

THE ENVIRONMENTAL HEALTH FIELD: AN OPPORTUNITY TO REACH SCIENCE EDUCATION GOALS

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1. History and contemporary views of scientific literacy and environmental health

1.1 *Scientific literacy*

The different definitions and perceptions about scientific literacy can be interpreted from the formulation of three main questions: a) what counts as scientific literacy, b) for whom, and, c) under what conditions (Brown et al. 2005). Since science is positioned within curricular contents we can identify that teaching goals have faced several changes. In this section we present a brief historical journey identifying the diversity targets that have been linked to scientific literacy as well as links in which social demands are established. The stages that make up our historical analysis resemble DeBoer's (2000) proposals, broken down into four periods: the first describes science's role in society before it was incorporated as part of our educational processes (before 1945); the second addresses the role of science in its early years of being incorporated into formal education (1945-1956); the third describes the great reform in scientific literacy that started at the end of the 1950s (from 1957 to 1984); and the fourth analyzes the role that scientific literacy has played in recent decades (from 1985 to the present).

1.1.1 *Science for the few: The status of science before 1945_*

For many years, science was part of philosophy in such a way that scientists were called natural philosophers. In English, the word "scientist" was used for the first time in 1883 when William Whewell referred to those present during a meeting of the British

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Association for the Advancement of Science. In the 17th and 18th centuries there were paid positions available to scientists. Science was an amateur activity, dominated in the 17th century by the aristocracy. However, by the 18th century it essentially became an activity for the middle class, resulting in great pressure for it to be turned into a profession.

During the 19th century, many positions were created for scientists, above all in the education system, for example in the *Écoles* of post-revolutionary France and in German universities. Given the importance that science came to have, governments started to give it support, which allowed for the strengthening of scientific careers. Nevertheless, during this time, science was only taught to students educated in “mechanical arts,” military science or agriculture. Science was basically taught to 10% of the population. According to Sanmartí (2002), the programs and structure for the science education, with the separation between the disciplines of physics, chemistry and biology, were conceived around 1860 in Germany, a country that at the time was a pioneer in the field of science.

1.1.2 Learning science as educational goal: from 1945 to 1956

It is not until mid-20th century when scientific knowledge is fully positioned as part of the curricular contents that it is embraced in the elementary school of all citizens. The scientific literacy concept was first developed by Paul DeHart Hurd in 1958 to represent the goals of science education. From his position he identified the main science axes for everyone based on the acquisition of an understanding of the nature of science and its applications in the social experience field. Generalization in the teaching in sciences arises from the need to train new scientists, therefore among its main sponsors we found more scientists than educators. As a result, teaching was focused on bringing students to the scientist's world rather than their usefulness in everyday life. Other arguments that allowed science position within educational programs emphasized the possibility for individuals to develop superior complex cognitive processes as opposed to simple deductive logic.

The vision of science was focused on scientific theories which were essential for the reflection as well as the main component for the curricular design. The main assumptions that guided these early years of teaching science can be summed up in: a) scientific knowledge is a finished knowledge, objective, absolute and true; b) to learn is: formally take ownership of such knowledge; c) learning is a single and homogeneous event and d) school contents must be selected from scientific concepts.

According to DeBoer (2000) by 1932 there was some concern that curriculum developers had gone too far in making subject matter relevant and had forgotten the fundamental reason why science was being studied, which was to provide a broad understanding of the natural world and the way it affected people's personal and social lives. Regarding these reflections and while adhering to the importance given to the mastery of the scientific contents, the need to establish linkages was emerging gradually between this knowledge and the social context. In such way science was conceived as an activity that would allow local social progress. The intention was to enrich scientific thinking from another perspective beyond experimentation; to establish linkages between science

and the past, as well as science and the social problems of the time. (National Society for the Study of Education, 1947).

1.1.3 Scientific Knowledge and Social Responsibility: From 1957 to 1984

In 1957 the launch by the Soviet Union of the first satellite (Sputnik) into space was quite an event in the field of science. This fact alerted the western countries especially the United States, and unleashed a great movement of renewal within the natural sciences teaching, an event that Akker (1998) called as the first-wave curriculum reform. More or less on the same dates –from 1960 to 1980, England was one of the countries that joined this curriculum reform movement in the field of science. In subsequent decades other countries joined these innovations but their reforms were not necessarily based on local and social needs but rather followed the steps proposed by the United States and the United Kingdom.

