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Faculty of Science and Environmental Engineering

Doctoral School Environmental Science

RISK ASSESSMENT RELATED TO VOLATILE ORGANIC COMPOUNDS EXPOSURE GENERATED BY WOOD PROCESSING INDUSTRIAL UNITS

- Thesis Summary -

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Content of the thesis

Keywords: effects on health, assessment, exposure, formaldehyde, cancer.

Summary contains parts of the thesis results, conclusions and selective bibliography.

Summary contains the same notations for contents, chapters, sub-chapters, figures, tables and equations as thesis.

RISK ASSESSMENT RELATED TO VOLATILE ORGANIC COMPOUNDS EXPOSURE GENERATED BY WOOD PROCESSING INDUSTRIAL UNITS

Novelty and importance of the topic addressed in this paper

General considerations related to air pollution and air quality in Europe (EEA, 2013)

Air quality continues to be an important issue for human health, the economy - in general - and the environment. In recent decades, Europe has significantly reduced emissions of some of the pollutants greatly decreasing emissions and exposure to certain substances, such as sulfur dioxide (SO_2), carbon monoxide (CO), benzene (C_6H_6) and lead (Pb). Despite improvements over the course of several decades, air pollution continues to harm human health and the environment. Particulate matter (PM), ozone (O_3), nitrogen-containing substances and some organic compounds is still a major threat. This leads to illness, premature death, damages to ecosystems, crops and buildings and represent real losses for Europe's economy, its workforce productivity, environmental health or natural. Effects of low ambient air quality were strongly felt in two major areas:

- In urban areas where the majority of the European population lives, and led to adverse effects to public health;
- Ecosystems, where air pollution pressure prevents the development of vegetation and harm biodiversity.

Emissions of air pollutants coming from all economic sectors and all social activities. Policies implemented at European, national and sectorial had - in time - as a result, a decrease in emissions of many pollutants and led to an improvement in air quality throughout Europe, for some pollutants, e.g. CO and Pb. However, road transport, industry, thermal power plants, household and agricultural activities continue to produce significant amounts of air pollutants.

Air pollution in Europe, caused by specific emissions can be seen as well as a transboundary problem, and as a local or regional problem, resulting - directly or through chemical reactions - the negative impacts. Each pollutant produces a number of effects, from medium to severe, as their concentration or exposure increases. The main effects of air pollution are:

- Degradation of human health from exposure to emissions of air pollutants or inhalation of these pollutants transported by air and by ingesting them because of the phenomenon of storage, followed by accumulation in the food chain;
- Acidification of ecosystems (both terrestrial and aquatic), which leads to loss of flora and fauna;
- Eutrophication produced in terrestrial and aquatic ecosystems, which may lead to changes in species diversity;
- Damage and loss of benefits for growing agricultural crops, forests and other plants caused by exposure to ground-level ozone;
- Impacts of toxic heavy metals or metalloids, and the product of persistent organic pollutants (POPs) on ecosystems, because of their toxicity or bioaccumulation their environment;

- Helping to accelerate climate change phenomena and, indirectly, their cumulative effect;
- Damage to materials and construction caused by contamination and exposure to acidifying pollutants and O3.

Effects of air pollution on human health

There is a large body of evidence of the impact that it causes air pollution on human health, but increased the level of knowledge in this field in recent decades. The recent analysis of the World Health Organization (WHO) on the effects of air pollution on health (WHO, 2013) concluded that a considerable amount of new scientific information have emerged on the market in recent years on the effect of suspended particles (PM), ozone (O_3) and nitrogen dioxide (NO_2) concentrations of pollutants common throughout Europe. These new scientific evidence supports the conclusions of the WHO guidelines introduced air quality guidelines, revised in 2005, which indicates that health effects can occur at low concentrations of pollutants. They also prove scientifically based arguments which have taken decisions that have to be taken to improve air quality and reduce the weight of disease arising from air pollution in Europe.

Most studies of the impact on health, reviewed by WHO are focused on the effects on respiratory and cardiovascular, are attributed to exposure to air pollution (WHO, 2005, 2006, 2007, 2008). But records also increased due to the wide range of effects caused by constant exposure to air pollution during different periods of life, ranging from prenatal exposure until adulthood. For example, exposure to air pollution during pregnancy was associated with reduced fetal growth, premature birth and spontaneous abortion (WHO, 2005). Maternal exposure during pregnancy increases the risk of developing allergies and asthma during their lifetime (Jedrychowski and others, 2010 – see references in EEA Report, no 9/2013; Baïz and others, 2011 – see references in EEA Report, no 9/2013). Moreover, the mechanism by which air pollution may act on the nervous system has recently been documented (Genc and others, 2012 – see references in EEA Report, no 9/2013), and several epidemiological studies have reported associations between exposure to air pollution and impaired cognitive function (van Kempen and others, 2012 – see references in EEA Report, no 9/2013) and yet, more research should be conducted to better explain these effects.

Health effects relate equally to those occurring due to short or long-term exposure to air pollution. The short term (a few hours exposure to several days) is connected to the acute manifestations of diseases, and the causes of long-term chronic diseases. Indicators quantifying health impacts of exposure to air pollution are mortality and morbidity. **Mortality** is reduced life expectancy due to air pollution, while **morbidity** is associated with the occurrence of diseases, ranging from minor effects - such as cough - until some serious requiring hospitalization.

Epidemiological studies assigned the most severe forms of the disease caused by air pollution, exposure to particulate matter (PM). The evidence is that short-term effects (and the term) became stronger. Recent studies have shown that long-term exposure to particulate matter causes a decrease in life expectancy at much lower concentrations of $PM_{2,5}$ than those specified in the guidelines developed by WHO that 10 g/m^3. The latest studies published by WHO (WHO, 2013) linking long-term exposure to PM with deaths from cardio-respiratory diseases, and increasing illness, such as respiratory illnesses in children.

Ozone (O_3) is also a marked effect on human health, and recent studies indicate that the mortality effects of this pollutant are much higher than previously thought (WHO, 2013). High concentrations of ozone cause breathing problems, reduced lung function, leading to the development of diseases, such as asthma (WHO, 2008). Short-term exposure to elevated concentrations of ozone in the summer in Europe has adverse health effects such as lung disease and lung congestion such respiratory symptoms. These symptoms, in turn, increase the morbidity and mortality, with a high consumption of the product.

Many studies reviewed by WHO (2013) which were not considered before, or were not published until 2004, provides a rich documentation showing the association between long-term exposure and the short-term NO_2, mortality and morbidity. Studies on the two types of exposure have shown the association between adverse effects and concentration that occurs at or below the limit set for this indicator (WHO, 2013).

Some polycyclic aromatic hydrocarbons (PAHs) are potentially carcinogenic and is often found attached to particles in suspension. WHO (2013) discovered the link between exposure to PAHs and morbidity, cardiovascular mortality, respectively, but - now - effects of exposure to PAHs cannot be separated from that of suspended particles. WHO recommends further BaP as an indicator that PAHs are carcinogenic, but cannot explain than half of this potential.

It is important to note that the percentage of the population exposed to low concentrations of air pollutants and less severely affected health impact is much greater than that affected by severe events that lead to more serious health effects. However, even these less severe effects on health could have major public health implications. And that's because air pollution affects the whole population, especially in large urban centers where a large majority of the population is constantly exposed. The total costs of the effects of less severe exposure may exceed those caused by severe air pollution exposures, if the population is exposed at all times. Despite all these records, but severe exposure results are taken into account in studies on the subject or when carrying out risk assessments. This is usually because these data are more available.

Developments in Community policy making

The European Union's air quality is currently a broad review process and two short-term measures have been adopted, such as:

- International Initiatives under LRTAP Convention on hemispheric transport of air pollution level culminating revision of the Gothenburg Protocol; it has set new limits on air emissions, already listed NEC Directive (NOx, VOC, SO_2 and NH_3) and direct emissions into the atmosphere of $PM_{2,5}$, ceilings to be attained by 2020.

Other measures being implemented are those included in the recent Communication from the European Commission, "Cars 2020", which outlines a timetable for implementing successful Euro 6 standard for vehicles in real operating conditions, and reviewing legislation on stationary engines.

General Program of the Environmental Action 2020 "A good life within our planet" (7th EAP) (Decision no. 1386/2013/UE the European Parliament and the Council, 2013)

At the end of 2013, the European Parliament and Council approved the 7th General Program of the Environmental Action, "a good life within our planet."

Seventh Environment Action Program has the following main objectives:

- the protection, preservation and enhancement of the natural capital;
- passing the Union to a green economy, competitive low-carbon and efficient in terms of resource use;
- protection of Union citizens environmental pressures and risks to health and welfare;
- increasing the maximum benefits of Union environmental legislation by improving its implementation;
- improving the knowledge base and data for Union policy on the environment;
- providing investment policy environment and addressing climate and environmental externalities;
- improving the integration of environmental considerations and policy coherence;
- improving the sustainability of cities in the Union;
- increasing the effectiveness of Union environmental challenges and climate worldwide.

7th EAP is based on the precautionary principle and on the principles that preventive action to remedy pollution at source and the "polluter pays" principle.

Levels of air pollution are still problematic in many parts of Europe and EU citizens continue to be exposed to hazardous substances that may affect health and wellbeing.

Integrated development and coherent environmental policy can help to ensure that the EU economy and society are adequately prepared to meet the challenges. In this respect, it is necessary to pay attention to the following three thematic objectives:

- Protection, conservation and enhancement of the natural capital;
- Transition to a green economy and EU competitive low-carbon and efficient in terms of resource use;
- Protection of Union citizen’s environmental pressures and risks to health and welfare.

Chapter 1. Introduction

Air quality in Europe has not always improved with the overall decrease of anthropogenic (man-made) of air pollutants. The causes are complex:

- there is always a clear linear relationship between decreasing emissions and concentrations of air pollutants measured in air;
- there is an increasing contribution of long-distance transport of pollutants from other countries located in the Northern Hemisphere to Europe.

Janez Potočnik, Commissioner for Environment, expressing concern about air pollution, rapid asked Member States to comply with EU standards on air quality and reduce air pollutant emissions.

EU long-term objective is to achieve levels of air quality that do not affect or induce unacceptable risks to human health and the environment.

GOALS AND OBJECTIVES

Regarding human communities, exposure should be differentiated according to concentration, which is an expression of the amount of pollutant within a given environmental factor. High concentrations of pollutants in ambient air are not necessarily implemented in high exposures.

Starting from the idea that urban sources of volatile organic compounds are numerous, car traffic is designated first, the emergence of new sources, significantly changing industrial distribution pattern of these pollutants, with direct implications for human exposure. While the concentrations of pollutants in the air can be very large near a major emitting facility, exposure to high levels of pollutants will occur only if we have populations near the facility. Exposure must also be differentiated based on the dose which relates the amount of pollutant barriers than one body.

In this context, the aim of our work is to elaborate a pilot model of integrated assessment of exposure to volatile organic compounds. We intend to follow the development of spatial distribution of VOC concentrations in order to assess human exposure and risk of cancer in calculating exposure to formaldehyde.

General and specific objectives of the work

The overall objective of this paper is the environmental risk assessment and public exposure to volatile organic compounds emitted by woodworking industrial units in Transylvania (Braşov and Reghin).

In order to develop the major objective of this paper has identified several specific objectives:

- Develop a unique methodology in order to obtain comparable database Brașov and Reghin areas by:
    - a study to identify areas of Brașov and Reghin exposure to volatile organic compounds (formaldehyde);
    - an assessment of environmental conditions, risk factors and impact on population groups associated with exposure to volatile organic compounds in the investigated areas.

Specific objectives:

- Analysis of national and international data on VOCs and formaldehyde exposure and health effects;

- Risk assessment and impact population groups associated with exposure to VOCs and formaldehyde in the areas investigated in correlation with the distance to the targets investigated and the measured concentrations of hazardous substances in the environment.
- By conducting pilot model of integrated assessment of exposure to VOCs estimate a positive impact of the project on knowledge of current environmental conditions in terms of VOC pollution of our knowledge and according to the published project is an absolute novelty for Romania and one of the few studies which addressed worldwide integrated exposure to formaldehyde in the unprofessional. The project will have an impact derived from the development of technical and medical measures to reduce exposure to VOCs in the study area that may guide the development of specific models. These benefits include: reduced health impacts - mortality / morbidity of acute and chronic; reducing negative effects on crops; reduce damage to the forests and ecosystems.

Chapter 2. Analysis of national and international scientific data on exposure to volatile organic compounds and health effects

2.1. Volatile organic compounds - effects on the environment and health

Volatile organic compounds or VOCs are an important class of air pollutants commonly found in the atmosphere at ground level in all urban and industrial centers. Organic compounds present in the atmosphere as a result of human activities, mainly from the exhaust emissions of motor vehicles, gasoline evaporation from fueling cars, the use of solvents, industrial processes, petroleum refining, storage and distribution fuels, waste disposal, waste food production and agriculture. Biogenic natural processes also give rise to substantial concentrations of organic compounds in the environment and include emissions from plants, trees, wildlife, forest fires and natural anaerobic ponds and swamps.

Once VOCs present in the atmosphere contribute to:

- stratospheric ozone depletion;

- photochemical ozone formation at ground level;
- toxic or carcinogenic effects on human health;
- intensifying the greenhouse effect globally;
- accumulation and persistence in the environment.

Aromatic compounds (AC), perhaps the most important class of VOCs are formed during incomplete combustion or pyrolysis of organic matter, which is part of the global consumption of liquid fuels, gas, coal and wood used to produce energy. Organic compounds which are present into the environment in large settlements characterized by the multitude of vehicles and heavy traffic are key results in exhaust gases of motor vehicles and gasoline evaporation from vehicles.

Additional contributions to increasing the concentration of AC indoor and the environment (into the air), they have smoke and heat sources in the home. Because these sources are practically omnipresent AC. AC is formed from a complex mixture of hundreds of chemicals, including aromatic compounds such as O, N, S, and more importantly, heterocyclic. H. Guo and others published in 2009 the results of a study on the presence and impact on the health of VOCs and formaldehyde analyzed in air of 100 homes in Hong Kong.

The 37 residential housing considered with high ambient were found only formaldehyde concentration exceeded without associated with increases in the level of VOCs in indoor air. Compared to other East Asian cities in the area under study, the levels of formaldehyde and styrene in indoor air were higher, thus it was concluded in Hong Kong homes are more polluted by products resulting from cooking or from different materials indoor facilities (H. Guo and others, 2009).

Attention of numerous scientists is focused at the populations with health risk, affected by the presence of these substances in the air which they breathe indoors. Thus in 2011 Sait C. Sofuoglu and others studied seasonally (autumn, winter, spring) concentrations of VOCs (including formaldehyde) indoor (nursery and school classes) and outdoor play spaces in Izmir, Turkey. Children's health risk assessment focused on tracking both acute effects (impaired smell, irritation of respiratory symptoms, eye) and chronic toxicity of the cancer. (Sait C. Sofuoglu and others, 2011)

Overall in Europe, the annual average (current) of VOCs in areas of large cities varies within 1-10 ng/m^3. In rural areas, concentrations are below 1 ng/m^3. Foods are considered to be the major source of exposure to AC (aromatic) for people, due to the fact that the AC is formed during the cooking process, emitted into the atmosphere, or because the ACs deposition on cereals, fruits and vegetables. These compounds occur during roasting meat grilled fish and even charred crust of bread or biscuits and other industrial food fried at temperatures above 300 ^{o}C, and smoked foods (fish, meat, cheese). Smoked products and even some alcohol may contain such aromatic compounds. There are about 100 types of AC identified in foods, many of which are mutagenic and / or carcinogenic: benzo(a)pyrene, benz(a)anthracene, benzo(e)pyrene, and dibenzchrysenul (a, h) anthracene. Benzo-a-pyrene (BaP) is the most studied polycyclic aromatic compound and the abundance of information on the toxicity and its appearance is extrapolated to aromatics. BaP is 1 to 25% of the total carcinogens in the environment, and AC is in the feed in a concentration of up to 50 mg/kg. Acceptable daily intake is unknown. The U.S. RDA is estimated at 1.6 to 16 mg of the 0.16 to 1.6 mg from BaP. Many of the AC ingested are rapidly absorbed and excreted in the feces and urine. Some retained in the adrenal glands, ovaries and fatty tissues, which were detected in a range of up to 8 days or longer. Epidemiological studies conducted in Europe and the U.S. has suggested an association between the consumption of foods high in AC and gastro intestinal malignancy. (H. Guo and others, 2009, Ralf Koppmann & Jürgen Wildt, 2007)

2.2. Characteristics of exposure to formaldehyde - actual scientific information

Physic and chemical proprieties, sources, atmospheric concentrations

Formaldehyde ($H_2C = O$) is present at room temperature and atmospheric pressure in the form of a colorless, flammable and reactive polymer; has a relative molecular mass 30.03 g/mol and a pungent odor. React rapidly with chemicals / pollutants in the atmosphere, so that its lifetime is very low in urban air; in the absence of nitrogen dioxide during the day, the half of the formaldehyde is 50 minutes and in the presence of nitrogen dioxide falls to 35 minutes. Under certain conditions can react with inorganic chlorides forming bischloromethyleter.

