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Reflection on Health Indicators for Atmospheric Chemical Pollutants

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Abstract. Health and environmental indicators are already a reality in some countries that have invested in technology, qualification of personnel, design of government frameworks, revision of legislation and an interconnected computerized structural web that allows actions of monitoring, planning and control, through these indicators, at the national level. Brazil, following the guidelines of the Action Plan for Sustainable Production and Consumption (PSPC) program, has sought to implement actions for technological and personnel development with international standards, and has obtained surprising results, but it is still necessary to commit efforts to implement the computerized system of indicators, among the main government agencies. This work proposes, through a bibliographical review, a reflection of the parameters used to indicate the local pollution levels, as well as, the systems of warning to the population for respiratory protection measures. The results demonstrate a need to update the concepts on alert and measures to prevent the exposure of atmospheric chemical pollutants to population.

Keywords. *Health and environmental indicators, atmospheric chemical pollutants, respiratory protection measures,*

Introduction. All fossil fuels and biomass contain carbon. When these fuels are burned they emit atmospheric pollutants [1]. Fires in industrial facilities for the production, storage and transfer of petroleum and its by-products are responsible for large emissions of air pollutants depending on the volume involved and the response time for their control [2]. Another condition to be considered is the exposure to vehicular air emissions in open urban areas, which has caused problems for the health of the world's population, according to the World Health Organization: 1.15 million, equivalent to 2%, of premature deaths around the world, with 0.61 million men and 0.54 million women, with 8% lung cancer death, 5% cardiopulmonary death, and 3% death from respiratory infection, [3].

Federal legislation in Brazil, through the Ministry of the Environment, published Resolution CONAMA No. 003, on 06/28/90, with the national parameters of air quality, and later in 2011 carried out the first national inventory of vehicular air emissions, in addition to the regulation of methodologies for calculating emissions. São Paulo State's Decree no. 59,113 of 04/23/2013, established air quality parameters, staggering emission limits in three stages

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interconnected with validity as of 2013. The State Technology Company of São Paulo, CETESB, carried out the inventory of vehicular atmospheric emissions in 2013, estimating that 423 thousand tons of carbon monoxide (CO), 72 thousand tons of non-methane hydrocarbon (NMHC), 192 thousand tons of nitrogen oxide were emitted (NOx), 5,400 tons of particulate matter (PM), 15,000 tons of sulfur dioxide (SO2) and 1,600 tons of aldehydes, all toxic pollutants, [4].

In the United States, the National Institute for Occupational Safety and Health (NIOSH), which is linked to the Centers for Disease Control and Prevention (CDC), annually publishes a review of exposure limits and toxicological effects for a large number of chemicals, we can find the main air pollutants, inventoried by CETESB, where there are worrying adverse health effects, which in the case of NO2, can cause from irritation to the eyes, cough, decreased respiratory function, chronic bronchitis, pulmonary edema, cyanosis, tachypnea, and tachycardia [5].

The World Health Organization (WHO) published its tenth review of the international classification of diseases (ICD-10) in 2010, where chapter 10 deals with the codes and names of respiratory diseases [6], important information for the survey of disease indicators related to atmospheric chemical pollutants. Despite the legal and methodological progress in the assessment and control of atmospheric emissions, much work still needs to be done to create an interrelated database between health and environmental areas to create more effective and efficient controls on air emissions and prevention of respiratory diseases.

This work is justified by the reflection of the main environmental and health indicators practiced in Brazil, compared to those established in other countries, through the analysis of success stories and methodologies. To this end, it is proposed to survey the national indicators as a starting point in order to reflect on the database and its treatment, with the elaboration of the means to make information more effective, involved in preventive actions, in the monitoring and control of respiratory diseases and concentrations of atmospheric emissions.

Method. The proposed method uses a bibliographical research, combined with a systematic analysis of environmental and health indicators, correlating the toxicology of the pollutants emitted, the combustion of fossil fuels and biomass, with the chronic and acute exposures related to the times of exposure and concentrations, and parameters used in other countries.