New proposals still emphasize the structure of the disciplines, the importance of science processes, and especially scientific inquiry. Identifying that while reform was approaching proposed the promotion of technological and practical applications of science, which were limited.

At this time science education was conceived as learning how scientists worked, but the conceptual content was considered as a backdrop. Priority attention was given to the process development of scientific activity; consequently scientific knowledge was obtained inductively from the central role of the experiences in the processes.

In the 1970s due to an increasing concern about the impact of urban growth and technology in the deterioration of the environment and health, and after the first world summit on the environment, the social role of science gained strength. Hence we find definitions about scientific literacy that show a relationship between science-society-environment. An example of such is proposed by the National Science Teachers Association (NSTA) that defines a person who is scientifically literate as: “the person who uses science concepts, process skills, and values in making everyday decisions as he interacts with other people and with his environment” and “understands the interrelationships between science, technology, and other facets of society, including social and economic development” (NSTA, 1971, pp. 47-48). However, these links were not strengthened in literacy practices.

In the early 1980s a science-technology-society approach arose with the aim of providing students with the skills that would enable them to make decisions about science and the urgent needs of local society. While these approaches would establish a closer relationship between science and society, the platform or ideology to accomplish scientific literacy raised the learning of the individual.

1.1.4 Scientific literacy in a globalizing world: From 1985 to present day

One important change in scientific literacy arose as part of the globalization processes and social problems occurred on an international level. At the beginning of the

1990s, international organizations began to once again question the role of science within an international framework in accordance with current problems and demands. The international evaluation around scientific literacy began to gain strength as a basis point for reorienting curricular reforms. As a consequence, associations like the Organization for Economic Cooperation and Development and the International Association for the Evaluation of Educational Achievement had to establish programs like the Program for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS). These programs sought to apply exams in order to obtain information that would allow them to assign a grade in order to evaluate what level of scientific literacy students from different countries had.

New perspectives about how to direct and achieve scientific literacy for everyone (and not just the student community) have been coming into focus. In recent years, two fundamental visions have been laid out regarding scientific literacy. Roberts (2007) calls them Vision I and Vision II and Brown et al. (2005) calls them *knowledge-centered* perspective and *sociocultural-centered* perspective. The former is focused on scientific knowledge acquisition training aimed at developing specialists in the sciences. Scientific literacy remains abstracted from experience and ultimately disconnected from the lives of people engaged in their own worlds. The latter is based on scientific knowledge acquisition to be used in socially relevant contexts focused on citizen education. This perspective seeks to situate any definition of scientific literacy in the actions of accomplishing everyday life. This considers how literacy is relevant to particular tasks at hand in some relevant social context.

According to Roth and Lee (2002), in the everyday world of a community, science emerges not as a coherent, objective, and unproblematic body of knowledge and practices, but rather it often turns out to be uncertain and contentious, unable to answer important questions pertaining to specific (local) issues at hand (Jenkins, 1999). Science then becomes known as the best line for decision making in a field of uncertainties, unfinished knowledge, hesitations and of truths that aren't absolute; science is therefore a social construction. The main purpose of this approach is to promote the science learning through the real-world context.

1.2 *Environmental health: Historical evolution of the field*

Much like scientific literacy, the environmental health field has been defined from different perspectives. For our historical analysis we will look at the perspectives of Foskett (1999) and Frumkin (2005). From within the main viewpoints of this field we can identify those that make reference to relationships between people and the environment that directly remind us of the ecosystem concept and others that have a wider focus, addressing specific environmental questions that emphasize the physical and chemical risks that come from environmental degradation in social surroundings such as housing, labor and recreation (Frumkin, 2005). This range owes in great part to the interdisciplinary nature of the field. Different issues like health as well as risk are touched on from different disciplines. In the historical rescue of the evolution of the field we will

identify how such perspectives have emerged and how they have focused the study on determining problem areas. For each analyzed period, what are mainly recovered are the type of risk that affects health, the change or modification to spaces, and the idea of environmental health that prevails.