Formaldehyde is the most common aldehyde into the environment; natural background concentration is below 1 mg/m^3, with an average of about 0.5 mg/m^3.

Urban atmospheric concentrations are varied and depend on local factors; an annual average typically ranges between 1 and 20 mg/m³. The maximum short-term (e.g. in traffic or atmospheric inversions) can reach up to 100 mg/m³. The formaldehyde concentration levels within the building are typically higher than the outside; in housing emissions frequently come urea-formaldehyde foam insulation, furniture and resins. Here the values founded are few milligrams per cubic meter; mean values measured today is around 100 mg/m³; average values measured in homes which are not insulated with foam varies between 25 and 60 mg/m³. (S.S. Srivastava & K. Maharaj Kumari, 2006)

Human exposure can be defined as "event in which a person comes into contact with a pollutant concentration of a certain time for a certain period of time" (WHO).

Conceptually, this occurs along the "path environment" between the strength and dose as follows:

- source;
- emissions;
- concentrations;
- exposure;

- dose;
- health effects.

Exposure should be differentiated according to the concentration. High concentrations of pollutants in ambient air are not necessarily implemented in high exposures. For example, while the concentration of contaminants in the air may be very high near a facility major emission, exposure to high levels of pollution will take place only if we have the facility in the vicinity populations. The display should also be differentiated based on the dose. The dose will be defined by the characteristics and exposure to a variety of factors specific pollutant (e.g.: solubility or model layout in the lung) and physiological factors such as physical activity level of the person's skin characteristics etc.

Possible exposure routes to humans are ingestion, inhalation, skin absorption and, very rarely, transfusion / dialysis.

Below are summarized the average formaldehyde exposure by inhalation:

Table no 2.1. Environmental exposure to formaldehyde by inhalation

Source	**Concentration (mg/m^3)**	**Exposure (mg/day)**
Outdoor (10% time, 2 m^3/day)	0,001 – 0,02	0,002 – 0,04
Indoor (65% time, 10 m^3/day)		
- usually	0,03 – 0,06	0,3 – 0,6
- trailer	0,1	1
- smoking	0,05 – 0,35	0,5 – 3,5
Workplace (25% time, 8 m^3/day)		
- usually	0,03 – 0,06	0,2 – 0,5
- occupational exposure	1	8
- environmental smoking	0,05 – 0,35	0,4 – 2,8
Activ smoking (20/day)	60 – 130	0,9 – 2,0

Acute exposure of humans to formaldehyde in the air we breathe has the immediate effects eye irritation, nasal passages and throat, accompanied by discomfort, hyper tearing, sneezing, coughing, nausea, shortness of breath, and even death at high concentrations. Symptoms are usually more pronounced after initiation of exposure and time gradually decreases. (Lippmann, 2008; U. Joerg Mueller and others, 2013)

Exposure to formaldehyde for 40 minutes (2.4 mg/m^3) of groups of healthy people smoking, asthma, and respectively foregoing persons has resulted in respiratory obstruction, changes in lung function and bronchial hyper reactivity. (Ahmed A. Arif & Syed M. Shah, 2007; Tatsuo Sakamoto and others, 1999) Increasing concentrations (3.7 mg/m^3) and duration (1-3 hours) to groups of people at rest or physical activity intense no significant changes in lung function. Exposure to 1.2 - 1.5 mg/m^3 for 90 minutes, including persons with fewer side effects relative to foam cells, the induced no significant changes in lung capacity and flow rates; nor in asthmatics exposed to 0.85 mg/m^3 not noticed an objective response. Spiro metric evaluation of residents of homes / caravans and offices (usual concentrations from 0.007 to 2.0 mg/m^3) demonstrated no change in lung function or airflow resistance. (M. W. Murphy and others, 2013)

Studies and reports the most significant acute exposure of the general population are summarized in the following table:

Table no 2.2. Acute exposure of the general population to formaldehyde

Concentration (mg/m^3)	Time (duration)	Health effects
0,03	Repeated exposure	Odor is detectable (10%)
0,18	Repeated exposure	Odor is detectable (50%)
0,6	Repeated exposure	Odor is detectable (90%)
0,1 - 3,1	Single and repeated exposure	Nose and throat irritation
0,6 - 1,2	Single and repeated exposure	Eye irritation
0,5 - 2	3 - 5 ore	Dryness of the nasal mucosa
2,4	40 minutes, 2 consecutive days, with exercise	Headache after exposure
2,5 - 3,7	-	Burning eyes and nose
3,7	Single and repeated exposure	Slight decrease in lung function (labor intensive)
5 - 6,2	30 minutes	Tolerated without tearing
12 - 25	-	Hyper tearing (1 hour)
37 - 60	-	Pulmonary edema, pneumonia
60 - 125	-	Death

Most research about the health effects of air pollution have focused on respiratory and cardiovascular effects following inhalation. It should be noted, however, that the exposure means in contact with any part of the human body, and not just by inhalation. Other major routes of exposure to air pollutants are, for example, dermal absorption and ocular exposure. For example, acute exposure to air pollutants can cause irritation of the eyes or skin.

The world can be divided brutally into eight microsystems based on the following three classification schemes:

- Inside versus outside. People everywhere spend most of their time indoors.
- Developed versus developing. More than 80% of the world population living in developing countries (WHO).
- Urban versus rural. Urbanization occurs rapidly, with almost half the world's population living in urban areas (Badar Afghan K. and others, 1974). While three-quarters of the population in developing countries lives in urban areas, about

60% of people in developed countries continue to live in rural areas. (Badar K. Afghan and others, 1974)

In light of this information, it is clear that the microsystem with the greatest contribution is the rural indoor. Not surprisingly, therefore, the global scale, much of the contribution to the exposure has indoor environment.

Official WHO recommendation

Air pollution is a major environmental risk to health and is estimated to cause approximately 2 million premature deaths worldwide per year.

Exposure to pollutants is largely beyond the control of individuals and requires the intervention of public authorities at national, regional and even international level.

Air quality criteria set by the World Health Organization (WHO) is addressing the most recent and approved contractors to assess the effects of air pollution on health, recommending air quality levels at which health risks are significantly reduced. By reducing air pollution levels, can help countries to reduce the overall load time of pathology caused by respiratory infections, heart disease and lung cancer.

The lowest concentration associated with nose and throat irritation is 0.1 mg/m³ formaldehyde in the air at short exposure. Some people may feel the presence of the compound and lower concentrations.

Recommendation on the general population in order to prevent sensory irritation provides an air quality limit of **0.1 mg/m³ formaldehyde averaged over 30 minutes**; value is an order of magnitude lower than the maximum presumed epithelial cytotoxicity, it is considered that compliance of such information leads to the existence of a negligible risk of upper respiratory tract cancer of population.

Chapter 3. Health assessment of the population and environmental assessment in the investigated areas

3.1. Health assessment of the population from Brașov municipality

3.1.1. Methodology of health impact assessment of the population

a. Description of the methods for the selection of subjects enrolled in the study.

The study area was the Brașov Municipality with a population of 284,596 inhabitants, respectively, Sânpetru town with a population of 3,400 inhabitants.

Demographic data were collected from Brașov County Statistics Directorate and morbidity data collection in the two locations was selected 18 family physicians in Brașov and two family doctors in the town Sânpetru.

Subjects included in the study were people of all age groups of both sexes in the study area and which were presented to the family doctor for a health problem within 17 years (1994-2009).

Data on chronic pathology were collected from the records of chronic patients, respecting confidentiality, and were then entered into a database in Microsoft Excel, is processed in both Microsoft Excel and using the statistical package STATA. Diseases investigated codes (according to WHO international classification - ICD 10) are presented in Annex no 4.

b. Methodology for statistical processing.

Entering data into a computer and their statistics was performed following a protocol work, e.g. morbidity data entry database created in Excel 5.0 twice by two different people, accepting database under a input errors below 5%, data processing in Excel.

Databases that were made final processing (frequency relationship disorders investigated the concentration of pollutants in ambient air) were made by introducing electronic exposure data (concentration of hazardous substances in air measured at the moment) and data on the health of the population (data from questionnaires and medical records of the family) and other possible risk factors / error in Microsoft

Excel program where they were transferred to STATA 5.0 program, where were statistically (statistical tests).

Regarding the relationship of exposure to hazardous substances in the air, as the concentrations measured frequency conditions investigated, it was done in STATA program using a linear regression model that can allow evidence of a correlation between the occurrence of adverse health population and exposure to hazardous substances analyzed.

3.1.2. Health impact assessment of population

3.1.2.1. Analysis of morbidity in the area of study

a. Incidence of acute respiratory diseases in the study area

Data from acute respiratory morbidity (IACRS, rhinitis, laryngitis, tracheid, bronchitis, and bronchiolitis) were taken over a period of two years from the period under review (2007-2008). Evolution is presented acute respiratory frequency compared to Brașov city level and county level Brașov, in the following figures.

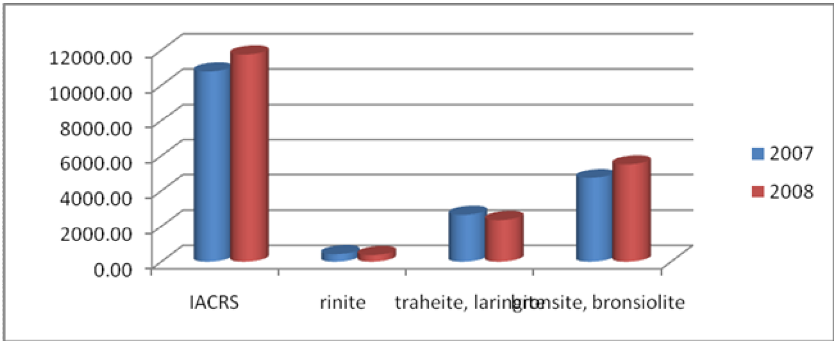


Fig. no 3.1.1. Evolution of frequency of acute respiratory infections – Brașov county

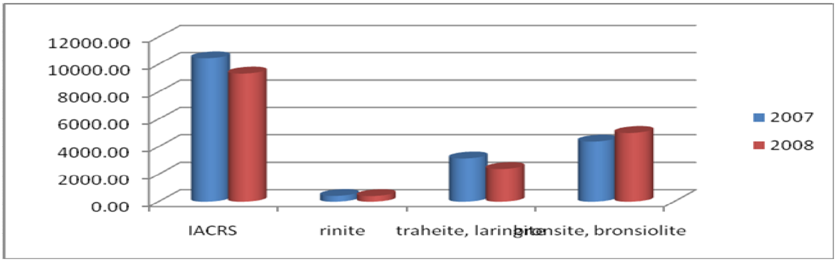


Fig. no 3.1.2. Evolution of frequency of acute respiratory infections – Brașov city

b. Morbidity by chronic diseases in the study area

Morbidity in the study area (number of cases per 100,000 inhabitants) – baseline

Chronic respiratory diseases

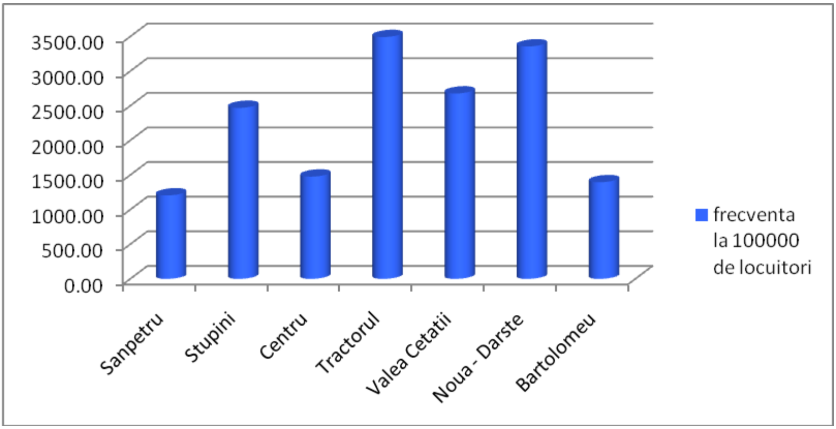


Fig. no 3.1.4. Frequency of cases of chronic respiratory diseases

Allergic diseases

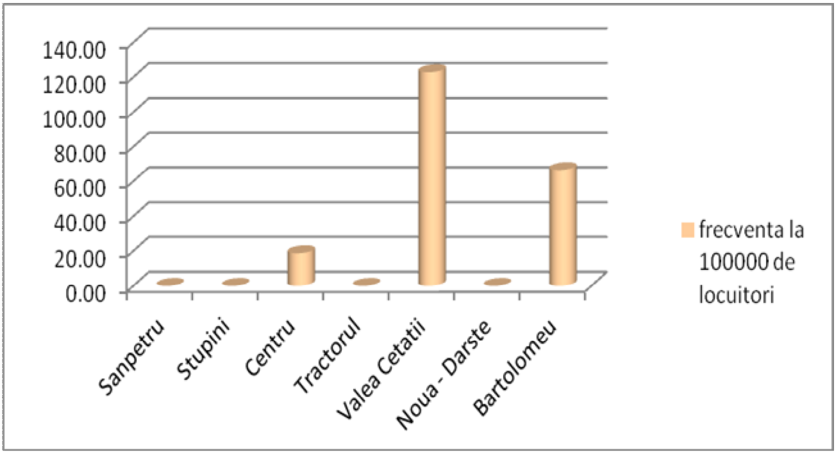


Fig. no 3.1.5. The frequency of cases of allergic diseases

Disorders of conjunctiva

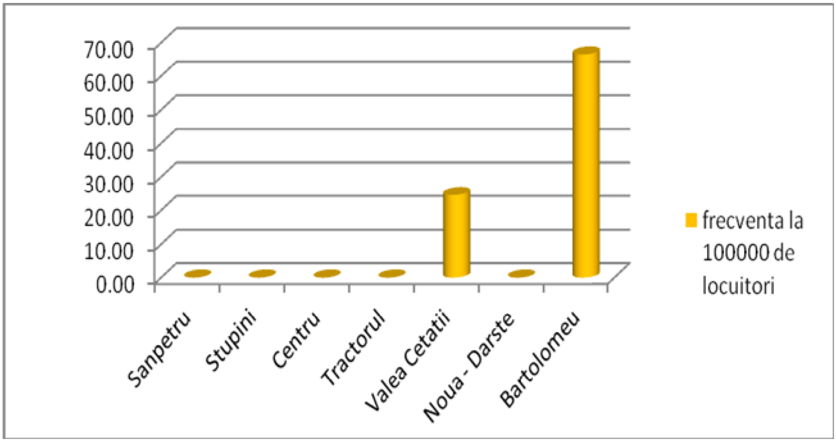


Fig no 3.1.6. The frequency of cases of disorders of the ocular conjunctiva

c. Incidence of malignant tumors in the study area

Malignant pathology regarding morbidity data from the study area were based on the number of cases of malignant tumors leading to death during the period 2003 - 2008.

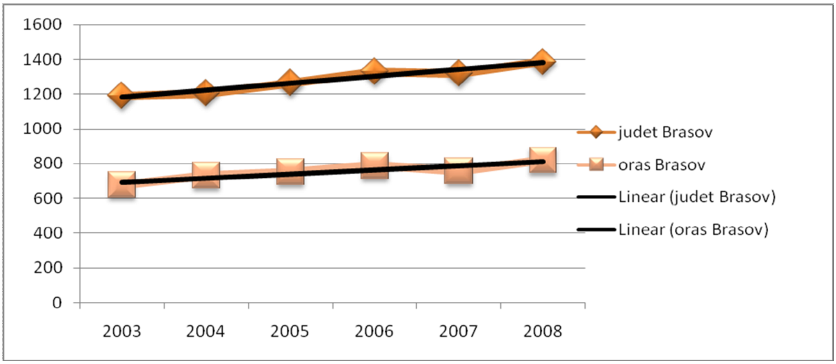


Fig. no 3.1.7. The evolution of the frequency of cases of malignancy

3.1.2.4. Discussion and conclusions

From the above it is noted that with the approach of the investment does not increase the frequency of diseases investigated. In other words, the values recorded Stupini diseases investigated frequencies lower than in other areas (with some minor exceptions, especially those related to the Bartolomeu).

Some models allow the calculation of the risk of developing specific diseases in different parts of the investigated area depending on the distance to the objects, which in terms of health, as the initial condition, we can provide evidence. It was found that in most cases these risks are higher than in other areas investigated in the immediate vicinity of the plant based on wood boards in Brașov.

At the same time have identified and quantified the major error factors in exposure to air pollutants. These factors are active and passive smoking, occupational exposure and indoor pollution, known as factors increasing influence in the development of adverse effects on health than pollution.

To properly characterize the relationship between health and environmental baseline, the study was completed by a comprehensive assessment which showed whether in terms of spatiality, e.g. with the approach, e.g. distance from the source, it appears that the initial condition of the environment and health, a positive and significant relationship. There appears a significant risk to the health of the population with proximity networking site when conducting environmental baseline to the original health. Moreover, the risks increase with the removal of the site.

