AMBIENTUM

CONTENTS – SOMMAIRE – CONTENIDO – CUPRINS

HEALTH RISKS AS A CONSEQUENCE OF DRINKING WATER TREATMENT TECHNOLOGY

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ABSTRACT. Water safety management demands a quantitative understanding of how processes and actions affect water quality, which in turn requires an understanding of risk assessment. Contamination of drinking-water by microbial pathogens can cause disease outbreaks and contribute to background rates of disease. There are many treatment options for eliminating pathogens from drinking-water, and finding the right solution for a particular supply involves choosing from a range of processes. Chlorination has been successfully used for the control of waterborne infectious diseases and is the most widely used cost effective method of disinfection. The identification of chlorination byproducts (CBPs) and their potential health hazards has created a major issue in balancing chemical toxicity with risks from pathogenic microbes. The process of providing safe drinking water has relied on the protection of water sources, the application of the specific treatment technologies and the protection and maintaining quality in the distribution system. The health risk factors which can be associated with a drinking water treatment plant are related to: water contamination during treatment steps, final disinfection efficiency, distributed water quantity and distribution continuity.

Key words: *drinking water treatment, technology, health benefits, health risks*

INTRODUCTION

From the public health perspective water is a determining environmental factor for promoting health. Drinking water must have a quality that promotes and protects the public health, the safe water expressing the accordance to the maximum admissible limits of the relevant water parameters for human health. Contamination of drinking-water by microbial pathogens can cause disease outbreaks and contribute to background rates of disease. There are many treatment options for eliminating pathogens from drinking-water, and finding the right solution for a particular supply involves choosing from a range of processes. The fundamental scope of water treatment is to protect consumers from pathogens and chemical impurities in water that can affect human health. The best results in obtaining an

adequate microbiological and chemical quality of the drinking water are provided by combining the treatment processes. For centuries, the process of providing safe drinking water has relied on the application of the "multiple barrier concept". Traditionally, the barriers have included: protection of the water source (water used for drinking water should originate from the highest quality source possible); water treatment (basically consisting in coagulation, decantation, filtration and disinfection); protection of the distribution system. (Mark W LeChevallier and Kwok-Keung Au. 2004)

Chlorination has been successfully used for the control of waterborne infectious diseases and is the most widely used cost effective method of disinfection. In order to achieve microbial safety criteria as well as the socio-economic acceptance, there are different treatment options of water source (ground water or rivers, lakes, streams) that included the final chlorination. The water chlorination procedure determines formation of chlorination by-products which creates an important problem of human toxicology.

The identification of chlorination byproducts (CBPs) and their potential health hazards has created a major issue in balancing chemical toxicity with risks from pathogenic microbes. The process of providing safe drinking water has relied on the protection of water sources, the application of the specific treatment technologies and the protection and maintaining quality in the distribution system. The health risk factors which can be associated with a drinking water treatment plant are related to: water contamination during treatment steps, final disinfection efficiency, distributed water quantity and distribution continuity

OBJECTIVES OF THE STUDY

We analyze in the present paper the functionality of the three drinking water treatment stations (Cluj-Napoca, Targu Mures and Zalau) which process conventionally (coagulation, decantation, rapid filtering, disinfection with chlorine) different water sources. The results refer also to the balance between the health benefits and the health risks as a consequence of drinking water treatment technology.

AREA OF STUDY

The area of study is represented by the central Transylvanian area (Cluj, Salaj and Mures counties). We proposed a synthetic data analysis concerning the quality of two artificial water accumulations that represent the water sources that are processed for drinking water purposes - Gilau and Varsolt reservoirs, and a source of running water - Mures River, followed by the functionality analysis of the treatment plants that use these sources.

There are recent studies data about the importance of the changes in reservoir water quality caused by climate. Reservoir water for drinking water production may undergo major short-term and long-term quality changes as a result of natural processes in the water body and of the water's quality entering and leaving the reservoir. These are results of natural processes in the water body and the water's quality entering and leaving the reservoir and also the tratament water processes. (I.Slavik and W. Uhl, 2009)

Gilau reservoir formed on the Somesul Mic River follows a system of reservoirs on the Somesul Cald River, receiving water from the Somesul Rece River and Agârbiciu Creek. It is the water source for the Gilau water treatment plant that provides the water for human consumption (drinking water) for Cluj-Napoca, Gherla, Baciu, Gilau, Floresti, Aghires and other localities (approximately 500000 inhabitants).