1.2.1 The microbiological health risk: Before 1945

While it is true that the origins of environmental health could be very old and date back to early interactions and challenges between humans and their natural environment in the permanent search of well-being, a key point of emergence of the field refers to the “industrial awakening” (Frumkin, 2005) and population movements from the towns to the cities. We can say that environmental health starts with two great revolutions: the agricultural and the industrial of 1712. A century later, due to a rapid deterioration of the environment, an approach to population health began (Garibay and Curiel, 2005). Therefore, the change ranged from the agricultural to the industrial, and thus triggered a series of new health risks.

Since the 18th century overcrowding both in housing and industries caused a serious deterioration in the environment resulting in human health damages. Health problems (e.g. housing and damp workplaces without ventilation, streets contaminated with excrement, standing water, etc.) increased exponentially. Everything seemed to indicate that technological and production advance were inversely proportional to the state of deterioration of human health and the environment.

“The bad environmental conditions were matched by the poor social conditions. Even though the working hours were very long, wages were low. As a result, workers suffered from malnutrition, and the poor physical condition was made worse by the ill-ventilated factories and, textile mills, the high temperatures and humidity” (Foskett, 1999: 25).

England is considered the country that began the industrialization process and in consequence the first to experience the adverse health effects; but it was also the pioneer in the search for solution strategies. While in England occupational health had been an issue since the first decades of the 19th century, in the United States it was not until the 20th century, when, thanks to the initiative of Alice Hamilton (1969-1970), they began to document links between toxic exposures and illnesses of workers such as miners, traders, and industrial workers (Frumkin, 2005).

During this period a health concept prevailed in absence of disease, and the idea that disease was the result of a microbe which could be cured by attacking it with drugs. Also the perception of environment referred to “everything that surrounds” the human being without being part of it. Subsequently, there is a utilitarian approach of nature as the provider of natural resources.

1.2.2 Toxicological risk: From 1945 to 1956

The period from 1945 to 1956 was characterized by a more urbanized society. Health risks were not only microbiological but also toxicological and related with industrial

products and waste as well as with air pollution, including fallout. Among various, the events that caused more deaths and hospitalization due to air pollution were: a) In December of 1952, four thousand people perished in the worst of the London “killer fogs.” Vehicles used lamps in broad daylight, but smog was so thick that buses ran only with a guide walking ahead; and b) At 1957-1958: Chelyabinsk-40 nuclear waste explosion in Kyshtym, Russia. Two million curies spread throughout the region, exposing over a quarter million people to high level radiation.

It is worth mentioning that from the decade of the 40's the need to ensure food for a growing population, led to development in areas such as chemistry and agrochemical manufacturing innovations (fertilizers and pesticides). Development in chemistry is considered the response to various problems, including pesticides to reduce populations of transmitting disease vectors and epidemics generation, such as mosquitoes, rodents, and ticks.

Also in that decade the United Nations announced the Universal Declaration of Human Rights (1945) aimed at guaranteeing human survival because “everyone has the right to a standard of adequate living for health and well-being of himself and his family, including food, work, education, clothing, housing, public health and the necessary social services and respect for nature and an environmental degradation control”. (Available in: <http://www.un.org/es/charter-united-nations/index.html>).

Moreover, damage to health was also present due to exposure to toxic substances such as methylmercury in the water that caused hundreds of deaths in the city of Minamata, Japan.

According to Frumkin (2005), the modern environmental health field dates back to the mid-20th century, an essential aspect that marked its start was the acknowledgement of risks involved with products that contain carcinogenic chemicals. Consequently, the number of studies assessing the exposure to these products increased.

1.2.3 Risks and the lack of control of urban population growth: From 1957 to 1984

Towards the end of the 1950s and the beginning of the 1960s risks became prevalent in the world, and thus excessive urban growth transformed into what we have come to call “unplanned urbanization.” This involves spontaneous growth based on do-it-yourself construction along with urban expansion that blurs urban areas and exposes inhabitants to geological, hydro meteorological, socio-organizational and health risks.

From the 1970s onward, the field of environmental health and the issues that it addresses expanded greatly. Damage to health and the environment began to take center stage to serious issues on an international level. Furthermore, health effects were identified from chronic exposure to different contaminating substances that had previously not been identified as having a risk factor. Some were even considered beneficial, but with exposure effects over time it became evident that they were harmful to peoples' health. One clear example of this was the effect of pesticides on health. In 1962, “Silent Spring” by Rachel Carson was published in which she described the detrimental effects of pesticides on the environment. For the first time, the dangers of using DDT and other chemical

products applied as pesticides were being talked about. Not only was their toxicity being identified but also their capacity to remain in organisms through the accumulation of fatty tissue. Another issue was chlorine use for water purification in big cities. On the one hand it helped to eliminate pathogenic microbes that are the cause of epidemics, but on the other hand they were also the cause of other kinds of diseases that develop due to exposure over a number of years.