The risk of developing specific diseases, taking into accounts the initial conditions of the environment and health, decreases with the removal of the site.

3.2. Particular aspects of the environmental status in Braşov municipality

Air quality in 2012

Emissions of air pollutants from most social and economic activities, they can sometimes be a risk to human health and ecosystems. In Brașov county, policies and actions at the local level have resulted in a reduction of anthropogenic emissions and consequently reduced the risk of exposure to harmful levels of the population, but still some air pollutants can affect human health.

Emissions are decreasing, but the air quality still needs to be improved.

The measurements made by the Local Network Monitoring Air Quality in Braşov were recorded exceedances of air quality objectives on the protection of human health for PM_{10} and O_3 in the troposphere, but the exposure of crops and vegetation to ozone is not expected to exceed long-term objectives of the European Union. In terms of emissions control is expected to comply with all four pollutant-specific emission ceilings set under EU and international law, the upper limit for nitrogen oxides (NOx) are the most challenging.

Exceeding the limit values of air quality in Brașov agglomeration

Much of the urban population is exposed to concentrations of pollutants exceeding the limit established for the protection of health or target values defined in the Directive on air quality. CO and SO_2 exposure risk and the environment, but this is not the case for other pollutants. Thus, PM_{10}, ozone and NO_2 are a topic of discussion related to air quality, since the limit values for the protection of human health were exceeded at the monitoring stations.

PM_{10} particles in the atmosphere are the result of direct emissions (primary PM_{10}) and particulate precursor emissions (nitrogen oxides, sulfur dioxide, ammonia and organic compounds) which are partly transformed into particles (secondary PM) by chemical reactions in the atmosphere.

Of PM_{10} monitoring conducted at monitoring stations in Brașov agglomeration is observed that some of the urban population is exposed to concentrations of particulate substances exceeding the limits set to protect human health.

Table no 3.2.1 highlights the existence of local sources, which brings PM_{10} concentration peaks for the period 2009 - 2012.

Table no 3.2.1. The numbers of exceedances of the daily limit value for PM_{10} in Brașov agglomeration

Year	Maximum value recorded			Number of exceedances of the daily limit value for human health		
	Station BV1	Station BV3	Station BV4	Station BV1	Station BV3	Station BV4
2009	*67,7 µg/m^3	169,1 µg/m^3	94,5 µg/m^3	8	72	11
2010	100,8	92,5	109,7	14	35	12

	µg/m³	µg/m³	µg/m³			
2011	92,0 µg/m³	165,1 µg/m³	76,4 µg/m³	27	60	19
2013	90,4 µg/m³	112,2 µg/m³	90,7 µg/m³	19	81	7

** valid data capture was less than 55%, measurements were made during June-December*

The decrease in emissions of ozone precursors seems to have resulted in lower concentrations of ozone in the troposphere, the target value for the protection of health when ozone is not exceeded in 2012 in Brașov, suburban station BV4 - Sânpetru recorded 62 exceedances. It should be noted that the population of the suburban area was exposed to concentrations that exceeded the level of 120 mg O_3/m^3 for more than 25 days in 2008, 2009 and 2012.

Table no 3.2.2. The number of exceedances of the target value for O_3 to protect health in Brașov agglomeration

Year	Station BV2		Station BV3		Station BV4		Station BV5	
	Capture	Exceding	Capture	Exceding	Capture	Exceding	Capture	Exceding
2008	61,1	2	33,8	1	57,5	56	60,0	14

2009	88,8	2	80,7	1	72,1	92	66,0	-
2010	89,8	-	90,7	-	81,6	-	37,4	-
2011	33,3	-	52,3	-	81,7	5	7,8	-
2012	84,9	-	78,6	-	89,7	62	89,6	-

Data acquired from monitoring stations indicate that in Brașov agglomeration, municipality population lives in areas with concentrations exceeding the annual limit value of 40 mg/m^3 nitrogen dioxide.

Table no 3.2.3. Annual average NO_2 concentration values

Year	Station BV1	Station BV2	Station BV3	Station BV4	Station BV5
2008	43,0 µg/m^3	58,1 µg/m^3	64,0 µg/m^3	10,9 µg/m^3	-
2009	40,8 µg/m^3	54,4 µg/m^3	63,2 µg/m^3	13,1 µg/m^3	44,5 µg/m^3
2010	38,0* µg/m^3	47,5 µg/m^3	42,2 µg/m^3	11,9 µg/m^3	27,9 µg/m^3
2011	-	-	56,7 µg/m^3	17,7 µg/m^3	21,0** µg/m^3
2012	25,7 µg/m^3	48,5 µg/m^3	35,5 µg/m^3	-	-

Note: *, ** Due to data availability, the seasonal distribution and data capture, it may not be representative of the estimated average level of the year.

Table no 3.2.3. present a trend to hold over VL ambient NO_2 concentrations during 2009 - 2012 in Brașov, especially in high traffic areas.

Main source of emissions in the atmosphere of nitrogen oxides (NOx) is the combustion of fuels in road transportation and electricity. Implementing current EU legislation and the provisions of CLRTAP protocols resulted in decrease emissions. This decrease is already reflected in the average annual concentrations at urban monitoring stations measuring concentrations of nitrogen oxides.

In this study it was shown compliance with the concentration limits for the protection of vegetation and "critical levels" established for the agglomeration Brașov suburban station BV4 - Sânpetru. From monitoring data, exposure of ecosystems to acidification, eutrophication and ozone has been maintained below critical levels during the monitoring period and, given the existing plans, expects further improvement in the situation and respect the target value and long-term target ecosystems to ozone exposure.

3.3. The health assessment of the population in Reghin municipality

3.3.1. Methodology of health impact assessment of population in the Reghin area

The study area included Reghin, with a population of 36 126 inhabitants, and Solovăstru village with 2,847 inhabitants. Data on the population of the study area are extracted from the census conducted by the National Institute of Statistics, in March 2002.

Subjects included in the study were people of all age groups of both sexes, in the area of study were presented to the family doctor for a health problem during 2000 - 2011.

The morbidity data collection took into account, among other things, target location, meteorological and geographical factors of the local population size and the number and location of medical practices family medicine. In the study area were selected seven family physicians.

Acute morbidity data (number of cases of rhinitis, laryngitis, tracheitis, bronchitis, bronchiolitis, dermatitis, hives, conjunctivitis, redness in 2011), as well as data on the number of persons receiving primary care medical services in 2011 (registered lists of family doctors) were collected from family doctors in the study area. For acute conditions were calculated frequencies per 1,000 residents (no cases of the disease during the period mentioned x 1.000/nr. population stated). Graphical representation of the results was done in Excel.

The study was divided according to the distance from the site, in five areas. In each of the five areas was achieved percentage distribution of cases of chronic disease during the period 2000 - 2011, to family physicians in the study. For each of the five areas was calculated percentage distribution of respiratory diseases and malignant tumors, including malignant tumors localized to the respiratory disorders of all recorded, and the spatial distribution thereof was plotted in Microsoft Excel.

Zone	Geographical representation
Zone 1	The area east of Mureș river, including the Railway Station
Zone 2	Central Area, including Mihai Viteazul Quarter and Liberty Quarter
Zone 3	The northern area of the city Reghin including Union neighborhood and street Rodna
Zone 4	Reghin southern area of the city, including neighborhood Iernuteni, Făgăraș and Pomilor
Zone 5	Solovăstru village

Data were collected from records of chronically ill and morbidity data from the selected family doctors respecting confidentiality. Data were entered into a database in Microsoft Excel and processed using Microsoft Excel and STATA statistical package. Data collected from family physicians were related to chronic pathology Codes investigated conditions (according to WHO international classification - ICD 10) comprising the same conditions as those investigated for the Braşov.

Entering data into a computer and their statistics also made like Brașov area.

3.3.2. Health impact assessment of population

3.3.2.1. Analysis of morbidity in the area of study

a. Morbidity by acute diseases

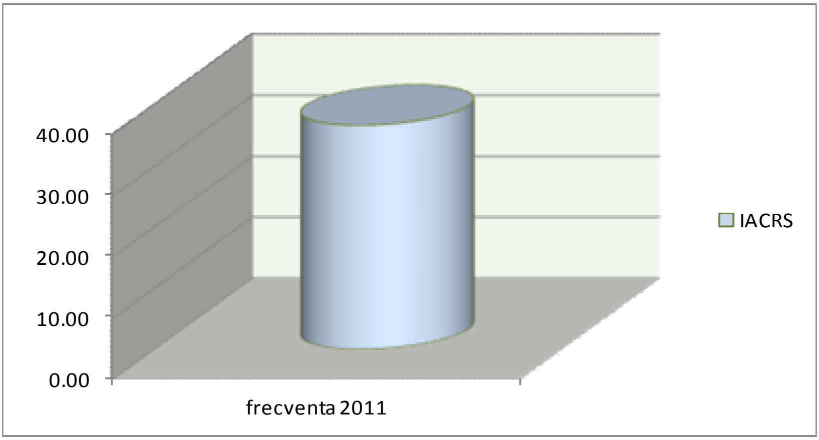


Fig. no 3.3.1. Evolution of frequency of upper respiratory tract infections (ICRS) in the area study

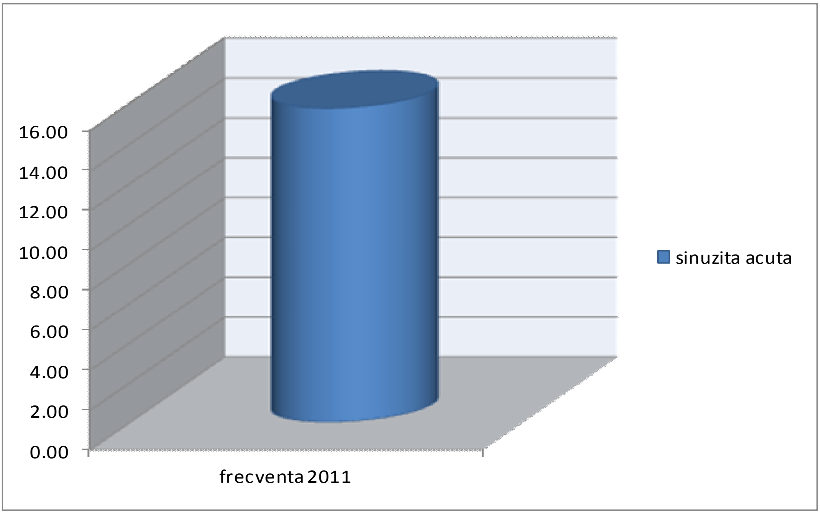


Fig. no 3.3.2. Evolution of frequency acute sinusitis in the study area

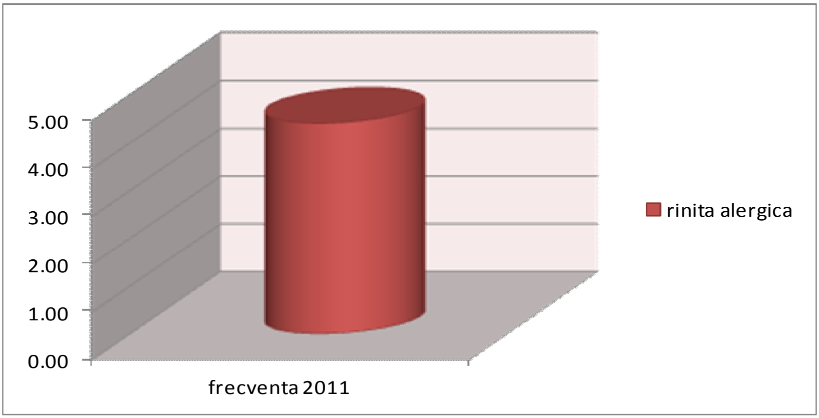


Fig. no 3.3.3. Evolution of frequency and vasomotor rhinitis in the study area

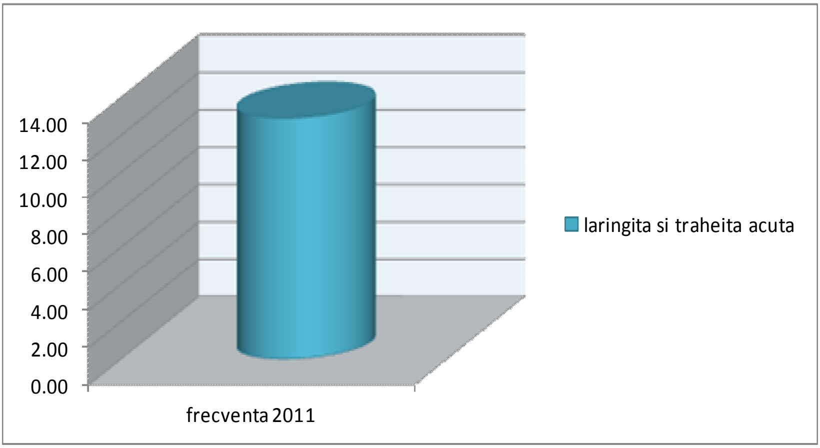


Fig. no 3.3.4. Evolution of frequency laryngitis / laryngotracheitis / tracheitis acute in the area of study

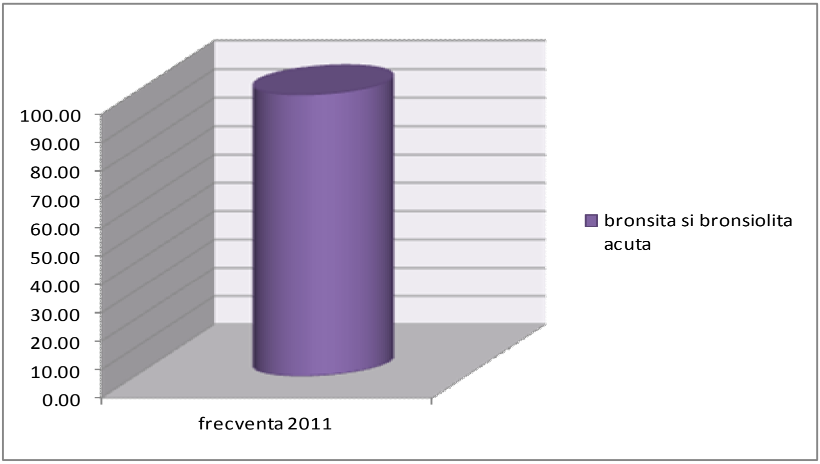


Fig. no 3.3.5. Evolution of frequency bronchitis / bronchiolitis acute in the area of study

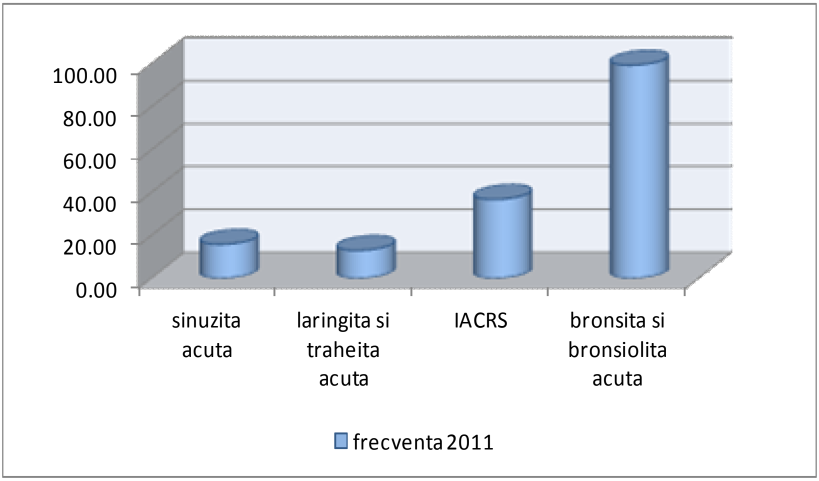


Fig. no 3.3.6. The evolution of acute respiratory overall rate in the area study

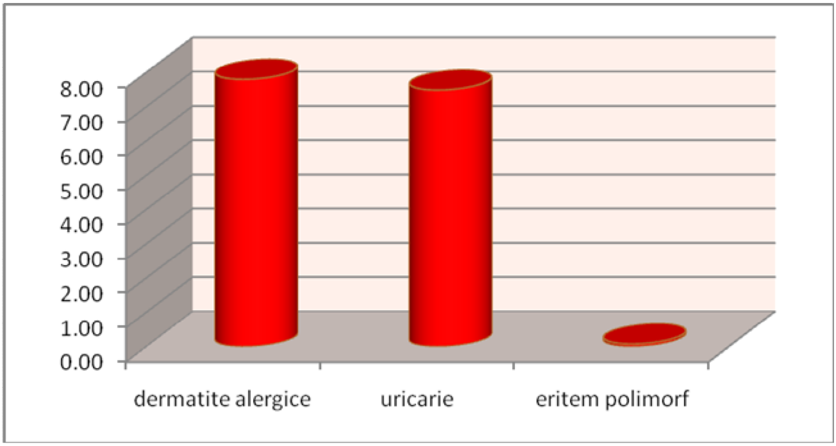


Fig. no 3.3.7. Evolution of frequency of allergic diseases (allergic dermatitis, hives and erythema multiform)

