions and become active members of society to ensure better air quality and environmental justice. More particularly, educational programs about air quality degradation and the relevant social injustice could aim at:

- **Investigating different lifestyles and the ways these affect air quality and enhance – or reduce-air pollution**
- Lifestyle describes the way an individual lives. It includes, among others, individual consumption behaviours and everyday life practises. Almost all of our daily activities and habits eventually produce indoors and outdoors air pollutants. Investigating their different lifestyles would give students the opportunity to understand how themselves and others affect air quality in their daily lives. Moreover, students could be encouraged to investigate alternative habits that would contribute to air pollution reduction, such as using alternative energy sources (e.g. solar, or wind energy), saving energy, or using eco-friendly products.
- **Assessing the personal ecological footprint on air and comparing ecological footprints of different socio-economic status individuals**
- This approach would provide students the opportunity to explore the way individuals of different economic status consume natural resources consequently affecting air quality. Since socio-economic status is plays a crucial role in determining consumption behaviours and everyday practices, such an assessment would aid students develop a deeper understanding of social and environmental injustice related to air pollution.
- **Estimating the factors influencing urban space quality (urban design, transportation networks, green spaces) and evaluating its quality in privileged and underprivileged areas within the same city to reveal ensuing injustice**
- Involving students in investigating urban space gives them the opportunity to realise that the way a city is organised affects the quality of citizens' lives. They are also assisted in recognising the relationship between environmental quality and human wellbeing and to locate environmental injustices in their local environments to concretise that urban quality is not the same within the same city. Students living in underprivileged areas, in areas of injustice, should be empowered to develop and participate in communities of resistance and planning (Peloso, 2007). As Bullard, one of the major researchers and organizers in the environmental justice movement, suggested: *"We have to educate young people that it is their right to have access to open space, green space, parks, outdoors, as opposed to people thinking that their supposed to be living in an area where the only park is a basketball court with no net. We have to give people this idea that it's their right to have access to open space and green space and we have to provide funds to make sure that we get them early on and take them on field trips, take them to a wilderness area, a refuge, a reserve, to a park-a real park and to integrate this information into our curriculum"* (Schweizer, 1999).

- **Estimating the effects of air pollution on human health and the distribution of relevant diseases in respect to environmental quality in privileged and underprivileged areas within the same city**
Estimating the distribution of diseases that are attributed to urban air pollution gives students the opportunity to understand that environmental justice is the most significant tool for a healthy environment for all people regardless of socio-economic status.
- **Exploring pollution sources and their distribution in the local environment in relation to the socio-economic status of residents**
This approach gives students the opportunity to realize that people of low income usually live in degraded residential areas where the main air pollution sources, such as industries, landfills, biological treatment facilities, highways, are usually located.
- **Determining the factors influencing air quality in different workplaces**
Students could be encouraged to investigate air quality at different workplaces to locate related environmental injustice experienced by specific groups of employees. In this framework, the “sick building syndrome” could also be explored based on real case studies.
- **Measuring air pollutant concentrations in the school, local and broader environment**
This activity would give students the opportunity to locate air pollutant sources in their immediate environment and suggest alternative interventions to their school in order to render it sustainable. Such interventions could include -among others- using building material, heating sources, furniture, and equipment with a low impact on air quality. Such actions would also enable all students participate in school life and in decision-making processes, to cooperate with local citizens and broaden their activities to improve the quality of the local environment and thus improve wellbeing of the local community.
- **Studying national and international legislation referring to air quality and engaging students in proposing legislative directions for the formation of urban environments, improvement of urban air quality and elimination of environmental injustice**
Student’s involvement in studying environmental legislation provides the opportunity of deeper understanding of the political dimension of air pollution and environmental injustice.
- **Familiarising students with national and local institutions in order to understand their role in the formation and conservation of the local environment**
Student’s familiarisation with institutions enables greater interaction with the community. It is also expected to increase their interest in local issues and their willingness to work together on reducing air pollution and promoting sustainability.