Using these situations as a starting point it became necessary to develop a conscience about chemical risks and from this sprang forth the analysis of new threats within the field of environmental health, above all, the acknowledgement of how big cities increase these threats. The urban population's increased vulnerability to, and perception of these threats, also began to be analyzed. Another risk associated with urban growth is pollution generated by increased motor vehicle use needed to satisfy commuting and circulation demands that in turn increase air pollution and accidents.

One of the most important contributions to the environmental health perspective in this period is René Jules Dobos' proposal. Starting with the search for environmental influences in disease mechanisms, he proposed a global model that considered that any living being could only understand itself within the context of the interactions it maintained with everyone else. Dubos considered the problem not to be disease control, but rather health promotion. He maintained that man would never be free of disease because he must continually adapt to a changing environment. "To be healthy does not mean to not have a disease, rather to be able to function, do what one wants and obtain what one desires." He worried about complacent adaptation and uncritical people in his surroundings who weren't bothered by living with the consequences of environmental degradation that they themselves had caused. "Think globally, act locally" was one of his mottos that continues to inspire ecologists today.

1.2.4 Risks to the shared layers of the atmosphere: 1985 to present

The current risks and recent problems that the environmental health field has faced are mainly global. Problems like the accelerated increase of the world's population along with food, energy, and raw materials supply are priority issues. According to Frumkin (2005), he deems it relevant to just how the 21st century is proceeding in regards to sanitary problems and environmental health issues. In like manner, chemical dangers continue to be applicable. Looking towards the future, there are a number of movements that will enrich environmental health such as: a) environmental justice, b) global change, c) vulnerable communities and groups and d) movements for sustainability.

Of these, perhaps the one that most characterizes this period is global change. Over-exploitation of the earth's resources and the impact on ecosystems and human health are prime concerns on a global level. This over-exploitation has ceased to be a consideration for only some countries. In August 2012 it became a world problem with the recognition that the planet no longer has the capacity to regenerate because of human pressures. The demands of the human population are increasingly greater on the works of nature, provoking global depletion that damages future stability. Other challenges

include food security which is tied to demand and growth of the world's population, food poverty, and changes to food preference patterns. Now that climate change and its effects on the regulation of water for production, soil degradation and biodiversity loss are being felt, they put food security at risk and increasing numbers of people migrate because of environmental degradation. Given the magnitude and diversity of each of these problems and their consequences to the ecosystem and human health, climate change has come to be considered the biggest challenge for environmental health in the 21st century, with heat wave deaths as the new disaster.

In current times, environmental health embodies an idea of health associated with a state of well-being that is linked to physical, chemical, biological, social and psychosocial factors. Similarly, it emphasizes the assessment of an environment connected to the study of ecosystem services and human well-being tied to physical, mental, individual and community health, with access to essential comforts for development, freedom and happiness.

The best known current definition of environmental health was defined by the World Health Organization in 1993: "The relationship between those aspects of human health, including quality of life, are determined by physical, chemical, biological, social and psychological factors in the environment. It also refers to the theory and practice of assessing, controlling and avoiding environmental factors that can potentially harm the health of current and future generations." (WHO, 1993:1)







2. A dialogue between the fields of scientific literacy and environmental health

A historical analysis of the scientific literacy and environmental health fields over four periods (see Table 1), enables the identification of characteristics associated with both emergence and development. It also helps to support ties that have been established between both fields so that strengths can be built on what contribute to advancing the creation of a society with greater well-being.