Varsolt reservoir (accumulation on Crasna River) provides raw water for the water treatment plant that provides the water for human consumption (drinking water) for Zalau and Simleul Silvaniei localities (approximately 79000 inhabitants).

Mures River is the drinking water source for Targu Mures municipality. The water intake is located in the area between Reghin and Targu Mures, an area that is subject to organized and non-organized pollution (sanitary sewer of Reghin city, floodable rural villages, etc.)

The best results in obtaining an adequate microbiological and chemical quality of the drinking water are provided by combining the treatment processes. In order to comply to the drinking water criteria these surface waters are treatment in those three drinking water plants used the classic procedure: coagulation/decantation, filtration and disinfection. To these technological steps that depend on the raw water quality a series of additional processes can be added such as KMnO4 before coagulation at Targu Mures WTP, or pre-chlorination and rechlorination (in the drinking water network) at Zalau WTP, processes applied to the raw waters containing a high load of pathogen germs and organic matter. Pre-chlorination consists in introducing a usually higher quantity of chlorine (1-5 mg/l and even more) than that used for the final chlorination, before coagulation, together with the coagulant or before filtration, thus filtration has a higher efficiency and through the final chlorination drinking water of proper quality is obtained (Ritter et al. 2002).

MATERIALS AND METHODS

In this paper we analyzed both the data collected in 2009 relative to the supervision of the three surface water sources: Gilau and Varsolt reservoirs and Mures River and the treatment water plants that process these water sources.

For the reservoir water quality assessment, we used the usual monitoring data for the 2009 year (January, April, July and October months) collected by the laboratories owned by the drinking water suppliers and for Mures River we used data from professional studies. The analysis results were processed for oxidability and content of ammonium, nitrates in these waters. During 2009, a total of 40 water samples were collected in three steps from the water source and during the technological treatment process at Gilau, Varsolt and Targu Mures water treatment plants. The raw water samples were analyzed in the laboratories of the Environmental Health Center Cluj-Napoca for a series of quality indicators using accredited analysis methods like: chemical oxygen demand – KMnO4 (CCOMn) – titrimetric method (SR EN ISO 8467); nitrates (SR ISO 7890-3) and ammonium (SR ISO 7150-1/2001) - spectrometric molecular method.

The treated water samples were collected three times (June-August 2009) and stored in 500 mL glass bottles. The water samples were stored at $4^{o}C$ until analyzed after sodium thiosulfate ($Na_2S_2O_3$) was added to quench residual chlorine.

These water samples, also, were analyzed in the laboratories of the Environmental Health Center Cluj-Napoca, for a series of indicator parameters for oxidizable organic matter content, chlorine (both precursors for THMs), total THMs and species (chloroform, dichlorobromomethane, dibromochloromethane and bromoform) using accredited/validated analytical methods such as: chemical oxygen demand – $KMnO_4$ (CCOMn) – titrimetric method (SR EN ISO 8467); nitrite (SR 3048-2), nitrate (SR ISO 7890-3) ammonium (SR ISO 7150-1/2001) - spectrometric method; free residual chlorine (Standard Methods 4500-Cl) and total chlorine (Standard Methods 4500-Cl) colorimetric test.

The trihalomethanes analysis was carried out by GC-2010 gas chromatography with electron capture detector (GC-ECD) and a Shimadzu AOC 5000 HSauto sampler. It was used the headspace technique. 10 mL of sample was filled into 20 mL headspace vials. They were shacked for 45 minutes at $60^{o}C$. A quantity of 2.5 mL from the gaseous phase was injected into GC. The results were read from the calibration curve, which was prepared using standard solutions of 0, 20, 40, 60, 80 and 100 µg/L each compound in Super Q water.

Databases were obtained by introducing water quality data in the Microsoft Excel version 5.0 program and processed statistically. Graphs were performed by the Microsoft Excel version 5.0 program.