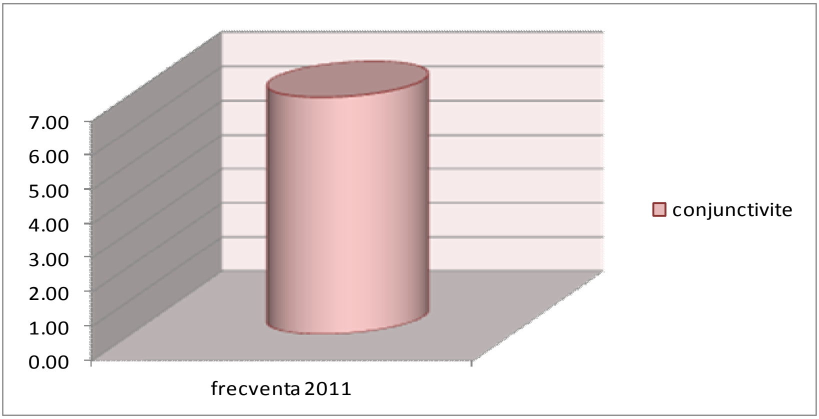


Fig. no 3.3.8. Evolution conjunctivitis frequency in the study area in 2011

b. Morbidity in the study area (number of cases per 1,000 residents) – baseline

Indicators of morbidity in the study area (number of cases per 1,000 residents) – baseline

Reghin city

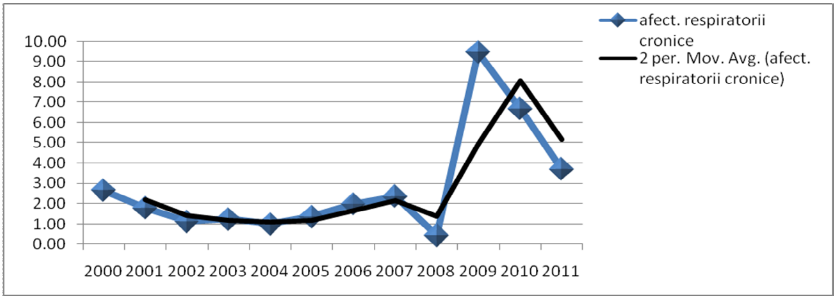


Fig. no 3.3.9. Temporal distribution of the frequency of cases of chronic respiratory diseases

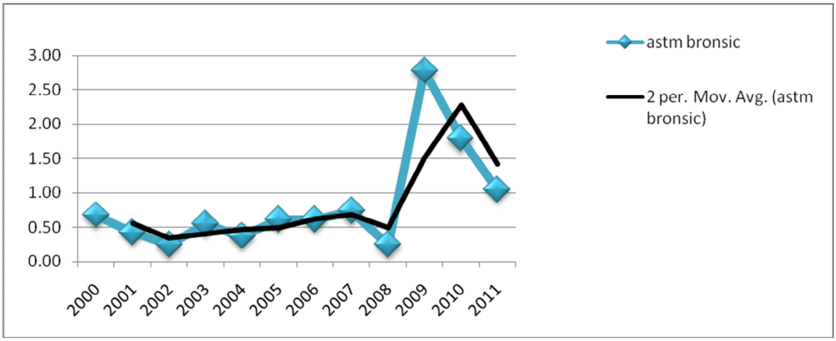


Fig. no 3.3.10. Temporal distribution of asthma cases

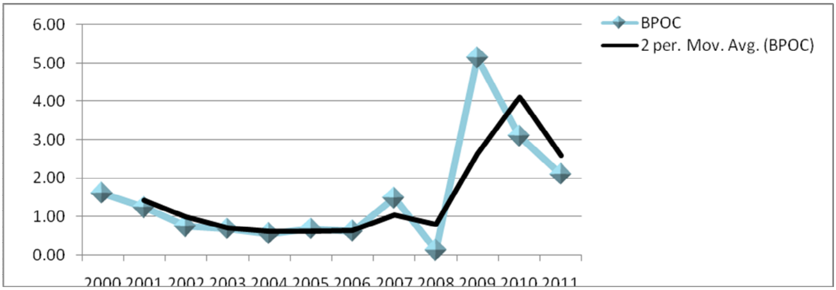


Fig. no 3.3.11. Temporal distribution of cases of chronic obstructive pulmonary disease

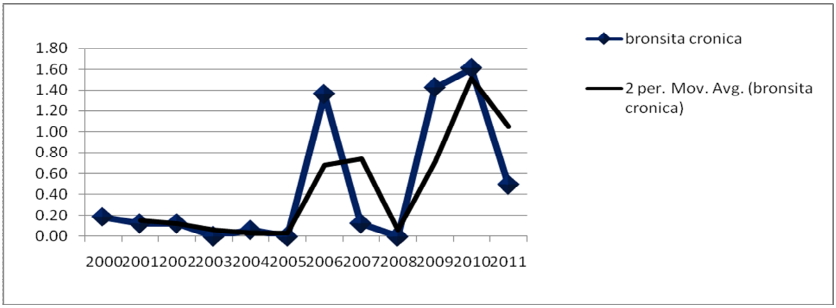


Fig. no 3.3.12. Temporal distribution of cases of chronic bronchitis

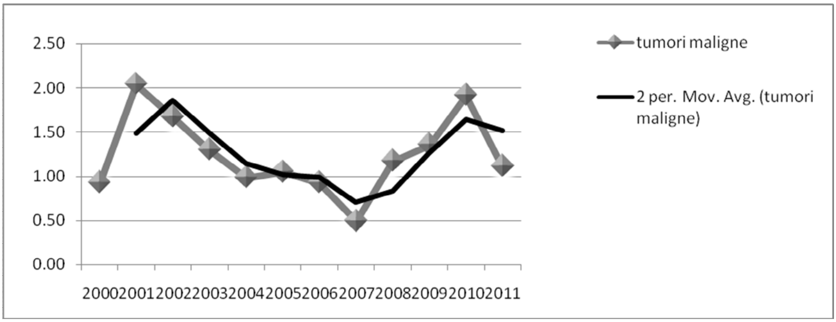


Fig. no 3.3.13. Temporal distribution of cases of malignant tumor

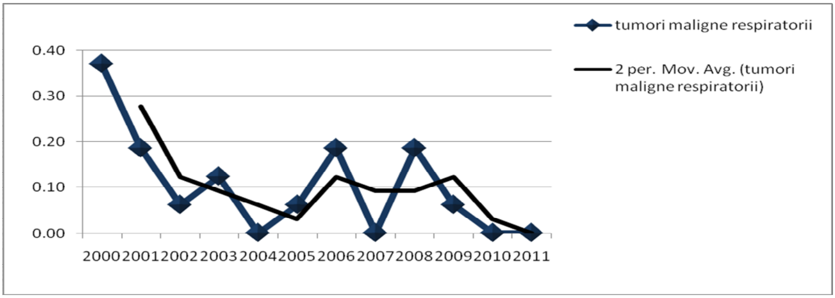


Fig. no 3.3.14. Temporal distribution of cases of respiratory malignancies

Solovăstru village

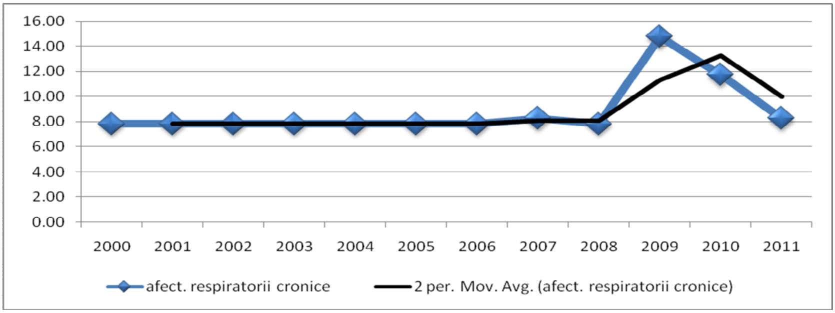


Fig. no 3.3.15. Temporal distribution of the frequency of cases of chronic respiratory diseases

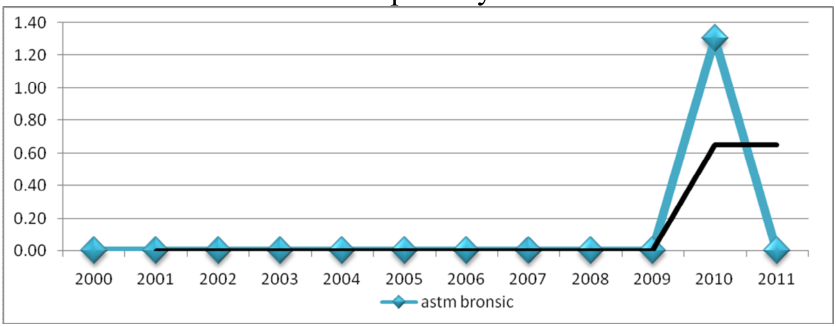


Fig. no 3.3.16. Temporal distribution of asthma cases

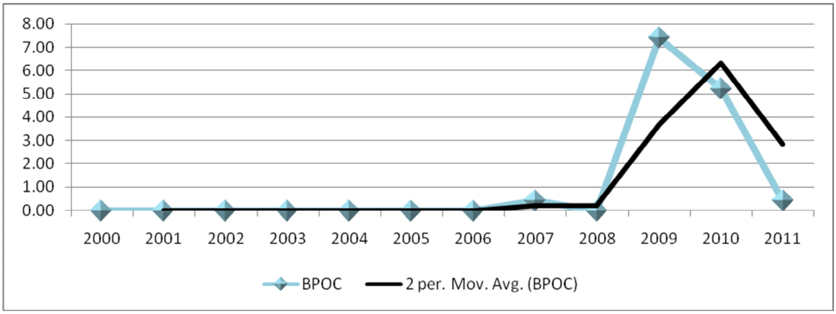


Fig. no 3.3.17. Temporal distribution of cases of chronic obstructive pulmonary disease

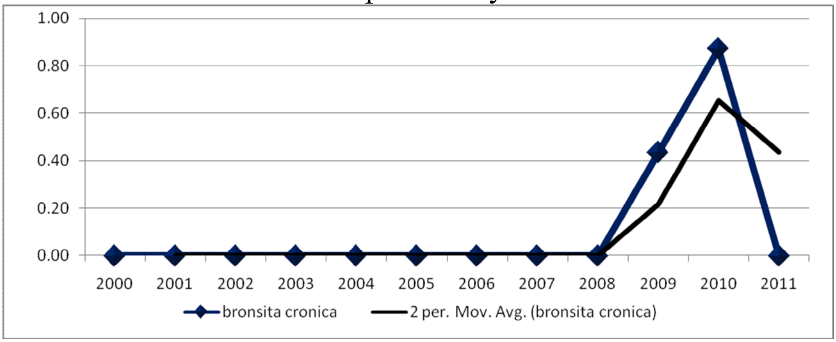


Fig. no 3.3.18. Temporal distribution of cases of chronic bronchitis

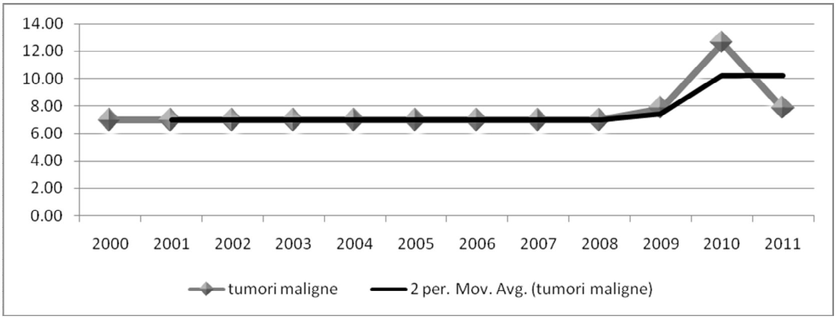


Fig. no 3.3.19. Temporal distribution of cases of malignant tumor

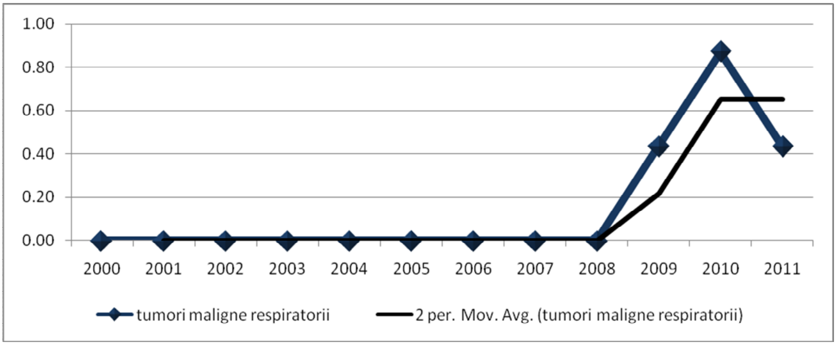


Fig. no 3.3.20. Temporal distribution of cases of respiratory malignancies

3.3.2.2. Health risk assessment in relation to the distance (spatiality risks) to the target investigated

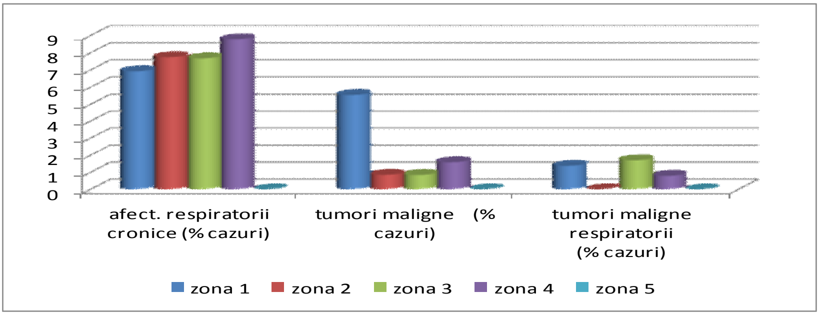


Fig. no 3.3.21. Spatial distribution of cases of chronic respiratory diseases, malignant tumors and malignant respiratory - 2000

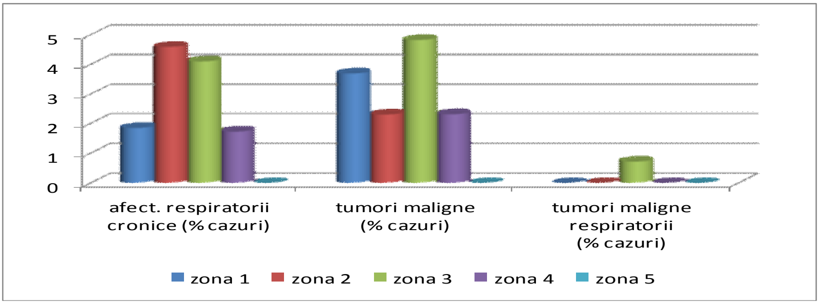


Fig. no 3.3.22. Spatial distribution of cases of chronic respiratory diseases, malignant tumors and malignant respiratory – 2001

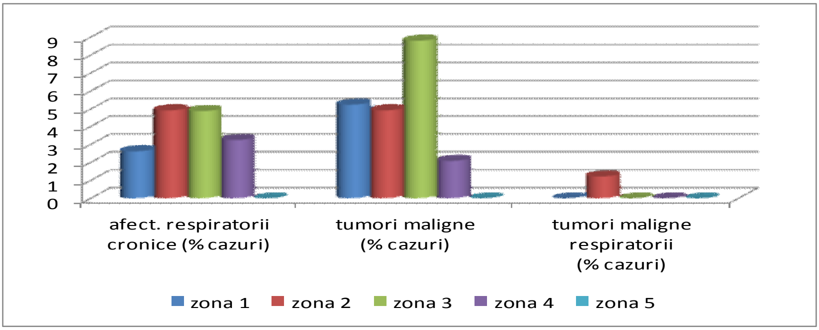


Fig. no 3.3.23. Spatial distribution of cases of chronic respiratory diseases, malignant tumors and malignant respiratory - 2002

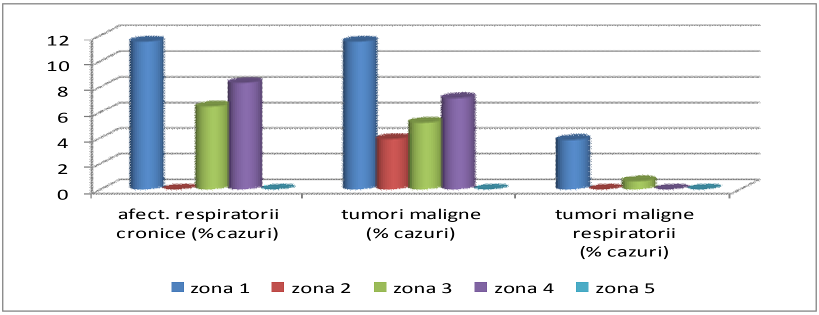


Fig. no 3.3.24. Spatial distribution of cases of chronic respiratory diseases, malignant tumors and malignant respiratory tumors - 2003