To determine environmental injustice at an international level, educational programs to assist students in understanding injustice between developed and developing countries could be developed. Indicative objectives of such programs would include:

- **Recording differences in energy sources used for satisfying basic daily necessities of developed and developing countries’ inhabitants and identifying indoor air pollution in each case;**
- **Studying indoor air pollution effects on human health and especially on children;**
- **Studying geographical distribution of diseases related with air pollution in developed and developing countries;**
- **Comparing personal ecological footprints on air between inhabitants of developed and developing countries;**

- **Understanding poverty experienced by people in developing or unprivileged countries as determinative factor for the environmental injustices they experienced.**

Probably, one could object that studying local environmental problems and pertinent injustices solutions is much more meaningful to students than grasping –for instance– environmental injustices between development and developing countries. Are students able to cope with these injustices and promote air quality for the people in developing countries? We strongly believe that education has to promote global citizenship and allow students to understand that environmental problems are linked to the social, economic and political situations in countries all over the world. Therefore, science and environmental programs about air pollution could start from the local environment and deal with real, everyday and concrete problems facing students and their community and subsequently be enriched with activities that enable students to develop a deeper and global understanding of poverty as a critical dimension of environmental injustice (UNCSD, 2003). After all, “education is one of the most effective forces to bring about the changes in knowledge, values, behaviour and lifestyles required to achieve sustainability and stability within and among countries, and to guarantee democracy, human security and peace” (UNESCO, 2005b, p. 10).

5. Conclusions

In this chapter we attempted to present environmental quality in the context of environmental injustice. The discussion was based on data provided by international institutions mapping environmental degradation, its consequences on human health, wellbeing and life quality. These data reveal that environmental injustice within countries is particularly experienced by low socio-economic level groups of the population living in underprivileged areas. Moreover, environmental injustice between countries is more intense and degrades health quality of their population, indeed contributing to increase of mortality.

The chapter particularly focused on the environmental problem of air pollution aiming at highlighting environmental injustice caused by the types, sources, and distribution of air pollutants along with their effects on human health and wellbeing. These issues were discussed in the scope of sustainability, which in our view is the only means to ensure environmental quality and justice for all. This is a requirement and a fundamental challenge for modern societies.

Sustainability and environmental justice can only be accomplished by means of active involvement of citizens in environmental actions. In other words engaging people in making crucial decisions about the quality of their environment is a prerequisite for environmental sustainability and justice to occur. Therefore, individuals should be supported in demanding life quality based on respect and justice for all human beings; in ensuring equal access to natural resources and health for all; in deciding upon a development of their cities in harmony with nature and with respect to the cultures of different communities.

In this direction we propose the design and implementation of relevant educational programs deriving knowledge, methods, and modes of thinking from science and environmental education. These two fields provide the necessary tools for understanding environmental degradation and pursuing sustainability and environmental justice. More particularly, science education supplies tools and methods for estimating environmental quality and protection, and for creating a healthy environment ensuring life quality and health for human beings. Environmental education can complement this endeavour by

critically supporting individuals in understanding environmental challenges and their causes, developing actions, and adopting practices to resolve them. Injustice, inherent in environmental degradation, can constitute an organising principle in designing and implementing educational programs for the environment, and more particularly in relation to air pollution.

The conjunction of science and environmental education organised along the concepts of sustainability and environmental justice also opens new grounds for research. Application of the general principles and stances outlined in this chapter in real school environments in the context of specific educational activities would allow a systematic and reliable estimation of their value. More specifically, evaluation of educational applications of the ideas presented in this chapter could investigate students' understanding of air pollution; their relevant speculations; the alternative solutions they propose for reducing air pollution along with pertinent environmental injustice; their views of the role of science in this enterprise. Systematic research on these topics is expected to yield documented, valuable, and productive outcomes to further promote education for sustainable development.

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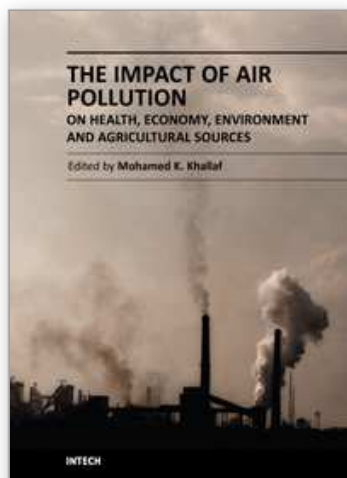
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This book aims to strengthen the knowledge base dealing with Air Pollution. The book consists of 21 chapters dealing with Air Pollution and its effects in the fields of Health, Environment, Economy and Agricultural Sources. It is divided into four sections. The first one deals with effect of air pollution on health and human body organs. The second section includes the Impact of air pollution on plants and agricultural sources and methods of resistance. The third section includes environmental changes, geographic and climatic conditions due to air pollution. The fourth section includes case studies concerning of the impact of air pollution in the economy and development goals, such as, indoor air pollution in México, indoor air pollution and millennium development goals in Bangladesh, epidemiologic and economic impact of natural gas on indoor air pollution in Colombia and economic growth and air pollution in Iran during development programs. In this book the authors explain the definition of air pollution, the most important pollutants and their different sources and effects on humans and various fields of life. The authors offer different solutions to the problems resulting from air pollution.

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