RESULTS AND DISCUSSIONS

Cluj central water supply and Gilau Water Treatement Plant

The bacteriological quality of the raw water entering the water treatment plant has the same progressive general characteristics of the parameters watched for the water from Gilau lake. We have noticed that in a short period of time (1-2 days) the quality of the water coming from Gilau lake may be significantly modified. The coagulation is not applied constantly because of the small turbidities of the raw water. An important coagulation inefficiency was observed, in rare cases corresponding or close to the recommended value (over 90%). The rapid filtration which is not preceded by coagulation/sedimentation is not efficient, as the risk of bacteriological and parasitical contamination is maintained. The affluent creek carries an important quantity of clay into the lake during precipitations periods or snow melting, this substance disturbing the process of coagulation/sedimentation. There are implications upon filtering efficiency and also regarding the total efficiency of the station - most probably inadequate filters exploitation (clogging and inefficient washing). The disinfection efficiency was 100% in all cases, in conditions of hyper-chlorination (0.67-0.95 mg/L free residual chlorine compared to the standardized value of maximum 0.5 mg/L), thus correcting the inadequate bacteriological quality resulted after a filtration that is often not efficient. The quality of the treated water going out the station was acoording to Romanian Water Law (The Law 458/2002 completed and modified by Law 311/2004) except for the free residual chlorine. Hyper-chlorination did not lead to excess development of chlorination by products (total trihalomethanes 75% from the standardized value).

Zalau central water supply and Varsolt Water treatement Plant

The daily averages of sedimentation efficiency calculated based on turbidity show values between 55 and 81 %, below the recommended ones (min 90%). Calculation based on colimetry shows higher values for efficiency (92-98%) as a result of pre-chlorination, especially during the warm period of the year. The daily average efficiency of filtration based on turbidity during the analized period was generally smaller than the reference value. The calculation based on colimetry shows low values of efficiency with the mention that the bacterial load was significantly reduced as a result of pre-chlorination and sedimentation. The total efficiency of the station calculated based on turbidity and colimetry showed values about 95 % for turbidity and 99% for colimetry. Disinfection efficiency was in all cases 100%, in conditions of hyper-chlorination. The level of free residual chlorine was in most cases 1.8-2 mg/l in the water going out the treatment plant. The quality of the treated water going out the treatment plant was according to Romanian Water Law, except for the free residual chlorine. Hyper-chlorination does not lead to form chlorination by products (trihalomethanes) in excess, because of the efficient decrease of organic substances by previous treatment steps.

Targu Mures central water supply and water treatment supply

Mures River, the drinking water source for Targu Mures WTP which has an important bacteriological contamination ("A3") is characterized (as any surface water quality) in unsteady flow and parameters with increasing variability in a very short time.Water treatment at WTP Targu Mures distinguishes by: the nitrates levels that are not reduced during treatment and fail to maintain a low level of oxidisability. The main problem of water quality exiting the treatment plant is on high levels of free residual chlorine . The average values of free residual chlorine value is around 1 mg / l or below, the values representing over 80% of total residual chlorine. These values of free residual chlorine, oxidisability and the possibility of formation of chlorination-products (trihalomethanes) is very low, (knowing that only the values of free residual chlorine above 3 mg / l, temperature and organic loading can be increased speak of the excessive, dangerous levels of the trihalomethanes). The current situation of water treatment and distribution in Targu Mures requires hyperchlorination. In order to achieve water microbiological safety consider necessary to maintain water hyperchlorinationin order to be assured a minimum free residual chlorine of 0.15 mg / l at different points in the distribution network.