The data collected are based on the reports prepared by the environmental and public health agencies at federal, state and municipal levels. The indicators generated from this database will be compared with those practiced in other countries such as the United States, New Zealand, England and Canada. In the next step, an analysis of the public availability of information to prevent exposure to atmospheric chemical pollutants, in areas considered critical, for a proposal for preventive control. As a conclusion the results analyzed provide a reflection of the public policies on the methodological practices used, nationally and internationally, for the availability of environmental and health indicators, in the prevention of the exposure of chemical atmospheric pollutants.

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Atmospheric emissions and health effects. At national level, Law No. 12,187 of 12/29/2009, established the National Policy on Climate Change - PNMC, regulated by Decree No. 7,390 of December 9, 2010, which contemplates the reduction target of 36.1% to 36, 9%. The inventory of atmospheric emissions corresponds to the survey of quantity per pollutant for a period of one year, from defined sources of pollution, in a geographical area of sampling [4]. The main air pollutants considered in the atmospheric emissions inventory are: carbon monoxide (CO), total aldehydes (RCHO), non-methane hydrocarbons (NMHC), particulate matter (PM) of gasoline and diesel powered vehicles. The estimate of greenhouse gas emissions is expressed in CO_{2eq} (CO_{2eq}), where emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are considered. The calculation for atmospheric emissions for each identified pollutant is carried out according to Equation 1. The idea is to verify the emission by atmospheric pollutants, from the volume of circulating fuel, in the reservoirs of the vehicles with the circulating fleet, the autonomy, through the intensity of the use or annual mileage per vehicle, corrected by the emission factor, which is obtained in an emission laboratory test for the years provided for in CONAMA.

$$E = Fe \times Iu \times Fr \quad (1)$$

At where:

E = mass of pollutant emitted during the period considered (g / year);

Fe = Emission Factor, depends on the type of vehicle, pollutant and fuel used (g / km);

Iu = Intensity of use or average annual mileage traveled by the vehicle (km / year);

Fr = Current fleet, by type of vehicle and per year (number of vehicles).

The pollutant emission estimate for the state of São Paulo in 2013, in tons (t), per pollutant was: 422,880 tons of CO, 72,339 tons of NMHC, 191,705 tons of NO_X, 5,418 tons of (MP), 15,048 tons of SO_2 , and 1591 tons of RCHO [4].

The estimated national vehicle emissions in 2010, in tonnes, per pollutant was: 96,909,652 tons CO_2, 1,371,743 tons CO_2, 223,039 tons NMHC, 949,578 tons NO_x, 28,807 tons PM, 7,163 tons RCHO , and 34,670 tons of CH 4 [7].

Another problem related to emissions of pollutants is the burning of biomass caused by forest fires and that according to a study carried out by the Institute of Physics of USP, in some regions of the Amazon (Alta Floresta, Rondônia, Balbina, Belterra, Ji Paraná, Cuiabá, Campo Grande and Rio Branco), where burnings occur that reach 10,000 to 15,000 km² per year, with a biomass per hectare of the order of 150 to 300 tons. These fires emit a large amount of particulate material, where particulate matter (MP) values were measured around 500 µg / m³, and the emission limit for particulate matter (PM10) is an annual average of 50 µg / m³ [7].

The emissions of chemical pollutants mentioned generally have the characteristic of causing changes in the state of health of the population, and in this sense it becomes important to understand these effects to health. The Toxicology is the science that studies the harmful effects arising from the interactions of chemical substances with the organism [8]. The Material Safety

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Data Sheets (MSDS) contain data records on exposure limits, health effects, and other information intended to prevent exposure to sources in the workplace. Table 1 below presents some identified health effects for chemicals identified as the major air pollutants, surveyed in the United States Centers for Disease Control and Prevention (CDC) database, State of Georgia [9].