2.1 *From exclusive positivism to social and critical approaches*

The needs, conditions, and social interest from which emerges both the scientific literacy field as environmental health refers to objects of study whose approach and inquiry are based mainly on the use of the scientific method, which is the only valid method of study to explain and understand natural and even social phenomena. We could say that in the first two periods analyzed (before 1945 and from 1945 to 1956), positivism is the main philosophical thinking which arose from both periods. According to Kincheloe (2008) the culture of positivism can be summed up in the following six epistemological (with ontological dimensions) assumptions: *formal*, *intractable*, *decontextualized*, *universalistic*, *reductionistic*, and, *one dimensional*. Its implications in the education field and specifically in scientific literacy collided with those approaches. Furthermore, he proposed that their sources of behavior were external; belonging to the environment. Consequently,

Table 1. Periods of analysis and development of scientific literacy and environmental health and their characteristics

Period	Scientific Literacy	Major Historical Disaster	Environmental Health
Before 1945	Science for the few 	In the last 112 years, the 10 main episodes of deaths from epidemics (bacteria and viruses) occur between 1901 and 1926 with 9 million deaths accumulated 	Microbiological health hazard
From 1945 to 1956	Learning science as educational goal.	1952 is the period of greatest historical damage in relation to air pollution deaths; in London from the 4 th to the 8 th of December: 4,000 deaths. 	Toxicological, chemical, and health hazard
From 1957 to 1984	Scientific knowledge and social responsibility	Society becomes more vulnerable due to rapid urban growth. In addition, cities as population concentrators become spaces of high pressure and environmental pollution	Organized and associated risk is increased by the triggering of uncontrolled population growth and the increase in vulnerability in urban centers. 
From 1985 to date	Scientific literacy in a globalizing world.	Nine more episodes of death by heat waves in the last 112 years occur in Europe and Asia between 1998 and 2010 causing 127,000 deaths. 	Risk due to global changes. 

there was a rejection of introspection and consciousness. Curricular design proposed the development of a sequence of definitive conceptual contents and unquestionable truths organized according to logic or discipline.

The environmental health field was established with a vision. The importance was to control the disease from a cause-effect approach; however it hardly analyzed the impacts caused by environmental degradation and its impact on human well-being. In addition, the forces that caused pressure and degradation to the environment including social, economical and political forces were barely considered. Progress made in each field under the positivist thinking had limits, due mainly to the recognition of the complexity that characterizes both the human being in his natural and social environment, as well as the changing nature of the social, cultural, political and environmental processes.

At the end of the decade of the fifties and early sixties, both fields underwent significant changes in their visions, object of study, and above all behaviors in how to research and interpret their reality. Environmental health and scientific literacy fields expanded and were strengthened through interdisciplinary approaches from which they assumed new forms of knowledge production and incorporated alternatives into research methodologies. Socio-cultural perspectives were included, from which the world vision and the events were no longer stable anymore, but rather dynamic and diverse, and changed from the lineal to the complex.

We are faced with an environmental degradation of great magnitude. Multiple damage to health and an urgent need to take care of them efficiently are today's links. Consequently, environmental health and scientific literacy fields are extremely important. In recent decades the impetus towards promoting human health through international agencies as well as formal and informal education spaces and media communication has been constant, but the results have not been as expected.

Since 1995, due to an initiative by the World Health Organization (WHO), health programs in schools have been implemented taking into consideration that such programs can be some of the most cost effective investments a nation can make to simultaneously improve education and health. This approach assumes that a scientifically literate society in health care increases its well-being level because it has the skill that allows the society to better meet issues such as health and the environment. In like manner, scientific literacy may be considered as an action indicator of the environmental community's health when directed to reduce pressure on the environment or exposure to contaminated environments.

3. Environmental health indicators as guideposts for science literacy

Indicators have different functions, one of them being that it allows for the impact of knowledge. This helps individuals to be conscious of the environmental risks they are exposed to, as well to understand and to make better decisions. It teaches them about the personal opportunities that they have to avoid or to reduce exposure and minimize the impact on their health. In this way, indicators are a means to achieve ends arrived at through conscious decision making processes, taken in order to interact in an effective way with everyday realities, while justifying scientific literacy.

Indicators for environmental health are those that identify a state of environmental degradation that people and communities are exposed to, such as air, water, or food

contamination. Life today, and above all well-being, is subject to making decisions that require timely, accurate, and trustworthy information about health and the environment. Indicators have the potential to build important tools for technical and scientific communication; transforming information into action and for that matter, into scientific literacy.

Given the characteristics and functions of environmental health indicators we consider the information relevant in identifying the principal environmental problems and subsequently of communicating them to the citizens, and of guiding problems in scientific literacy. In this regard, and since the scientific literacy of Vision II, environmental indicators contribute to the acquisition of scientific knowledge being used in socially relevant contexts, and therefore should help to resolve environmental problems. In other words, they contribute to scientific literacy, both formally and informally, addressing in an effective manner the current problems in the field of environmental health.