Quality of treated waters in Gilau, Varsolt and Targu Mures water treatment plants - 2009

According to the legislation in force (HG 100/2002) source waters treatment is performed in accordance with the water quality regarding the following treatment standard technologies: A1 - simple physical treatment and disinfection, A2 - normal physical and chemical treatment and disinfection (pre-chlorination, coagulation, fluoridation, decantation, filtration and disinfection). Gilau water treatment plant applies the standard procedure for processing water for drinking purposes: decantation, coagulation, filtration and disinfection producing quality water whose values for the

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analyzed chemical parameters correspond to human consumption. (Fig.1). We estimated the efficiency of water filtration and disinfection in relation to the raw water by reducing the values of indicators as oxidability and nitrites. The values of the chemical oxygen demand (CCO-Mn) in the raw water and filtered water show a significant decrease.
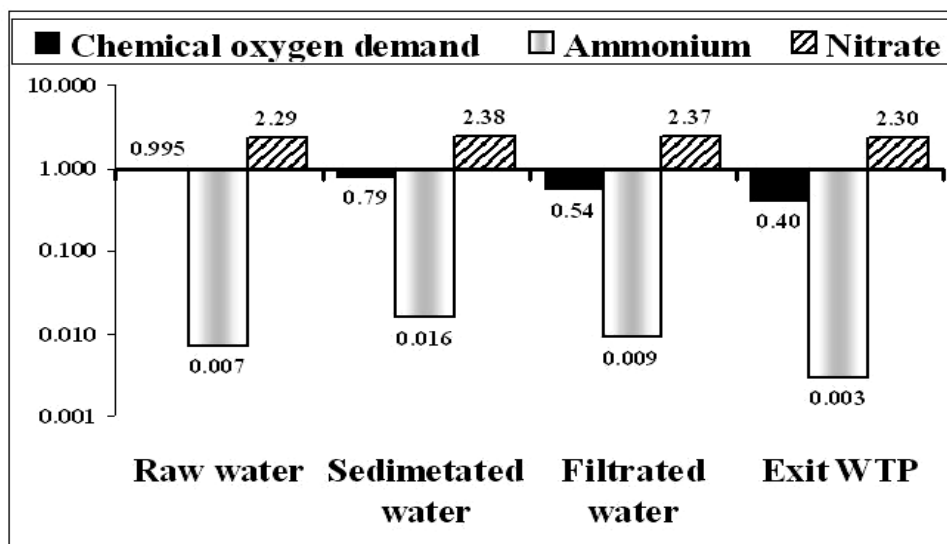
Fig. 1. *Comparative values for oxidability, ammonium, and nitrates in water Gilau water treatment plant 2009.*

Starting from the water source quality and in full agreement with the historical pollution data Varsolt water treatment plant (Fig.2) applies in relation to Gilau water treatment plant an additional pre-chlorination process prior to coagulation and decantation obtaining finally a water that meets the quality criteria for consumers' safety (according to Law 458/2002 with subsequent amendments Law 311/2004). Generally the treatment determines a concentration decrease of the values of different chemical water indicators: oxidability and ammonium. However, nitrates have a particular evolution, their level increases in water during potabilisation operations. The pre-chlorination effect is relieved by the appearance of differences of the chemical oxygen demand values between the raw water and the decanted water, filtered water and water exiting the water treatment plant.
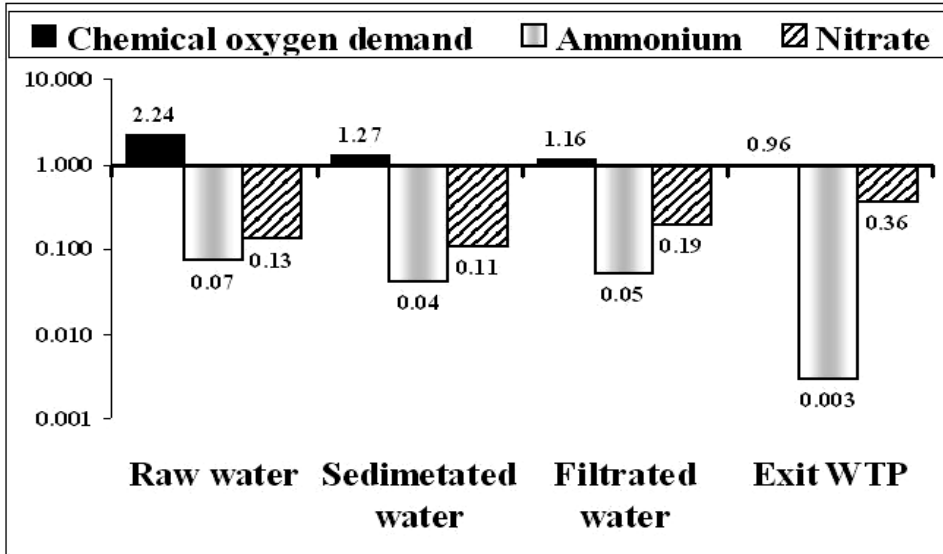
Fig. 2. *Comparative values for oxidability, ammonium and nitrates in water*
Varsolt water treatment plant 2009