Table 1. Chemicals with indication of health effects [9]

Pollutants	**Effects Health**	**Exposes Limits**	**Target Organs**
Nitrogen Dioxide (NO2)	Irritation eyes, nose, throat; cough, mucospough expectoration, decreased lung function, chronic bronchitis, pulmonary edema, cyanosis, tachypnea, tachycardia.	1.8 mg / m³ (1 ppm) NIOSH	Eyes, respiratory system, cardiovascular system.
Nitrogen Oxide (NO)	dyspnoea (difficulty breathing), drowsiness, headache, asphyxia, reproductive effects, (liquid): burns.	46 mg / m³ (25 ppm) NIOSH	Sist. respiratory system. reproductive, sist. central nervous system.
Carbon Dioxide (CO2)	headache, dizziness, agitation, paresthesia, dyspnea (difficulty breathing), sweating, malaise (vague feeling of discomfort), increased heart rate, cardiac output, blood pressure; coma, suffocation; convulsions; freezing (liquid, dry ice).	9000 mg / m3 (5000 ppm) NIOSH	Respiratory system, cardiovascular system.
Carbon Monoxide (CO)	headache, tachypnea, nausea, tiredness (weakness, tiredness), dizziness, confusion, depression, ST depression / depression of the electrocardiogram, cyanosis, angina, syncope.	40 mg / m³ (35 ppm) NIOSH	Cardiovascular system, lungs, blood, central nervous system.
Black Carbon (C)	Cough, Irritation to eyes; in the presence of polycyclic aromatic hydrocarbon (occupational carcinogenic potential); cancer in the lymphatic system (in the presence of PAHs).	3.5 mg / m³ NIOSH	Respiratory system and eyes.
Sulfur Dioxide (SO2)	irritation in the eyes, nose, throat, coryza (muconasalfina discharge), choking, cough, reflex bronchospasm; liquid: freezing.	5 mg / m 3 (2 ppm) NIOSH	Eyes, skin, respiratory system.
Formaldehyde	eyes irritation, nose, throat, respiratory tract, tearing (tear discharge), coughing, wheezing, (potential occupational carcinogen.	0.016 ppm NIOSH	Eyes, respiratory system (nasal cancer).

An important aspect is the identification of the health effects correlated with exposure to the pollutant (chemical), indicating which target organ can be damaged. The effects on health, in addition to concentration, also depend on the time of exposure and the concentrations in the environment, and the effects may be chronic, over a long period of time, or acute over a short period of time [8]. Although exposure limits are set for indoor workers and the exposure limits for external populations differ, the effects indicated depend only on the susceptibility of each, depending on the concentration in the air, respiratory activity and kind of display. The World Health Organization published in 2011, revision 10 of the International Classification of Diseases - ICD-10, which relates Chapter X, Respiratory Diseases, in codes from J00 to J99. The classification of diseases can be defined as a system of categories for which morbid entities are assigned according to established criteria. The objective of the ICD is to allow the systematic recording of analysis, interpretation and comparison of mortality and morbidity data collected in different countries or areas, and at different times. The ICD is used to translate the diagnosis of diseases and other health problems, from words into a numerical alpha code, which allows easy storage, retrieval and analysis of the data. It can therefore be used to classify the recorded data as: "diagnosis", "reason for hospitalization", "treated conditions" and "reason for consultation", which appear in a wide variety of health records, from which the statistics and other information on the health status of a given population are derived [6].

According to the United Nations Environment Program (UNEP) in 2010, there were 3 million premature deaths from air pollution in urban areas [10][11]. The World Health Organization in 2009 reported 1.15 million premature deaths due to particulate air pollution in urban areas, of which 8% were lung cancer deaths, 5% were deaths due to system failure cardiopulmonary, and 3% of deaths due to respiratory infection [12].

According to a study conducted in pre-natal and 5-year-old children in Canada, Vancouver metropolitan centers (population 2,250,000) and Victoria (population 325,000), 3,482 children (9%) were classified as of asthma. Conclusion: Early childhood exposure to air pollutants (CO, NO, NO_2, PM10, SO_2) plays the role of asthma, [13].

Table 2 shows the premature deaths, due to causes in the respiratory system, with the respective ICD-10 codes for the years 2007 to 2011 [14][15].