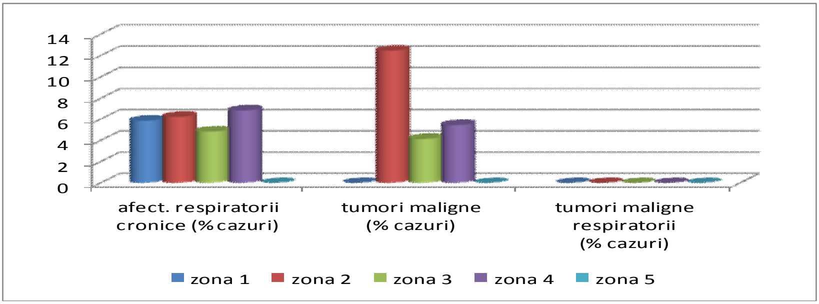


Fig. no 3.3.25. Spatial distribution of cases of chronic respiratory diseases, malignant tumors and malignant respiratory - 2004

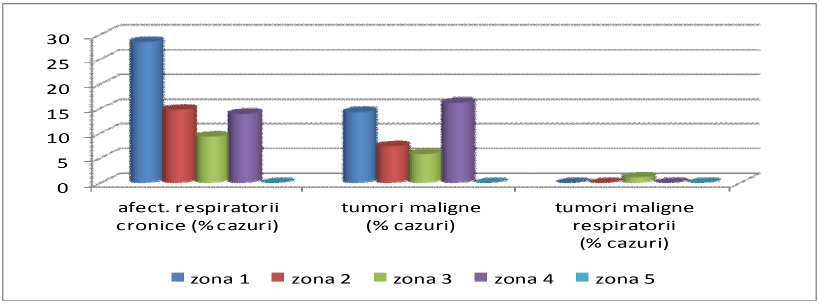


Fig. no 3.3.26. Spatial distribution of cases of chronic respiratory diseases, malignant tumors and malignant respiratory - 2005

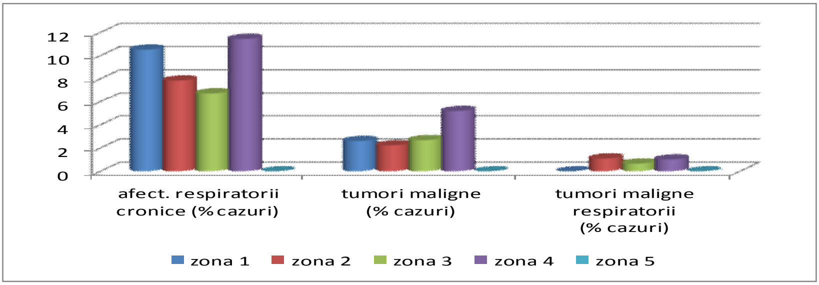


Fig. no 3.3.27. Spatial distribution of cases of chronic respiratory diseases, malignant tumors and malignant respiratory - 2006

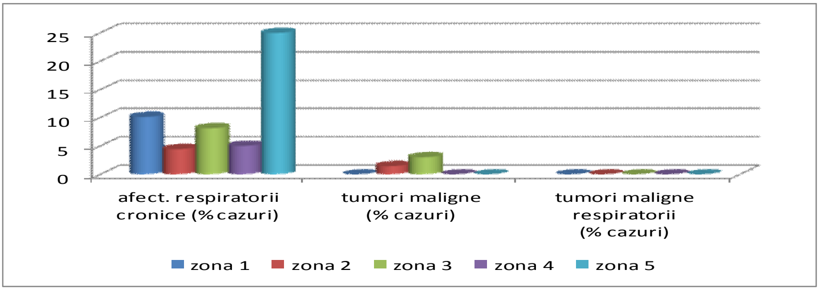


Fig. no 3.3.28. Spatial distribution of cases of chronic respiratory diseases, malignant tumors and malignant respiratory - 2007

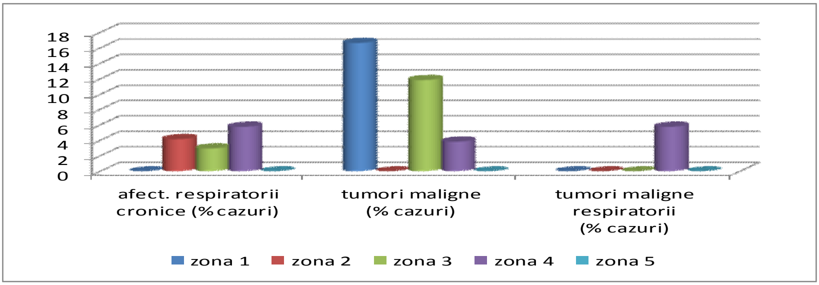


Fig. no 3.3.29. Spatial distribution of cases of chronic respiratory diseases, malignant tumors and malignant respiratory - 2008

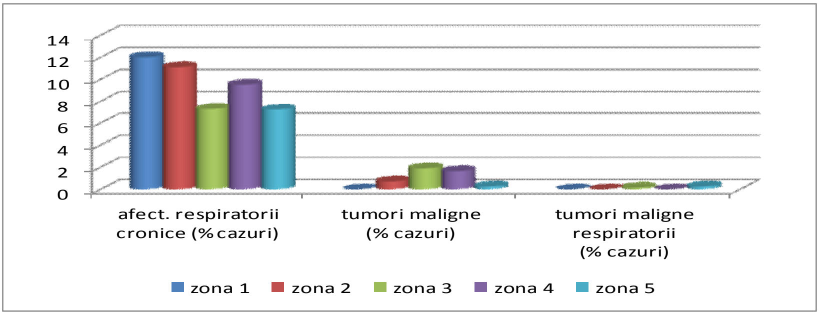


Fig. no 3.3.30. Spatial distribution of cases of chronic respiratory diseases, malignant tumors and malignant respiratory - 2009

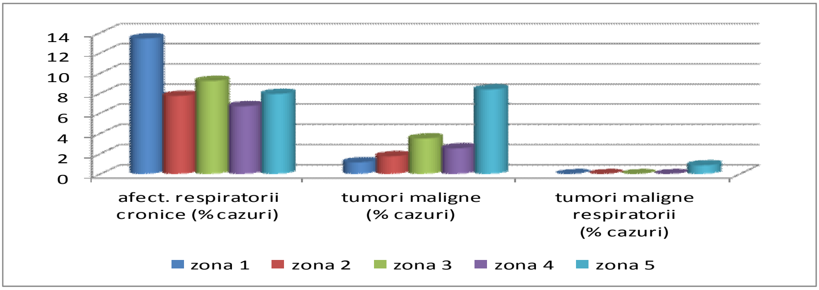


Fig. no 3.3.31. Spatial distribution of cases of chronic respiratory diseases, malignant tumors and malignant respiratory - 2010

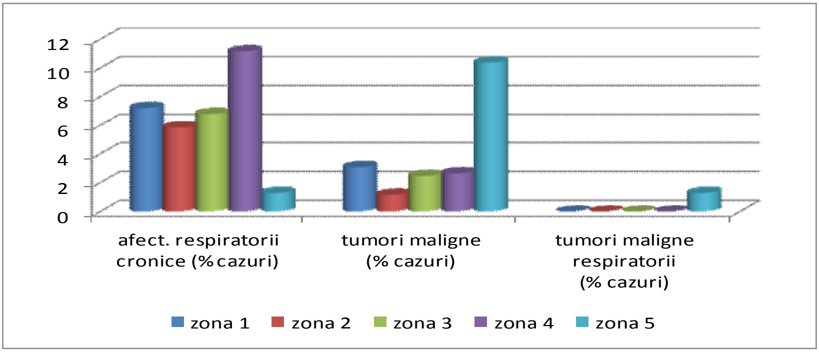


Fig. no 3.3.32. Spatial distribution of cases of chronic respiratory diseases, malignant tumors and malignant respiratory - 2011

3.3.2.3. Conclusions

1. Picture obtained from analysis of data collected from practitioners in the area of study, there is no specific pattern, in the sense that a higher frequency is present both for pathology that could be related to exposure to hazardous substances in environment due target specific activities (chronic respiratory pathology) and where pathology that has no relation to exposure to hazardous substances specific target activity (chronic gastrointestinal pathology, pathology of the nervous system and so on).

2. As baseline health status, chronic pathology investigated the spatial distribution of the study area (chronic

respiratory disease and malignancy), was characterized by a great variability in the sense that growth trends observed percentages of cases that declining trends and rates of cases during 2000 - 2011, but without preferential find higher values of the percentages of cases in the area located close to the site.

3.4. Particular aspects of the environmental status in Reghin city

Air quality in 2012

Mureș county

Mureș county ambient air quality is influenced to a moderate extent of emissions from economic and social activities. Anthropogenic sources of emissions in the atmosphere with significant potential are located in Târgu Mureș, Luduș and Târnăveni, while in areas like Reghin and Sovata where anthropogenic emission sources do not produce significant pollution.

Air quality in Mureș county maintains a slight trend of improvement. Since 2006, it was substantially reduced emissions from industrial processes and the number of pollution incidents is decreasing. However, traffic growth still causing local air quality problems.

In Mureș county no air pollution problems that require the establishment of special measures air quality management in order to meet the quality standards required by law.

Chapter 4. Risk assessment related to exposure to volatile organic compounds generated by wood processing industry

4.1. Case Study I: Kronospan Brașov

Location

The plant location is in the extreme north of Brașov, East Stupini between rail Brașov - Rupea and E60 Brașov - Sighișoara (DN13), at a distance of approx. 0.6 km from the railway station Stupini.

Distance to target - Factory wood-based boards

Table no. 4.1.1. Distance to target - Factory wood-based boards

Location	Geographic positioning	Distance (m)
Tractorul neighborhood	S-SE	4.000
Bartolomeu neighborhood	S-V	4.000
Bod village	N-E	7.500
Hărman village	E	7.500
Braşov downtown	-	5.000 – 6.000

Location	Geographic positioning	Distance (m)
Hălchiu village	N-V	6.000
Ghimbav village	S-E	9.000
Sânpetru village	E	3.000
Stupini neighborhood	V	1.100 – 1.600
Baciului street	N	200 – 1.100

Closest housing to the target analyzed area is located in the north, on Str. Baciului dwellings at distances ranging between 150-1100 m from site boundary "Kronospan". In this area are parceled plots of which some of them are built housing scheme P, P + E, P + M. For this reason the north side of the plant is restricted to a ground of approx. 8 m high with large base trapezoidal approx. 25 m, the small base of 4.5 - 6 m on its surface were planted shrubs and trees that beautify the area.

Unlike residential neighborhood located on the right side Stupini European road E 60, west distance is about 1 - 1.5 km.

The site isn't located in an area of environmental importance in terms of biodiversity, nor to limit or neighborhood. The nearest protected area is a Natura 2000 site ROSCI0055 - "Fortress Hill - Lempeş - Hărman Swamp" is located in the eastern part of the site PUZ at a distance of approx. 4 km.

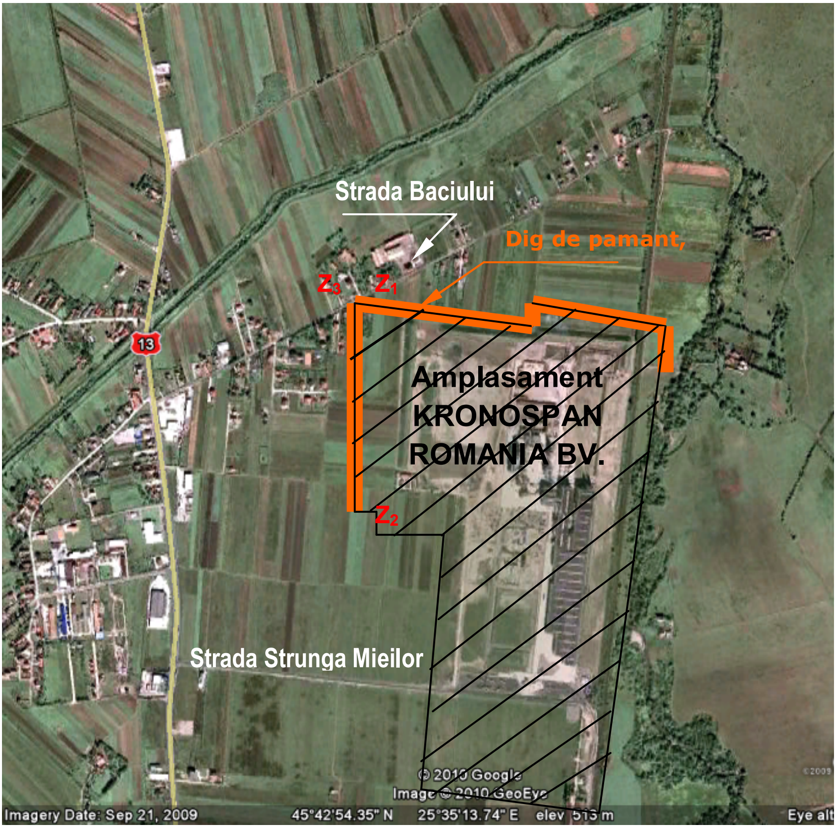


Fig. no 4.1.1. Site plan - earth dam location (Source Google Earth - image from 2009)

4.1.2. Methodologies used in the study case Kronospan Brașov

4.1.2.1. The sampling and analyze methodology of formaldehyde in the air

To identify the impact on the health and safety of the community and natural resources, measurements were made to determine the concentration of formaldehyde emission and immission within the factory and in the influence area of the site: residential areas and traffic. Sampling points are shown in Annexes 1 and 2.

Sampling and analysis of air samples to determine the formaldehyde content was carried out according to NIOSH Method 2541; Application: workplace air, indoor air. Methods for measuring and assessing the concentration of pollutants in the air at the workplace and the atmosphere are standardized.

Sampling and analysis procedure was performed under RENAR procedures as required by the certification body.

4.1.2.2. Estimate of doses exposure to formaldehyde

To calculate the exposure dose, the risk of developing a malignancy in their lifetime as a result of exposure to formaldehyde and characterization of real exposure to formaldehyde in the investigated area, we used a public program belonging ATSDR (Agency for Toxic Substances and Disease Registry) of the CDC (Center for Disease Control and Prevention), which is used in integrated risk analysis in the United States. The dose of exposure and the risk of developing a malignant tumor following exposure for 15 and 35 years were calculated taking into account the measured concentrations of formaldehyde in the area of study in the reference population (adult, male and female).

The equation for calculating the dose of exposure to contaminants in the air is:

ED = (C x IR x EF x AF) / BW, where ED = exposure dose, C = concentration of contaminant in air, IR = intake rate of the contaminant in the air, EF = exposure factor AF = bioavailability factor, BW = body weight.

After a specific exposure dose of the area of influence of the investigated target site was estimated, these doses were compared with the reference value which provides adequate protection against potential side effects that may arise as a result of exposure to a specific contaminant. These benchmarks below which no adverse effects are recorded on the health of the population varies by route of exposure (ingestion, inhalation), duration of exposure (acute, sub chronic / intermediate, and chronic), and final adverse effect (carcinogenic, non-carcinogenic).

4.1.2.3. Quantitative risk analysis for formaldehyde

Quantitative risk analysis was performed according to the methodology ATSDR (Agency for Toxic Substances & Disease Registry) with Dose Exposure Calculator program. According to the quantitative risk assessment methodology, location-specific doses and concentrations investigated are multiplied by units of risk exposure by inhalation (IURs - Risks inhalation unit) calculated by the Environmental Protection Agency U.S. (EPA - Environmental Protection Agency), to estimate a theoretical risk of developing a malignant tumor, as a result of exposure to the substance. For formaldehyde unit inhalation risk exposure is 1.3 x 10-5 (mg/m^3). Calculation equation is:

$$CR = ED \times IUR \times \left(\frac{EY}{70}\right)$$

where:

CR = theoretical risk of cancer - term risk of developing a malignant tumor (without measure), ED = exposure dose [mg/kg/day], IUR = unit risk exposure by inhalation [g/m^3] EY = exposure time [years].

4.1.3. Health risk assessment in relation to activities Kronospan factory Braşov - Stage I

4.1.3.1. Monitoring of hazardous substances from emissions and immissions at the factory wood-based boards

Scenario 1. FACTORY IS OPERATING

For scenario 1, samples were taken from both the factory and residential areas in the neighborhood.

Initial measurements were performed only at the factory and were sampled in three different points (hall bonding, press output PAL, output OSB press).

In the third quarter it was decided that it is necessary to conduct a more thorough monitoring of emissions of formaldehyde. The study was extended to residential areas in the vicinity of chipboard factory where they could be affected by pollution potential of this plant.

Thus, in the last two quarters of the year, measurements were carried out in residential areas in 10 different positions to see if and how the plant affects human communities of the related PAL plant.

Scenario 2. PLANT IS NOT OPERATING. Sampling October - November to December

Because particleboard plant during operation were recorded several complaints from people / authorities, factory management decided that after completion of monitoring during operation on the 4 quarters, to achieve a series of measurements during the 12 hours of factory overhaul, while it is non-functional.

There were sampled in nine different points, both on-site and residential areas. In addition, there were taken 9 extra samples from the traffic to see if formaldehyde pollution is not due to external factors, such as emissions from automotive exhaust gases.