According to the results obtained by analyzing the indicators parameters in 2009, water treatment at Targu Mures water treatment plant distinguishes by the nitrates levels that are not reduced during treatment, moreover their value in the water exiting the water treatment plant is slightly higher than in the source (Fig.3). Inadequate filter exploitation may lead to increased values of indicators such as nitrates, by mobilizing them as a result of organic matter decay in the filter layer. Instead, decrease of the ammonium level and the chemical oxygen demand are due to the treatment, situation observed also in Varsolt water treatment plant.

The values of the indicator parameters for pollution with oxidizable organic matter (precursor of THMs) and their evolution in the raw, sediments, filtrated, chlorinated and network water, during the study period of 2009 are shown in precedent figures The clear and significant qualitative difference is observed between the water sources, the lowest organic load being recorded at the water source for Gilau water treatment plant (Gilau reservoir). Although these indicator parameters had low levels in all three sources, they presented significant variations, the most important increase being recorded in July, corresponding to a period of intense rainfall and high temperature.
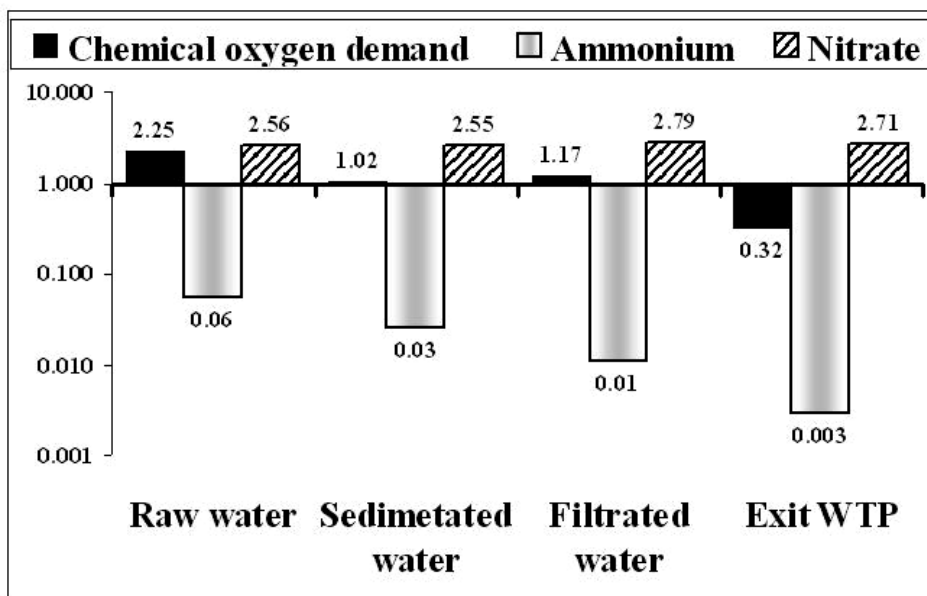
Fig. 3. *Comparative values for oxidability, ammonium and nitrates in water Targu Mures water treatment plant 2009*

The highest average concentration of nitrates in the raw water from Tg. Mures WTP is specific to the rivers crossing localities and receiving tributary flow which also run through localities. A recent study conducted in the Mures County area (Hajdu et all, 2007) showed that the pollution sources (diffuse and punctual) from the localities effects the pollution of surface waters with nitrates. Raw water quality due to the oxidizable organic matter load and treatment process efficiency resulting in their significant reduction before chlorination is essential in controlling the formation of trihalomethanes. The formation of THMs and implicit chloroform is also influenced by the raw water composition as like the presence of natural organic substances (humic substances, microbial exudates and other dissolved materials originating from soil and terrestrial vegetation or from other aquatic biological processes) (Chan at all, 2002; Ristoiu et all, 2008, Nicolaou et all 1993). Although the oxidizable organic matter recorded low levels in raw water, much below the maximum admitted limit in drinking water, reduction during the treatment was significant in all three water treatment plants and especially at Tg.Mures and Varsolt/Zalau water treatment plants where pre-chlorination of the raw water is used (fig.4). The quality of the water supplied for the population by the three drinking water suppliers met the requirements for use in potable purposes. Uniformly, the average values for the precursors of THMs in the treated water except for the free residual chlorine framed in the maximum admitted limits (fig.4).