Table 2 - Respiratory system - CID-10 code of cause of death for the period 2007-2011 – Canada

Cause of Death (ICD-10)	**2007**	**2008**	**2009**	**2010**	**2011**
Influenza and pneumonia (J09-J18)	5452	5386	5826	5106	5767
Other respiratory infections below acute (J20-J22)	105	86	83	82	69
Respiratory diseases below chronic (J40-J47)	10659	10923	10859	10757	11184

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Pneumoconiosis and chemical effects (J60-J66, J68)	85	90	84	90	102
Pneumonitis due to solid and liquid (J69)	1614	1629	1710	1959	2006
Other diseases of the respiratory system J00-J06, J30-J39, J67, J70-J98)	2603	2614	2734	2763	2956

Respiratory illnesses are quite common in Canada, and can range from minor symptoms such as runny nose, sore throat, cough and allergies to more serious conditions such as asthma, chronic bronchitis, emphysema and pneumonia, all directly related to air pollution [16]. In 2004, more than 10% of hospital admissions were recorded for respiratory diseases. In this same period, more than 37,000 deaths were recorded from respiratory diseases, including cancer [17][18].

In New Zealand, the indicators are related to the PM10 pollutant, as it causes the most worrisome health effects, and are divided into three categories: the estimated number of premature deaths due to PM10 exposure; estimated number of hospitalizations due to PM10 exposure; and the estimated number of days of activity restriction due to exposure to PM10. Health impacts are estimated by determining the concentration of the pollutants to which the population is exposed and the likelihood of the risks after exposure to these concentrations. The monitoring of PM10 concentrations comes from monitoring stations, and the population survey comes from the population census conducted. The dose response function is calculated from national and international epidemiological studies. The focus of the study is the anthropogenic sources of PM10 that can be managed and eliminated. The results obtained and compared, from 2006 to 2012, of the estimated health impacts by exposure to PM10 are shown in Table 3 [19].

The Ministry of Health in Brazil has created an interrelated structure for risk identification, called the Health Surveillance of Populations Exposed to Atmospheric Pollution, known as the VIGIAR Program, which has its attributions defined at national, state and municipal levels. This program uses the Risk Identification Instrument - IIMR for the elaboration of surveillance programs, in order to guide managers and workers of the SUS (Unified Health System), in the development of health surveillance actions, as well as, the development of sectoral strategies for the prevention and control of diseases and health problems related to human exposure to air pollutants. The IIMR contains environmental information related to fixed sources (industries), mobile sources (vehicle fleet, and heat sources), as well as health information with mortality rates and hospitalizations for diseases of the respiratory system, according to ICD-10, chapter X - Respiratory System Diseases. The IIMR allows a prioritization, as well as the characterization of the population exposed to atmospheric pollutants. The data

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contained in the IIMR allows the planning of preventive actions and helps in the adoption of corrective measures [20].

In the United States, the Environmental Data Management Committee (EDMC) coordinates NOAA development and management strategy, which includes acquisition, quality control, validation, processing, storage, retrieval, dissemination, and long-term data preservation activities. The NOAA monitoring program provides high accuracy measurements of the global values and distribution of long-lived greenhouse gases that are used to calculate climate changes. Air samples are collected through the NOAA / ESRL global air sampling network, including a co-operative program for carbon gases that samples approximately 80 sites, distributed according to the pictograms indicated in the legend of Figure 1 below, on the surface (red), observatories (light blue), towers (green) and aircraft (blue).