Within this framework in the environmental health indicators we undertake an exercise to identify the main environmental quandaries that are present in the second most populated city in Mexico: Guadalajara. Once identified, we pose one of the best strategies to deal with it through scientific literacy of its citizens.

We have three main references: a) a local citizens' forum which emerged in 1995 wherein the principle environmental problems are revived and are identified by different social sectors; b) a worldwide scientific report on air quality published in 2012 prepared by the United Nations Environment Programme, and 3) a study carried out by Bell *et al.* (2011), on air pollution in sixteen Latin American cities.

3.1 Ecology forum in the metropolitan area of Guadalajara

The information provided by the residents on the environmental conditions of the community in which they live is of the utmost importance given the fact that they are affected by their surroundings. One of the most complete studies on the problems identified by the residents of the city of Guadalajara was the Ecology Forum organized by the Guadalajara City Council (1995) with the purpose of structuring a Municipal Development Plan. In it were presented environmental matters that were deemed relevant; thus the participants could assess them in order of their importance. The call was open and issued by means of daily newspapers and radio spots. The results are presented in the following table:

In the preceding chart we can observe that air pollution is found within the three main problems mentioned by the different participants in the social sector.

3.2 The United Nations Environment Programme and the health indicators of air pollution in Latin American cities

Studies carried out in recent years confirm the problem of air pollution. It is increasingly serious, principally in the city of Guadalajara. In the UNEP Year Book 2012, the United Nations Environment Programme studied for the second consecutive year the topic of air pollution and human health in cities as an emerging topic for the global environ-

Table 2. Main environmental problems identified by different social sectors. (Curiel y Garibay, 2006)

PARTICIPATING SECTORS	Number of Participants	Air Pollution	Water Pollution	Municipal Solid Waste	Deforestation	Uneven Urban Growth	Loss of Biodiversity	Risk	Poverty	Hazardous Waste	Population Growth	Desertification	Poor Quality Foods	Soil Contamination	Consumerism
Academic	14														
Governmental	11														
Corporate	9														
NGO	8														
Agricultural Commodities	8														
Social (Health Sector)	7														
Nonpartisan Citizens	7														
Youths (< 25 years)	6														
Total	70	8	8	8	7	7	7	5	5	5	4	3	1	1	1

ment. Both in 2011 and 2012 urban air pollution on a global level has been presented as a relevant indicator, including three contaminating criteria: particulate matter of less than ten microns, nitrogen dioxide and sulfur dioxide. On the American continent, the three countries with the biggest problem in particulate matter are Argentina, Chile, and Mexico. The countries most contaminated with nitrogen dioxide are Brazil, Mexico, and Venezuela; and in the case of sulfur dioxide: Mexico, Argentina, and Brazil. Consequently, the first conclusion one reaches is that Mexico on a world level requires scientific literacy because of environmental health problems, which originate from air pollution in cities where 77% of the population lives.

In 2011, Bell *et al.* carried out an investigation on environmental health indicators regarding air pollution in sixteen Latin American cities, of which six were chosen from Mexico: Toluca, Puebla, Guadalajara, Mexico City, Juarez and Monterrey.

The study is very interesting and presents a contribution to environmental health as well as scientific literacy, if we take the information and look at it for example on the level of average pollution by particulate matter less than ten microns. We find that the order of the cities studied according to conditions from good to poor is the following: Toluca, Puebla, Guadalajara, Mexico City, Juarez and Monterrey.

But through the environmental health indicator related to the order of cities with regard to exposure of the population under five years old (which is the most vulnerable), particulate matter pollution levels that affect health would be in the following order: Juarez, Toluca, Puebla, Monterrey, Guadalajara and Mexico City.

Several studies report that children under five are most vulnerable to damage their health to acute and chronic exposure to air pollutants levels. Their physiological immaturity is because of their organs, tissues and systems are under development. Consequently they are more susceptible to damage by pollutants. Proportionally children breathe more air than adults, are more exposed to pollutants and enter more noxious compounds to their body (Makri and Stilianakis, 2008; WHO 2005; Salvi 2007).