Results and discussion after formaldehyde measurements made during the two scenarios

Scenario 1. FACTORY IS OPERATING

In the factory measurements were conducted in the three sampling points (hall bonding, output PAL releases, media outlet OSB) for all four quarters (2010 - 2012).

In the chart below it can see the comparative presentation of formaldehyde concentrations (mg/m^3) measured in the factory in Quarter I, II, III and IV.

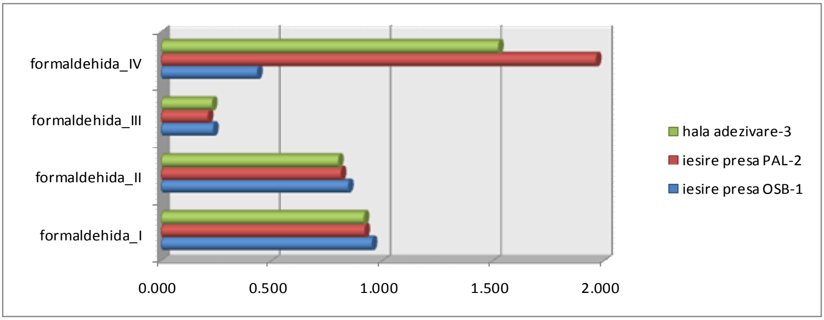


Fig. no 4.1.2. Comparative presentation of formaldehyde concentrations (mg/m^3) measured in the factory in Quarter I, II, III and IV

Also, the chart below can highlight and comparative presentation to the maximum permissible concentration (CMA) of formaldehyde concentrations (mg/m^3) measured in the factory in Quarter I, II, III and IV.

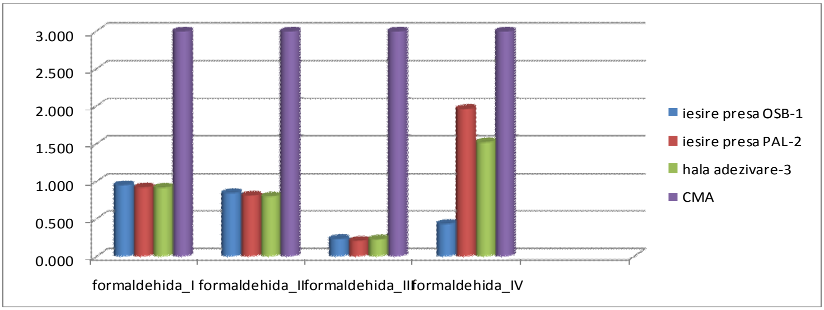


Fig. no 4.1.3. Comparative presentation to the maximum permissible concentration (CMA) of formaldehyde concentrations (mg/m^3) measured in the factory in Quarter I, II, III and IV

Regarding formaldehyde, formaldehyde concentrations comparative presentation (mg/m^3) measured in the factory in Quarter I, II, III and IV, shows the lowest values of concentrations of formaldehyde in the third quarter and that the highest values measured, in the fourth quarter. It should be noted that all concentrations measured during the monitoring period were below the MAC value (measurement of 30 minutes), according to STAS 12574/87.

<u>In residential areas</u>, measurements were performed on samples taken from the 10 points in the third quarter and fourth quarter.

In the chart below you can see the comparative presentation to the maximum permissible concentration (CMA) of formaldehyde concentrations (mg/m^3) measured in residential areas in the last two quarters of the year.

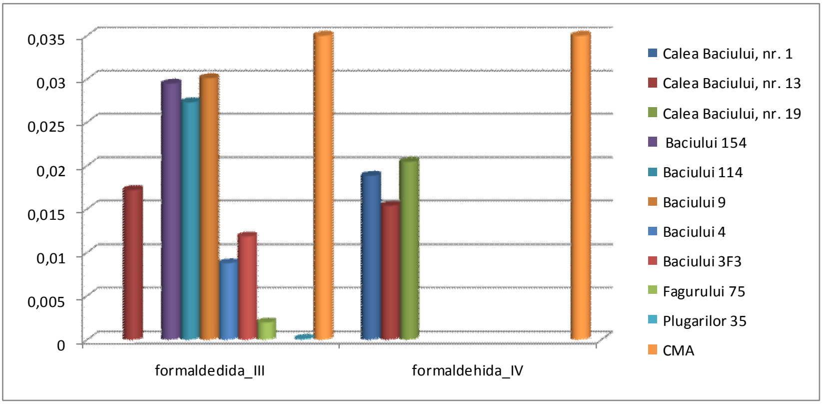


Fig. no 4.1.4. Comparative presentation to the maximum permissible concentration (CMA) of formaldehyde concentrations (mg/m^3) measured in residential areas in the last two quarters of the year

Regarding the levels of formaldehyde concentrations measured in residential areas in the third and fourth quarters, they were located below the maximum permissible concentration (CMA).

Scenario 2. PLANT IS NOT OPERATING. Sampling October - November to December

Measurements taken in October - November-December were made for the 12 hour inspection of the factory (part of each month), when it was non-functional. In addition to measurements of the factory and residential areas were carried traffic measurements to see if formaldehyde pollution is not due to external factors such as exhaust emissions.

Measurements on site, residential areas and traffic were conducted simultaneously.

In the factory measurements were performed for the 9 sampling points.

In the chart below you can see the comparative presentation of formaldehyde concentrations (mg/m^3) measured at the factory in October - November to December.

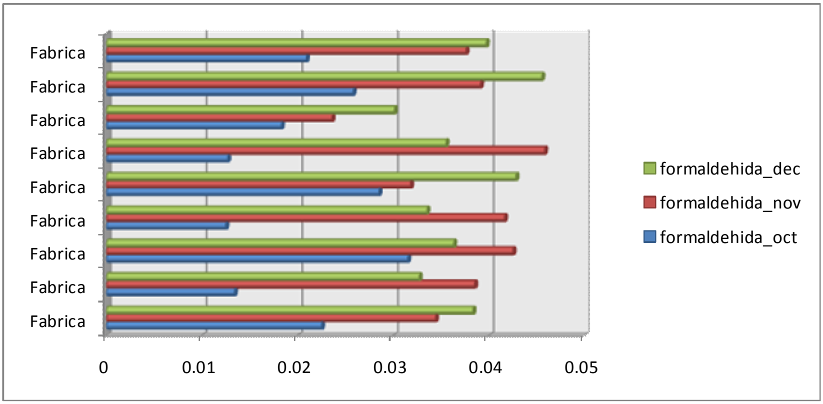


Fig. no 4.1.5. Comparative presentation of the formaldehyde concentration (mg/m^3)

Comparative presentation of formaldehyde concentrations (mg/m^3) measured at the factory in October - November-December, shows somewhat higher values of concentrations of formaldehyde in November and December, compared with October, but all measured values were are situated below the maximum allowable concentration (CMA) work.

In residential areas were also conducted measurements for nine sampling points. In the chart below you can see the comparative presentation of formaldehyde concentrations (mg/m^3) measured in the residential area in October - November to December.

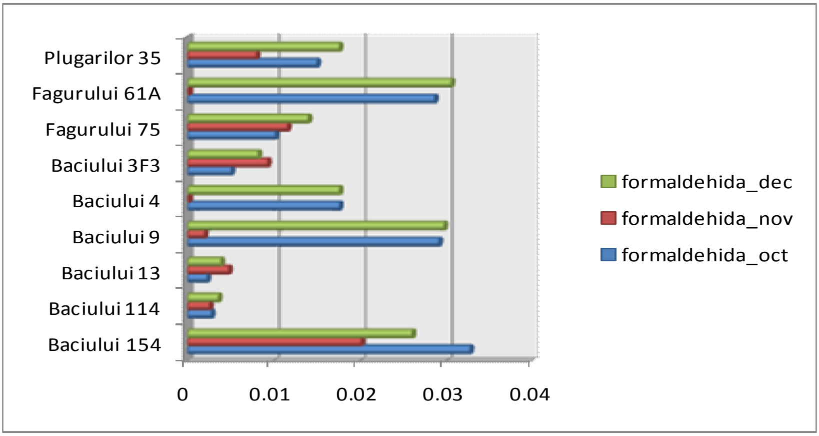


Fig. no 4.1.6. Comparative presentation of formaldehyde concentrations (mg/m^3) measured in residential area

Also conducted a comparative presentation to the maximum permissible concentration (CMA) of formaldehyde concentrations (mg/m^3) measured in residential areas in October - November to December.

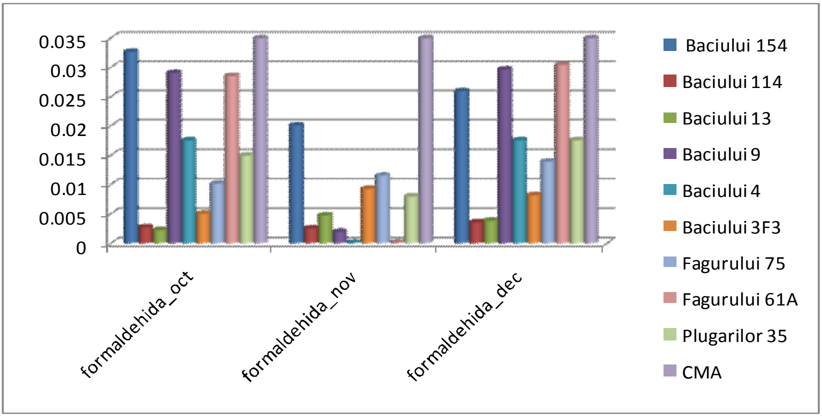


Fig. no 4.1.7. Comparative presentation to the maximum permissible concentration (MPC) of formaldehyde concentrations (mg/m^3) measured in residential areas

Comparative presentation of formaldehyde concentrations (mg/m^3) measured in the residential area in October - November-December, showed somewhat higher values of concentrations of formaldehyde in October and December, compared with November, but all the measured values were below CMA.

For the traffic was also carried out measurements in 9 sampling points.

In the chart below you can see the comparative presentation of formaldehyde concentrations (mg/m^3) measured in traffic in October – November - December 2010.

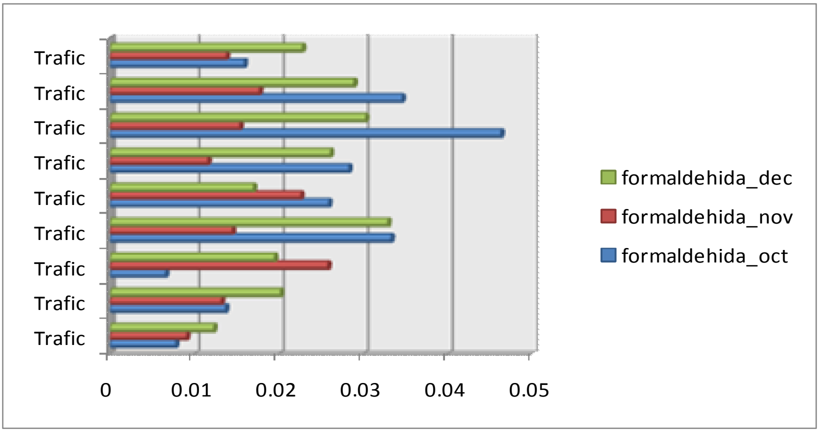


Fig. no 4.1.8. Comparative presentation of formaldehyde concentrations (mg/m^3) measured traffic in October - November to December.

Comparative presentation of formaldehyde concentrations (mg/m^3) measured in traffic in October - November - December, showed somewhat higher values of concentrations of formaldehyde measured in the traffic in December and October compared with November.

Conclusions

1. Formaldehyde concentrations (mg/m3) measured during the monitoring of the factory were located

below the maximum admissible concentration (CMA) in this location.

2. Formaldehyde concentrations (mg/m3) measured in ambient air in residential areas during the monitoring was situated below the maximum permissible concentration (CMA) in ambient air in residential areas.
3. There were no statistically significant differences in terms of the concentration of formaldehyde measured in ambient air in residential areas, between quarters, during monitoring.
4. Comparative statistical analysis revealed no statistically significant differences in value between the measured concentrations of formaldehyde in the traffic, respectively, in the residential area.
5. Comparative statistical analysis of the measured values of the concentration of formaldehyde in the residential area where the plant operated, respectively, when no operated, no statistically significant differences between the concentrations of formaldehyde measured in the residential area where the plant operated to situation that did not.

6. Comparative analysis of the measured values of the concentration of formaldehyde in the residential area where the plant operated, respectively, when the factory did not work, showed somewhat higher values of concentrations of formaldehyde in residential areas when compared to factory work where did not work. There were no statistically significant differences between the values measured in the factory when compared to the case where the function does not work, if either of the two sets of measurements.

4.1.3.2. Estimate of doses and risk analysis in exposure to formaldehyde

There have been scenarios exposure to different concentrations of formaldehyde measured in the ambient air, respectively, inside the housing air in various locations investigated in the area of influence of the site, in a reference population, and has been reached the following conclusions:

1. Exposure dose (indicating risk of developing adverse effects due to exposure) calculated immission concentrations formaldehyde generated as a result of activities in the factory were located

below the reference value that ensures protection of the health population.

2. For the worst case scenario, theoretical estimates values for the additional risk of cancer due to exposure to formaldehyde in the study area were classified in a range of values, the order of magnitude between 10^{-8} and 10^{-3}.
3. Theoretically expected values for the additional risk of cancer in the area of study is in the range of theoretical values expected by the U.S. Environmental Protection Agency (with the upper limit value of the order of 10^{-3}) under the conditions of exposure to atmospheric air concentrations measured.

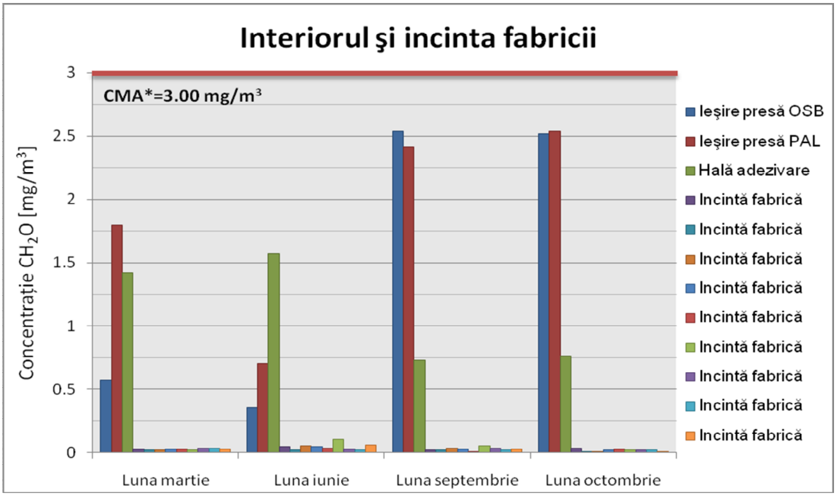
4.1.4. Health risk assessment in relation to activities Kronospan factory Braşov - Stage II

4.1.4.1. Monitoring of hazardous substances in emissions and immissions at wood-based boards factory

a. Measurements inside the factory

Inside the factory identified three production departments to achieve monitoring (1 - Exit Press OSB, 2 - Press Exit PAL 3 - Milking bonding) and 9 points in the factory, shown in Annexes 1 and 2. Pollutant mainly from technological process is formaldehyde. Measurements were performed for short period of time (15 min), fixed to characterize the exposure of the worker at work.

Comparison of concentrations determined by the maximum allowable concentrations



* According to G.D. 1218/2007 and G.D. 1093/2006 - the maximum value permitted in short period of time (15 min.)

Fig. no 4.1.9. Comparison of concentrations of formaldehyde with CMA

According to the General Norms of Labor Protection, formaldehyde is rated 3 mg/m^3, average for short period of time. Indicator values determined with the formaldehyde concentration is below the maximum allowed the months in which measurements were made. The highest value was determined release point out OSB (2.54 mg/m^3) in September 2012 and release point output PAL (2.54 mg/m^3) in October 2012.

b. Immission measurements in the residential areas

Measurements were performed and the influence area of the site, on ambient air quality, through the work of woodworking factory. Average measurements of short duration (30 min) were performed simultaneously in the residential area and traffic near the national road DN 13. Were chosen by 9 monitoring points for each area (detailed in Annexes 1 and 2) and sampling was performed simultaneously with the 9 points of the factory.

According with STAS 12574-87, formaldehyde is rated 0,035 mg/m^3 (CMA); this is the average for the short period of time.

There were four measurements that exceeded the maximum permissible concentration of formaldehyde, and these were recorded in traffic.