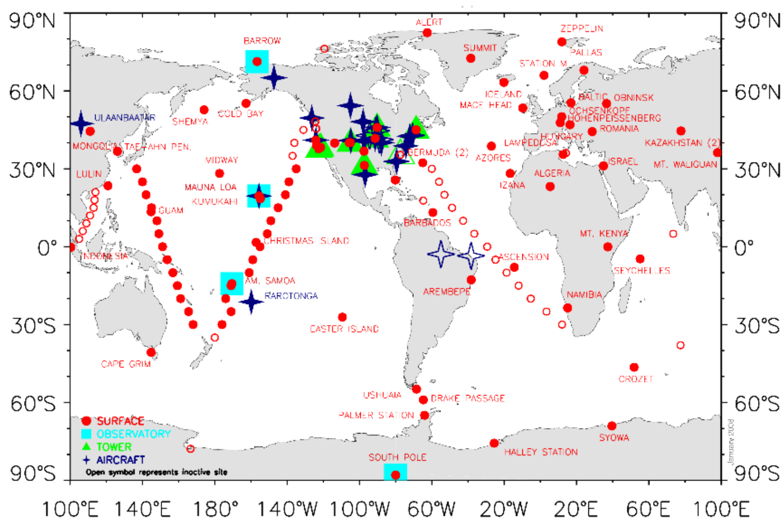

Figure 1. The global cooperative network NOAA System Research Laboratory used air sampling to determine the AGGI. Source: Earth System Research Laboratory of the Global Monitoring Division - NOAA. The NOAA Annual Greenhouse Gas Index (AGGI).

In Brazil, the National Institute for Space Research (INPE) of the Ministry of Science, Technology and Innovation is integrated into a network of its own artificial satellites and other institutions such as NOAA, which monitor the continent in real time with information space weather, climate and weather, fires, and emissions of pollutants (carbon monoxide). Among the objectives of INPE is to expand and consolidate science, technology and innovation competences in the space and terrestrial environments to respond to national challenges. Recently, the National Observatory of Climate and Health, known as Observatorium, was created in a partnership between the Oswaldo Cruz Foundation (Fiocruz), through the Institute of Communication and Scientific and Technological Information in Health (ICICT), and the National School Sérgio Arouca (ENSP), together with INPE, for mediation and better treatment

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of data, through the interactive website (http://www.climasaude.icict.fiocruz.br/#) for the adequacy of environmental, climatic, epidemiological, socioeconomic and public health data, for a more effective information.

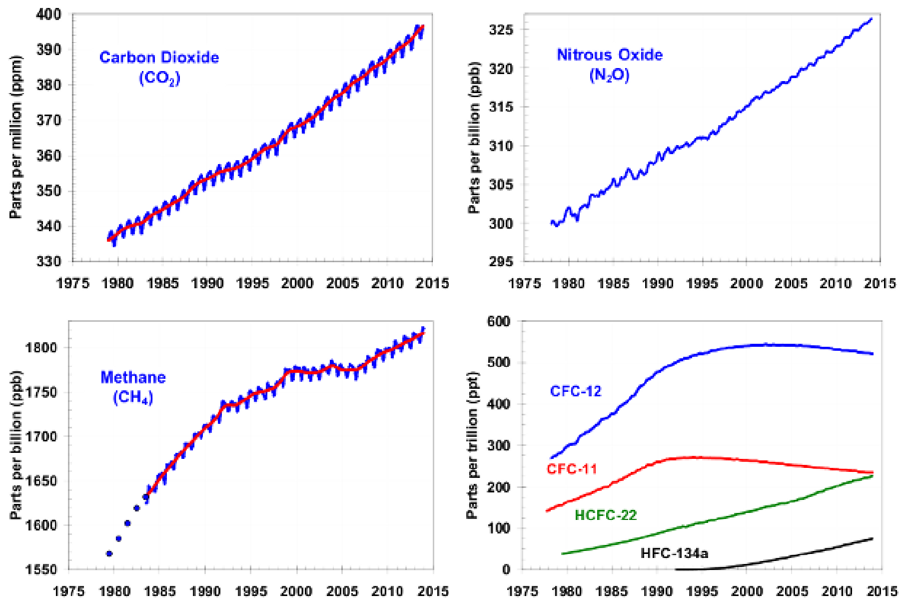

Figure 2. Overall averages of the main long-lived greenhouse gases: carbon dioxide, methane, nitrous oxide, CFC-12 and CFC-11. These gases account for about 96% of long-lived greenhouse gases since 1750. The remaining 4% is a contribution of a variety of 15 smaller halogen gases, including HCFC-22 and HFC-134a.