The previous information would be a result of changing the state indicator (average levels of pollution) to one of exposure. In other words, there is a need for scientific literacy in order to know how *not* to be exposed to dangerous levels of pollution. Such a need to protect one's health is greater in Guadalajara and Mexico City.

Nevertheless, when discussing the indicator for areas where pollution originates, one recognizes that the main cause (more than 70%) is from motorized vehicles. When the proportion of numbers of vehicles to inhabitants is analyzed we see that it is greater in the city of Guadalajara than in Mexico City, the latter considered as the metropolis with the greatest population in the country.

In short, from these examples (Curiel and Garibay, 2006; UNEP, 2012 and Bell et al., 2011) we confirm the main environmental problem that is present in the city of Guadalajara. Likewise, we recognize that a strategy to deal with it is increasing the social capacities in the fields of scientific literacy for its citizens. Air pollution is an environmental health problem with a tendency to increase in recent years; thus measures are being taken to resolve the structural causes that provoke it. Furthermore, it is a problem before which we are exposed, and its solution not only depends on the individual, but rather on the collective interest and the political will. That is to say, air pollution implies a statement before which the citizen must reduce his vulnerability to lessen the damages to his/her health.

3.2 Air pollution as a relevant issue to be dealt with by scientific literacy for the citizens of Guadalajara

We must take into account that the analysis of environmental health indicators is a source of valuable information to guide scientific literacy processes. That is to say, a scientifically literate population is capable of stopping and reversing the risks that atmospheric pollution represents to health. According to information from the WHO (2011), it is estimated that air pollution causes approximately two million premature deaths per year in the world, a situation that is possible to change as long as citizens make appropriate decisions regarding their health and the health of their ecosystems.

The importance that we assign air quality lies in the recognition that without distinction we are all affected and/or benefit from it. Air quality is our main link to the environment. Each time we breathe we are connected to and at the same time exposed to its degradation and quality. The study and understanding of how different kinds of practices harm its state constitute fundamental aspects for the development of sustainable societies. Moreover, air quality is an indicator that in turn allows us to evaluate practices of human civilization like consumption, production, mobility and industrialization. As a

consequence, it is accepted that air quality is an indicator of the level of scientific literacy in a community and its relationship with the planet.

Generally, residents with low educational (illiterate or elementary school) had a higher number of deaths from air pollution-related effects than those with high educational attainment (middle school or above). The effect estimates of pollutants were 1–2 times larger among the low-education group compared with the high-education group (Kan et al, 2008).

In many countries, road traffic is the major source of ambient air pollution in urban areas, where most people live. In 1989, in Denver, Colorado, showed elevated risks of cancer among children living near streets with high traffic density. These results indicate an association between traffic density near the home occupied at the time of diagnosis and childhood cancer (age 0–4 years), Evidence of increasing risk with increasing traffic density was found for the total number of cancers and leukemias (Savitz, 1989).

Childhood obesity has emerged as a major public health problem in the United States and elsewhere. Recently, researchers examined the role of traffic density around the homes of children. Jerrett et al (2010) found that higher levels of vehicular traffic were associated with higher attained body mass index (BMI measured as kg/m²) in children aged 10–18.

Other research indicates that air pollution exposure, with traffic as a major source in many cities, may operate through inflammatory pathways to initiate metabolic processes contributing to diabetes formation (Brook et al, 2008).

As investigators, professors, and propagators of environmental health sciences, and revisiting the concept of environmental health that recognizes the theory and practice of assessing, correcting, and preventing those factors in the environment that can potentially adversely affect the health of present and future generations (CIEH, 1995), we regard literacy for environmental health is effective when it allows individuals to make decisions that improve his/her health and well-being.

Accordingly, and given the situation that exists in the city of Guadalajara, we urge that curriculum design for both compulsory education as well as for non-formal education be flexible; with an ability to address problems that are causing the most damage to human health and its surroundings. A greater effort will be necessary for the application of literacy strategies that assist the population that are not a formal education process. The situation that currently exists in Guadalajara is an indication that its citizens do not have literacy which affords them a quality of life; and therefore they are incapable of reducing the sources of pollution (vehicles) or exposure to pollution.

From this brief sketch about air pollution problems in cities and their implications for the health of inhabitants, it is crucial to highlight the importance of focusing efforts on citizen scientific literacy and topics or situations that accomplish criteria suggested by Aikenhead (2012), educational soundness and relevancy rather than political expediency. Considering these criteria, environmental topics should hold a privileged spot in science curricula and should promote an educated citizenry able to critically examine issues of local importance and global significance in ways they currently do not (Dillon, 2012a).