Temporal variation of the concentration of formaldehyde measured in the influence area of the wood-based boards factory in Brașov

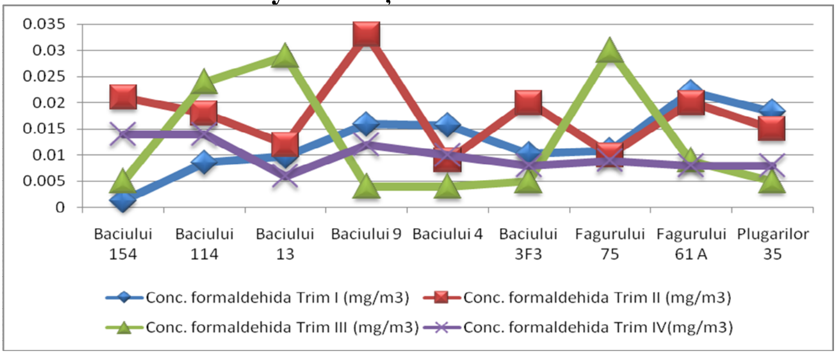


Fig. no 4.1.10. Temporal variation of the concentrations of formaldehyde measured in the residential area adjacent wood-based board's factory

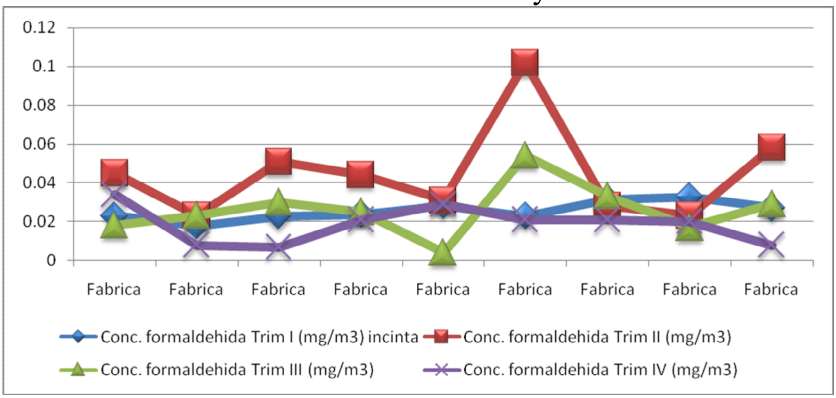


Fig. no 4.1.11. Temporal variation of the concentrations of formaldehyde measured in the wood-based board's factory yard

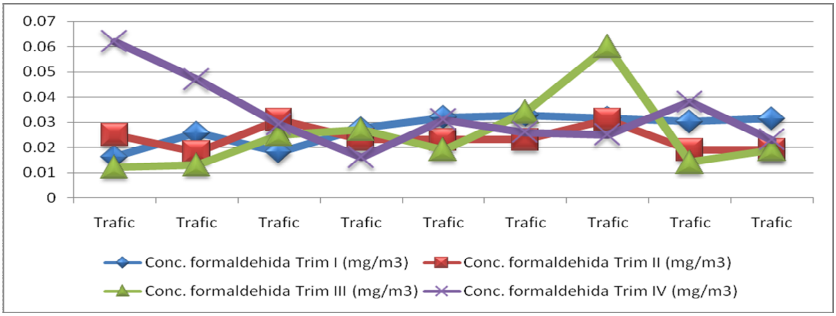


Fig. no 4.1.12. Temporal variation of the concentrations of formaldehyde measured in high traffic area adjacent to wood-based board's factory

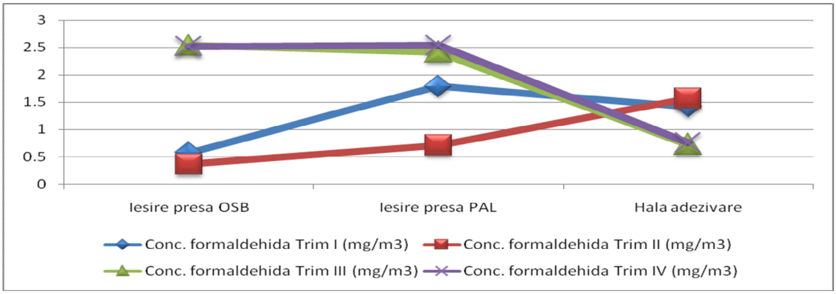


Fig. no 4.1.13. Temporal variation of the concentrations of formaldehyde measured in the wood-based board's factory

Temporal and spatial variation of concentrations of formaldehyde measured in the influence area of the factory wood-based boards in Brașov

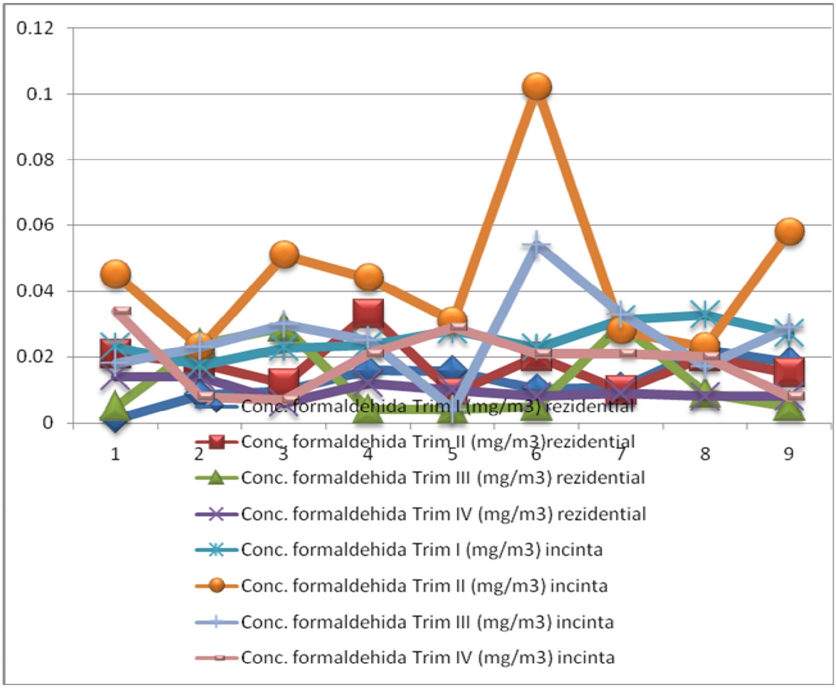


Fig. no 4.1.14. Temporal and spatial variation of concentrations of formaldehyde measured in the influence area of the wood-based boards' factory (residential area compared to factory area)

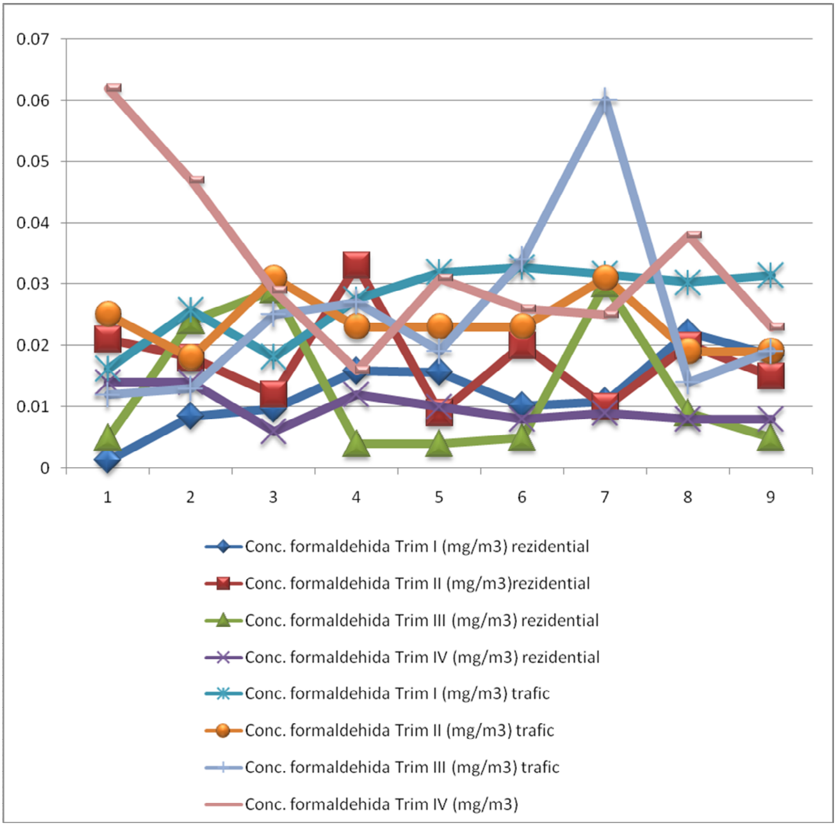


Fig. no 4.1.15. Temporal and spatial variation of concentrations of formaldehyde measured in the area of influence of the wood-based boards' factory (residential areas compared to high traffic area)

4.1.4.2. Estimate of doses and risk analysis in exposure to formaldehyde

Monitoring campaign carried out during phase II, it appears that there were no exceedances of the current rules regarding formaldehyde concentrations measured in the residential area of influence of the factory wood-based boards in Brașov.

Indicator values determined for formaldehyde in residential areas were below the maximum permissible concentration. The highest value was recorded in section 4 - Calea Baciului no. 9 (0,033 mg/m^3) in the second quarter of this stage.

Regarding the dynamic evolution, during stage II formaldehyde concentrations measured in the residential area of influence of the factory plates, it is found that the lowest values of formaldehyde concentrations were measured in the first quarter and the fourth quarter; variation value was also lower in the first quarter and the fourth quarter compared with the other two. For the second quarter, there is much greater value variations of the concentrations measured in the residential area without them exceed the maximum imposed by environmental legislation, the measured value being recorded in the location of the Baciului street no. 9. Third quarter is also characterized by significant variations. Concentrations of formaldehyde measured value recorded three peaks, which do not exceed the maximum amount required by environmental legislation being to values smaller than the tip above, for the second quarter.

Indicator values determined for formaldehyde in occupational environment are below the maximum permissible concentration. The highest value was determined in point 1 - Exit Press OSB (2.54 mg/m^3) in the third quarter and that in point 2 - Exit PAL, in the fourth quarter.

Regarding formaldehyde concentrations measured in the factory, there is variation much lower and less frequent than those described above for the residential area. Concentrations of formaldehyde measured in the factory, in the first quarter is almost constant and nearly overlaps with the concentrations measured during the third quarter, except the peak value recorded in the third quarter, which is not found in quarter I. Values slightly increased compared to the other two quarters were recorded in the second quarter, including a peak value. In the fourth quarter, measured concentrations varied very little, and these values were very close to those measured in the first quarter, in some ways even more determination than those measured in quarter I.

Regarding the concentrations of formaldehyde measured in high traffic area adjacent factory variations observed much lower and less frequent than those described above for the residential area. Concentrations of formaldehyde measured in high traffic area in the vicinity of the factory, in the first quarter is relatively constant, numeric values are close to the concentrations measured during the second and third quarter, except for a peak value recorded in the third quarter, which is not reflected in the first quarter and occurs with a much smaller number in the second quarter. In the fourth quarter, there is a peak value in one of the points for determination, but otherwise formaldehyde concentrations were similar to those measured in the other three quarters.

Conclusions

1. If we look at comparative concentrations of formaldehyde measured in the residential area during this phase, with those measured in the factory, it is found that variations in the residential area does not overlap with those made in the factory and also do not overlap perfectly nor on the measured in high traffic area, advocating that in the residential area influences are many.

2. Regarding the concentration of formaldehyde levels in some sections of the factory wood-based boards in the monitoring carried out, there were no exceedances of the maximum permissible concentrations in the workplace as required by law, provided that ensure all safety measures including personal protective equipment.

3. Using the measured concentrations computing imissions residential area as permanent exposure levels for different populations with different susceptibilities of the target area of influence (adults of both sexes), theoretical estimates for the additional risk of cancer due to exposure to formaldehyde the study area were classified in a range of values, the order of magnitude between 10^{-4} and 10^{-6}.

4. Regarding the health of population groups living in residential areas in the area of influence of the factory plates, theoretically estimated additional risk of developing a serious adverse effect on health (such as malignant tumors) due to long exposure term (15-30 years) to formaldehyde is very low. We stress that this additional risk was estimated and specifically state that the real risk is unknown and cannot be calculated accurately by anyone, anywhere, because it depends on an extremely large number of factors with high variability, which have not been quantified in this study, such as genetic factors,

metabolic contribution of other sources to which it is exposed subject, etc.

4.2. Case Study II. Kastamonu Reghin

4.2.3. Health risk assessment and control of human exposure in relation to plant activities Kastamonu Reghin (measurements of emissions and imissions)

Risk assessment of health and human exposure and control presented in this chapter was based on measurements made on site and in the vicinity of a factory of wood-based boards in the town Reghin Mureș (Fig. no. 4.2.1.) in 2013.

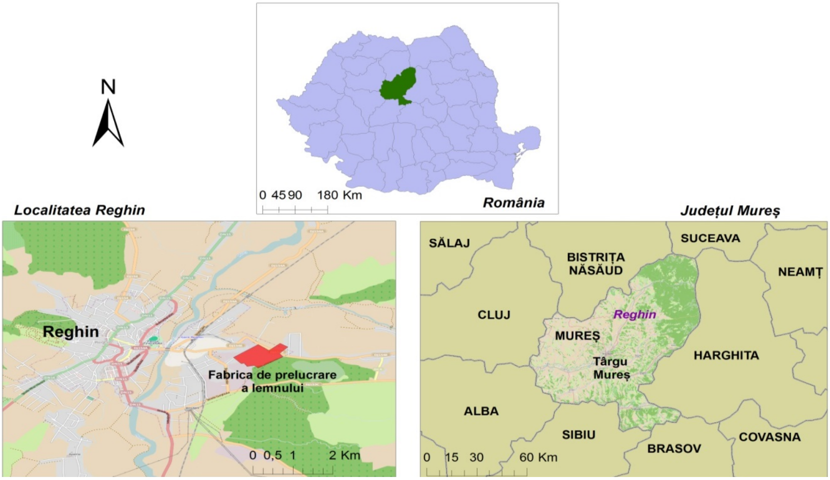


Fig. no 4.2.1. City Reghin in Mureș county

Based on the measurement results, we calculated the contribution of particulate emissions as cumulative exposure to formaldehyde.

The main air pollutants resulting from activities in the factory boards are:

Fixed sources

Wood dust resulting from machining operations technology of wood, such as chopping chips, chips drying, grinding, sorting chips, silage cutting, sorting chips, pressing and sizing plates, chopping boards fault, grinding and transportation.

Formaldehyde, resulting from the processes of drying chips and hot pressing plates using the PAL release.

A part of the emission of formaldehyde emission occurs together with the powders (the sources P1 and P2 and the power DOORSKIN the PAL WESP) and is therefore a part of formaldehyde may be adsorbed on dust particles. In other words, some of the powder particles dispersed into the atmosphere, of the total emitted powder may also contain formaldehyde absorbed.

Out of the 10271.93 g/h dust emitted into the atmosphere from any plant source of wood-based boards, 2423.76 g/h (from the WESP) + 2235.5 (from P1) + 115.2 (from P2) = 4774.46 g/h are powders which can be impregnated with formaldehyde, i.e. 46.5%, of which 23.6% resulted from the PAL. The average content of formaldehyde may be present (adsorbed) in these powders is 1849.05 / 4774.46 * 100 = 38.7%.

The following map (Fig. no. 4.2.2.) is shown the spatial distribution of PM concentrations present in immission caused in the area of influence of wood processing factory.

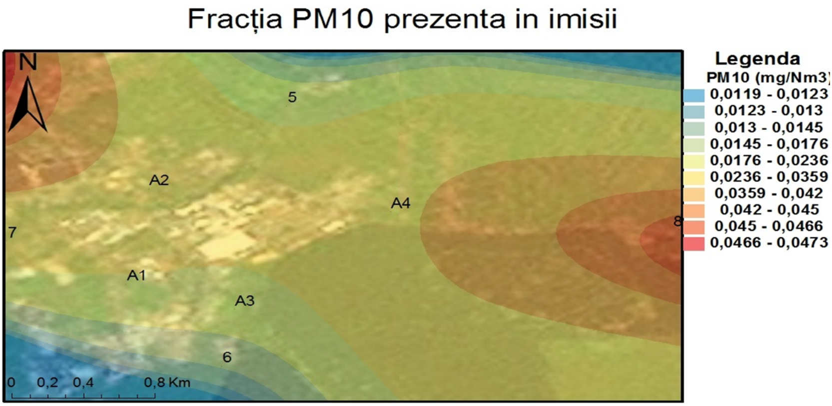


Fig. no 4.2.2. Spatial distribution of PM_{10} fraction

It can be seen that the highest concentrations were measured at the point 8, the other points are the lower, the lower the concentration of particulate PM_{10} fraction being determined as present in the immission point 6. Points A1, A2, A3, A4, 5, 6 and 7 are located in the area of influence of wood processing factory and paragraph 8 is at a greater distance from the site studied.

Some of the particles released into the atmosphere particulate matter may contain adsorbed formaldehyde (38.7%), so the spatial distribution of concentrations of formaldehyde is the same as the distribution of matter, as shown in the map above.

Point sampling of particulate matter are shown on the map in Annex 3.

Chapter 5. Final conclusions

- The European Community policy on health and safety of the population in relation to air is a priority at this time.
- Starting from the idea that urban sources of volatile organic compounds are numerous, car traffic is designated first, and the emergence of new sources, industry will significantly change the distribution pattern of these pollutants, with direct implications for human exposure.
- From the perspective of risk assessment was required under the existing methodology, a baseline health assessment and health risks associated with current environmental conditions in the two areas of Brașov and Reghin.
- Specific models and toxicology of environmental epidemiology have different shades of spatial / ecological via transverse to the case / control and cohort retrospective.
- This thesis is focused on concrete analysis of two areas of woodworking industry, generating specific emissions of formaldehyde which has a primary role relational

potential health effects and particularly occupational health unexposed population.