Discussion. The inventories of atmospheric emissions for vehicular sources are carried out annually for the state of São Paulo, by CETESB, and the parameters of air quality are defined by State Decree nº 59.113 of 04/23/2013. The Ministry of the Environment carried out the inventory of national air emissions in 2011. The parameters of air quality were defined in Law 12,187 of 12/29/2009, which also established the National Policy on Climate Change (PNMC). In 2010, the World Health Organization published its tenth revision of ICD-10, International Classification of Diseases, where chapter 10 deals with the codes and names of diseases of the respiratory system. The Centers for Disease Control and Prevention (CDC) provides a database on health effects from exposure to chemicals, including air pollutants. Some countries, such as New Zealand and Canada, have a national health data collection system on atmospheric pollutant concentrations by site and the health effects of this exposure, which are basically represented by three types of indicators: premature deaths, those of hospital admissions and those of days lost due to respiratory diseases.

NOAA, in the United States, has a system of artificial satellites, to which INPE, in Brazil, is interconnected, which allows the monitoring of greenhouse gases, burned, among others, that ensure a monitoring of 82, of the major urban centers on the planet. The Ministry of Health in Brazil has a computerized, integrated and structured system between IBGE, DENATRAN and INPE that enables the monitoring of health and environmental indicators. However, there is still no requirement for the introduction of health effects data by municipal health institutions, which makes the results of the system ineffective. The data available in the system, which are recorded by those responsible, still do not allow a good representation for the interpretation of the indicators.

Conclusion. In Although there is already a computerized integration in Brazil that allows the achievement of health effects indicators, exposure to atmospheric pollutant concentrations, and health effects, some adjustments are still necessary. For example, the design and implementation of atmospheric pollutant monitoring equipment for locations that do not have an air quality monitoring system, and the scaling and implementation for locations that do not yet have sufficient air quality monitoring points . At the level of municipalities, the data are quite scarce, as they depend on their initiative for the collection and feeding of the database. The creation of a respiratory protection program, providing masks for populations exposed to high concentrations of pollutants, and air quality indicator systems, with new parameters to make information available to the population on critical levels, or of concern , so that the population can seek available forms of protection. The creation of an indoor air quality control program, located in the most polluted centers with monitoring indicating levels of concentration of atmospheric pollutants, which may affect the health of employees, arising from the external source of air pollution. The creation of mask distribution stations to protect against gases or particulates, when pollution indices were critical, which would be available, at the indicated concentrations at local monitoring stations. The withdrawal by the user would be performed, through the use of bank cards or other type of cards, only for data information. The location of these automatic masking stations would be in public places linked to the air quality indicator information panels.

The need to revise the guidelines of the Ministry of Health's Manual of Instructions - 2014, prepared for the Risk Identification Instrument - IIMR, of the VIGIAR Program - Health of Populations Exposed to Atmospheric Pollution, making it mandatory to health and environmental indicators, by the managers, through the qualification and re-dimensioning of the SUS frameworks, to capture, analyze and release data in the structure already created on the website. The creation of a supervisory system to control the data of: related hospital admissions, premature deaths and the loss of days related to respiratory diseases, by exposure to air pollutants for adequate screening and identification of data, increasing the effectiveness of recorded information. Expand a research network, through projects, for the inventory of local fixed sources of emissions of atmospheric pollutants (chimneys, flares, diesel, gas and gas generators), with local cadastre and monitoring of these sources, through environmental agencies municipal, state and national levels, linking the indicators directly to the process of operating licenses, with annual evaluation. Adequacy of vehicle inspection system systems, increasing mandatory for all vehicles in the fleet, with the annual inclusion of data of: mileage per vehicle and mileage in the period, corrective maintenance requirements and preventive reviews. It’s needed revision of legislation and inventory implementation for mobile sources, including rail, water and air, as well as agricultural and industrial machinery. It's necessary an effective implementation of the "Observatorium Program", of the Ministry of Health, to align data available between IBGE, INPE, DENATRAM and the Ministry of Environment. Thus, with better data management, the indicators obtained may be more representative, in order to obtain more effective control actions: from sources that emit pollutants and prevent health effects.

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