4. Attention to problems in the environmental health field: An opportunity to improve scientific literacy for citizens.

Scientific literacy is necessary to address environmental problems and thus requires an interdisciplinary collaboration between natural and social sciences. Regarding this approach Chapin, et al. (2011), emphasizes that strategies for social–ecological transformation to reverse planetary degradation must propose an interdisciplinary literacy and community based programs. This type of environmental literacy has as its main purpose in providing scientific, economic, and social information which would allow the building of a foundation that would guide their actions in both reducing the uncertainties as well as improving their well-being.

When we discuss citizen literacy regarding environmental health we would like to emphasize that the concept is not limited to individual actions aimed at mitigating environmental impact problems by the prevailing development systems, but rather we consider the transformation capacity derived from the social awareness that leads to a better cultural relationship with the environment; leads individuals and communities to take the environmental issues as a matter of interest, and responsibility and collective action. Scientific literacy should recognize the need to make science education more culturally and socially relevant (Roth and Barton, 2004).

Touching upon the air pollution problem once again in the Metropolitan Area of Guadalajara, concurrently we consider that the current situation demonstrates the quality practices of its inhabitants. Although actions have been taken to resolve this situation, it has not yielded the desired effects. However, what we deem important is that it represents an opportunity to undertake community practices which create a permanent scientific literacy process that may lead to a better understanding of the decision making population and its well-being.

We recognize that environmental health is a condition for a sustainable development to which we aspire; not only as a technical and specialized issue, but rather a human one as well. Primarily the most important challenge is to generate a better understanding of environmental and health problems and provide tools that enable citizens to become more participative in committed action, i.e., citizens committed to search for and develop strategies. In consequence, “focusing on issues of health and the environment might motivate more students to appreciate the value of science and to consider studying it for longer either at school or elsewhere.” (Dillon, 2012: 1082).

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THE ENVIRONMENTAL HEALTH FIELD: AN OPPORTUNITY TO REACH SCIENCE EDUCATION GOALS

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Abstract: This paper highlights the relevance of the connection between environmental health and scientific literacy. It takes a historical approach looking at the contribution of environmental health to scientific literacy and it analyzes a contemporary case: air pollution and human health in urban areas. We recognize the importance of learning about daily exposure in large cities with regard to air and the effects on human health when air quality deteriorates. This allows establishing air as an indicator of environmental health and a relevant benchmark to be included in scientific literacy in order for individuals to be able to make responsible decisions for the well-being of healthy persons, and communities.

Key words: scientific literacy; environmental health; air pollution; citizenship.

Resumen: Este trabajo destaca la importancia de la conexión entre la salud ambiental y la alfabetización científica. A través de un enfoque histórico se describen las aportaciones de la salud ambiental a la alfabetización científica y se analiza un caso contemporáneo: la contaminación del aire y la salud humana en las zonas urbanas. Destacamos la importancia de aprender acerca de la exposición diaria a la contaminación del aire y los efectos sobre la salud humana, cuando la calidad del aire se deteriora. Establecemos al aire como un indicador de la salud ambiental y un punto de referencia que deberá figurar en la alfabetización científica para que las personas sean capaces de tomar decisiones responsables para su bienestar así como para el bienestar de las comunidades.

Palabras Clave: alfabetización científica; salud ambiental; contaminación del aire; ciudadanía.

Resumo: Este artigo destaca a importância da conexão entre saúde ambiental e alfabetização científica. Através de uma abordagem histórica se descrevem as contribuições da saúde ambiental para a educação científica e se analisa um caso contemporâneo: a poluição do ar e a saúde humana em áreas urbanas. Reconhecemos a importância de se aprender sobre a exposição diária à poluição do ar nos grandes centros urbanos e sobre seus efeitos na saúde

humana, quando se deteriora a qualidade do ar. Isso permite estabelecer o ar como um indicador da saúde ambiental e um ponto de referência para ser incluído na alfabetização para que as pessoas possam ser capazes de tomar decisões responsáveis para seu bem-estar e para o bem-estar das comunidades.

Palavras-chave: alfabetização científica; saúde ambiental; poluição do ar; cidadania.