- In Kronospan Brașov case, formaldehyde exposure assessment, in relation to distance from the objective investigation, revealed the following:
    - formaldehyde concentrations (mg/m^3) measured in the factory and residential areas during monitoring were located below the maximum admissible concentration (CMA) for each location;
    - there were no statistically significant differences in the concentrations of formaldehyde measured in the atmospheric air in residential areas, season, during the monitoring period;
    - comparative statistical analysis revealed no significant difference between the measured concentration of formaldehyde in the traffic, respectively, in the residential area;
    - there were statistically significant differences between the concentrations of formaldehyde measured in the residential area of factory where work, compared to a situation without the function (a value higher formaldehyde

concentrations were measured in residential areas where factory work).

- Risk analysis in correlation with doses of hazardous substances in the atmosphere allowed the following observations:
    - exposure doses (indicating risk of developing adverse effects due to exposure), which were calculated for formaldehyde immission concentrations generated by the activities on site investigated were below the reference value which provides protection of the health of the population;
    - the worst case scenario, theoretical estimates for the additional risk of cancer due to exposure to formaldehyde in the study area were classified in a range of values as orders of magnitude, between 10^{-8} and 10^{-3};
    - additional theoretical estimates of cancer risk in the area of study is in the range of theoretical values expected by the U.S. Environmental Protection Agency (with the upper limit value of the order of 10^{-3}) under the conditions of

exposure to atmospheric air concentrations measured.

- In comparison, concentrations of formaldehyde measured in the residential area during stage II with those measured in the factory, it is found that:
    - o variations in the residential area does not overlap with those made in the factory and also do not overlap perfectly nor on the measured traffic area, **advocating that in the residential area influences are many**;
    - o calculation using the measured immission concentrations in the residential area, the permanent exposure levels for different populations with different susceptibilities of the target area of influence (adults of both sexes), theoretical estimates for the additional risk of cancer due to exposure to formaldehyde the study area were classified in a range of values as orders of magnitude, between 10^{-4} and 10^{-6};
    - o regarding on the health of population groups, those living in residential areas in the area of influence of the factory plates, theoretically estimated additional risk of developing a serious

adverse effect on health (such as malignancy), as a result of exposure long-term (15-30 years) to formaldehyde is very low.

- These risks, although very low, is added to the existing morbidity that shows:
  - in the area adjacent industrial complex Brașov diseases investigated frequency does not increase, so the nearby area recorded values diseases investigated frequencies lower than in other areas, in general;
  - not shown a significant risk to the health of the population with proximity networking site when conducting environmental baseline to the original health. Moreover, the risks increase with the removal of the site.
- In Kastamonu Reghin case, the model assessment of human exposure to formaldehyde in the influence area of the unit was based on indirect methods.
- Estimates have shown that some of the fractions of particulate dispersed in the atmosphere can also contain adsorbed formaldehyde (38.7%).
- Spatial distribution of concentrations of formaldehyde is the same as the distribution of dust.

- Estimation of concentrations of formaldehyde concentration on particulate matter is a new method, we addressed so far in terms of comprehensive assessment of exposures and risks associated when operating plants using technology (the modern present) described and evaluated.
- From the perspective of the impact on human health, formaldehyde adsorbed on particulate matter is at least as important as free formaldehyde.
- As a result, the evaluation of exposure to formaldehyde indirect measurement of the particulate matter and the estimation of the distance function, it is efficient and less costly in method compared with measurements of formaldehyde concentration.
- The picture obtained from analysis of data from practitioners in the area Reghin not follow any specific pattern, in the sense that a higher frequency is present in both the pathologies that could be related to exposure to hazardous substances in the environment due to target specific activities (chronic respiratory pathology) and if the pathology that has no relation to exposure to hazardous substances specific target activity (chronic

gastrointestinal pathology, pathology of the nervous system and so on).

- As baseline health status, chronic pathology investigated the spatial distribution of the study area (chronic respiratory disease and malignancy), was characterized by a great variability in the sense that increasing trends observed rates of cases and trends that lowering rates of cases during the two years of study, but without preferential find higher values of the percentages of cases in area situated close to the investigated sites
- The spatial distribution of disease with distance from polluting industrial sources has allowed us to establish and characterize how the frequencies of a large group of diseases (most diseases) are distributed spatially.
- By conducting pilot model of integrated assessment of exposure to VOCs estimate a positive impact of the project on knowledge of current environmental conditions in terms of VOC pollution of our knowledge and according to published data, **the project is an absolute novelty for Romania and one of the few studies which addressed worldwide integrated non occupational exposure to formaldehyde.**

Chapter 6. Recommendations

Given that this project is almost absolute novelty in Romania, providing unique information and data interpretation, considering that the issue of air pollution, the working environment and living spaces with formaldehyde is extremely important, we must emphasize the following:

A. In terms of air pollution

It will need to consider and implement the acquis requirements transposed into national law on the rules imposed concentrations of volatile organic compounds (VOCs). A relevant document is the "Thematic Strategy on Air Pollution in European Union", which set targets for health and the environment and targets for reducing emissions of major pollutants. These objectives will be achieved in different stages and it will do everything possible to protect European citizens from exposure to particulate matter and ozone in the atmosphere, more protecting ecosystems Europe from active acid rain, excess nutrient nitrogen and ozone. In addition, to achieve these objectives, SO_2 emissions will need to decrease by 82%, NOx emissions by 60%, volatile organic compounds (VOCs) by 51%, ammonia by 27% and primary $PM_{2,5}$ particles

(particles emitted directly into the air) by 59% compared with 2000.

Moreover, at national level will be implemented as soon as possible all the requirements from the 7th EAP (Seventh Environment Action Program), so EU vision for 2050 will help to elucidate the action of all stakeholders by 2020 and beyond.

B. From the point of view of the working environment (workplace conditions)

It is clear that a major role is the care employers to offer their employees working environment. This issue is supported by a good legislative framework in place, where control bodies have a role. On the other hand, national law is and can be successfully completed in each business owner through the development and approval of procedures and work instructions own - in some cases more stringent than the legal requirements - in many cases part of an Integrated Management System which these companies are internationally certified under ISO standards - in this case OHSAS 18001. Fully support implementation of international standard in each industrial operator whose activity involves the management of such substances – such as the formaldehyde – which is omnipresent and is therefore required careful attention to the concentrations in the work environment.

C. From the point of view of space of the housing

To the best of our knowledge, emphasize that studies on impact assessment of formaldehyde present in enclosed spaces (in our case of residential premises) on human health have not been made in Romania, were developed some research on the schools and kindergartens in Bucharest. Being about 90 years, it has a great importance because they are isolated cases, and with the level of scientific knowledge at the time.

Therefore our recommendation is that these types of studies to be carried out regularly, especially that a fair assessment of the health status of the population - policy declared by all politicians, regardless of orientation. Public health is, in fact, a matter of general interest, national security. Under these conditions, the causes of the acute diseases (in case of poisoning by substances whose concentrations exceed the maximum permissible concentrations in a short time), chronic diseases (following prolonged exposure to concentration levels just below the maximum allowable – in some cases), leading to premature deaths, have discovered and studied at the scientific level. This paper is intended to be as an example in this area, showing the approach in a sector in which – for the moment – it's only a pioneer for this field.

A closer cooperation even approved by a law, between different state institutions, as it is the Ministry of Environment and Climate Change and the Ministry of Health, in scientific research, having such a topic could have beneficial results for all Romanian society. We support, strongly, such an approach. And our experience acquired over the years can help those who will initiate such action.

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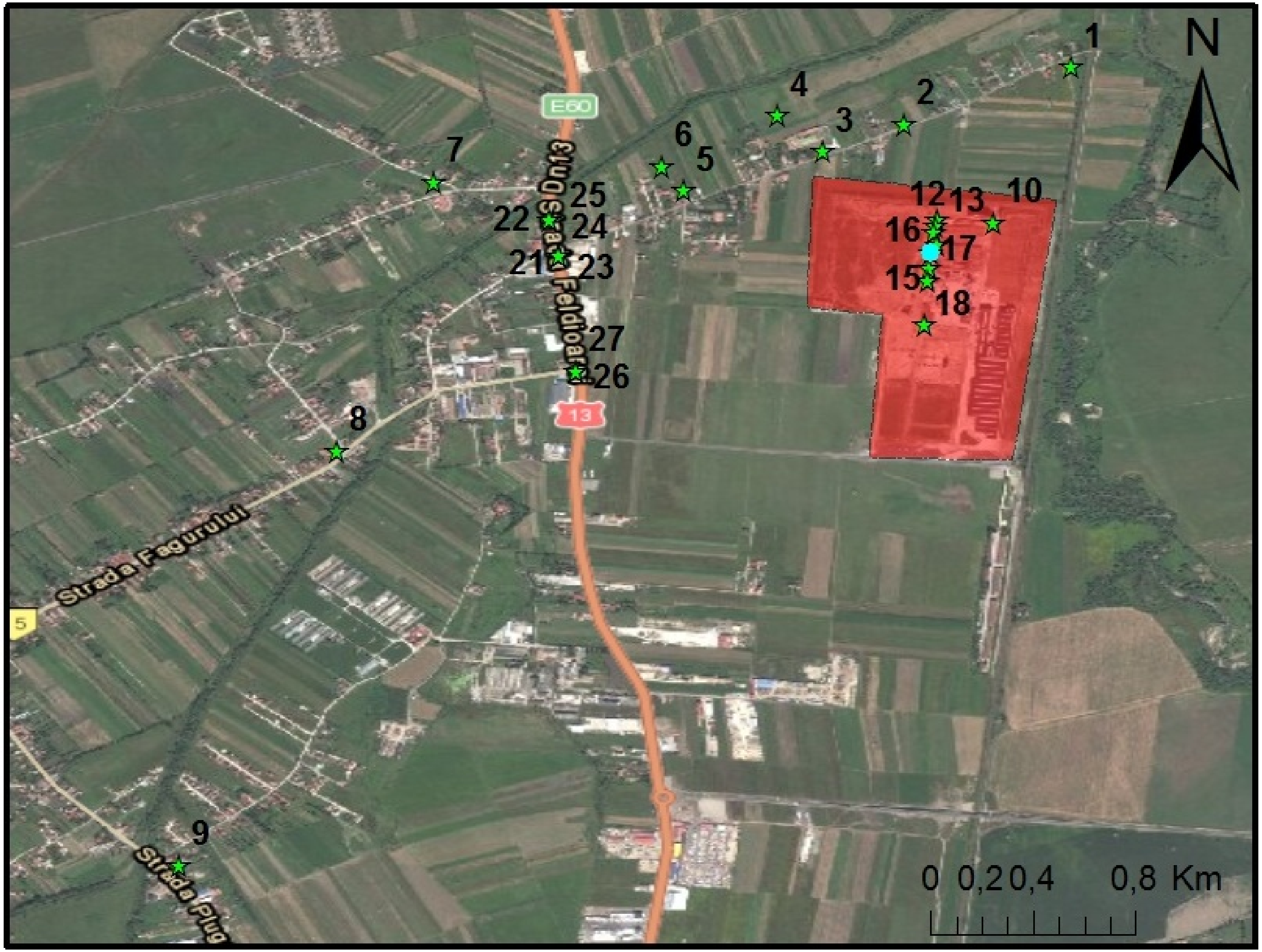
Annex 1 – Point sampling air to determine the formaldehyde content in the area of influence of the Kronospan factory Braşov

ID	Sampling point	GPS Coordonates	
1	Baciului 154	N 45°43'08.3"	E 25°35'52.0"
2	Baciului 114	N 45°43'01.1"	E 25°35'30.8"
3	Baciului 13	N 45°42'57.66"	E 25°35'20.49"
4	Baciului 9	N 45°43'02.2"	E 25°35'14.8"
5	Baciului 4	N 45°42'52.7"	E 25°35'03.0"
6	Baciului 3F3	N 45°42'55.7"	E 25°35'00.2"
7	Fagurului 75	N 45°42'53.8"	E 25°34'31.4"
8	Fagurului 61 A	N 45°42'19.8"	E 25°34'19.2"
9	Plugarilor 35	N 45°41'27.5"	E 25°33'59.2"
10	Plant site	N 45°42'48.65"	E 25°35'42.0"
11	Plant site	N 45°42'49.11"	E 25°35'34.97"
12	Plant site	N 45°42'48.21"	E 25°35'34.68"
13	Plant site	N 45°42'47.47"	E 25°35'34.62"
14	Plant site	N 45°42'45.8"	E 25°35'34.89"
15	Plant site	N 45°42'44.90"	E 25°35'34.18"
16	Plant site	N 45°42'43.00"	E 25°35'33.90"
17	Plant site	N 45°42'41.40"	E 25°35'33.78"

Annex 1 – Point sampling air to determine the formaldehyde content in the area of influence of the Kronospan factory Braşov

ID	Sampling point	GPS Coordonates	
18	Plant site	N 45°42'35.78"	E 25°35'33.45"
19	Traffic	N 45°42'44.52"	E 25°34'47.12"
20	Traffic	N 45°42'44.52"	E 25°34'47.12"
21	Traffic	N 45°42'44.52"	E 25°34'47.12"
22	Traffic	N 45°42'44.52"	E 25°34'47.12"
23	Traffic	N 45°42'44.52"	E 25°34'47.12"
24	Traffic	N 45°42'44.52"	E 25°34'47.12"
25	Traffic	N 45°42'48.97"	E 25°34'46.01"
26	Traffic	N 45°42'29.92"	E 25°34'49.29"
27	Traffic	N 45°42'29.92"	E 25°34'49.29"

Annex 2 – Map of sampling points where they have been analyzed air formaldehyde content in the area of influence of the Kronospan factory Braşov



Annex 3 - Map of sampling points where they have been analyzed air formaldehyde content in the area of influence of plant Kastamonu, Reghin

Annex 4 – WHO international classification - ICD 10

Table no. A4.1. Codes investigated conditions (according to WHO international classification-ICD 10)

	Primary malignancies with specific locations, with the exception of lymphoid tissue, hematopoietic and connective
C00-C14	Lip, oral cavity, pharynx
C15-C26	Digestive organs
C30-C39	Respiratory and intrathoracic organs
C43-C44	Skin
C45-C49	Soft tissue and mesothelial tissue
C50	Breast
C51-C58	Female genitalia
C60-C63	Male genitalia
C64-C68	Urinary tract
C69-C72	Eye, brain and other parts of the NCS
C73-C75	Thyroid and other endocrine glands
C81-C96	Primary malignant tumors of lymphoid tissue, hematopoietic and connective
D10-D36	Benign tumors
	Hematologic system disorders
D50	Iron deficiency anemia
D51-D53	Nutritional anemia
D60-D64	Aplastic and other anemia

	Endocrine, nutritional and metabolic diseases
E00-E07	Thyroid diseases
E10-E14	Diabetes
E20-E35	Other endocrine disorders
E50-E64	Other nutritional deficiencies
E65-E68	Obesity and hyperfood
	Central Nervous System diseases
G50-G59	Nerve disorders, their roots and plexus
G60-G64	Polyneuropathy and other disorders of the peripheral nervous system
	Eye disorders and annexes
H10-H13	Disorders of conjunctiva
	Diseases of the circulatory system
I05-I09	Chronic rheumatic heart disease etiology
I10-I15	Hypertensive disease
I20-I25	Ischemic heart disease
I26-I28	The heart lung and other diseases of pulmonary circulation
I30-I39	Diseases of the pericardium, endocardium and valves
I40-I52	Other heart disease
I60-I69	Cerebrovascular diseases
I70-I79	Diseases of arteries, arterioles and capillaries

	Diseases of the respiratory system
J41	Simple and mucopurulent chronic bronchitis
J43	Emphysema
J44	Other chronic obstructive pulmonary diseases
J45	Asthma
J80-J84	Other interstitial lung disease
	Diseases of the digestive tract
K25	Gastric ulcer
K26	Duodenal ulcer
K29	Gastric and duodenal
K70	Liver disease by ethanol cause
K71	Cause toxic liver disease
K72	Hepatic insufficiency unclassified elsewhere
K73	Chronic hepatitis
K74	Hepatic fibrosis and cirrhosis
K75	Other inflammatory liver diseases
K76	Other liver diseases
K80	Cholelithiasis
K81	Cholecystitis
K87	Disorders of gallbladder, biliary tract and pancreas occurring in other diseases

	Diseases of the skin and subcutaneous tissue
L20-L30	Dermatitis and eczema
L50-L54	Urticarial and erythema of the skin
	Diseases of the musculoskeletal system and connective tissue
M15-M19	Arthritis
M60-M63	Diseases of muscles
M80-M85	Diseases affecting bone density and structure
	Chronic kidney diseases
N10-N16	Renal tubule-interstitial disease
N17-N19	Chronic renal failure
N20-N23	Kidney stones and urinary