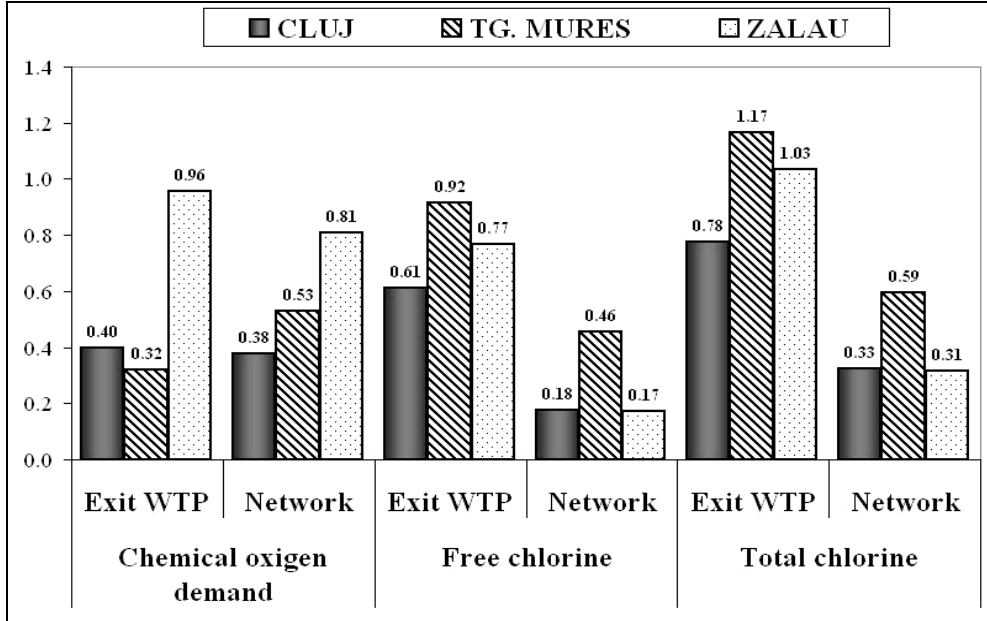**Fig. 4.** *Average value for oxidability, free chlorine and total chlorine in the drinking water exiting the water treatment plant and in the distribution system (mg/l).*

Referring to the maximum admitted levels for the free residual chlorine in the water exiting the water treatment plant/entering the distribution system (0.5 mg/L) we observed that the hyper-chlorination is practiced at all three water treatment plants, for the reason of maintaining the microbiological safety in the distribution system placed at distance and/or have a poor technical condition. As a result similar or higher values are recorded for oxidability coupled with a decrease by consumption of the free residual chlorine and of the total chlorine afterwards. The presence of an increased level of free residual chlorine in the treated water is an important factor of an enhanced genesis of disinfection by-products, even in conditions of low levels of oxidizable organic matter. As shown in this paper if the water exiting the water treatment plant contains levels of free and total residual chlorine exceeding the admitted limits, the recommendation that the free residual chlorine level has to represent 80% of the total residual chlorine (for the disinfection to be efficient) is not achieved. Moreover, this percent of free residual chlorine is even lower in the distribution system, indicating the formation of trihalomethanes. Figure 5 shows the average concentrations of the four important compounds from the THMs group, both in the water exiting the water treatment plants and the water in the distribution systems of the investigated localities. The main component, chloroform, is responsible for increasing the concentration of THMs in the distribution system in Cluj-Napoca and Tg.Mures, the latter recording the highest concentrations of chloroform (50.17-78.24 μg/l) out of the three cities.
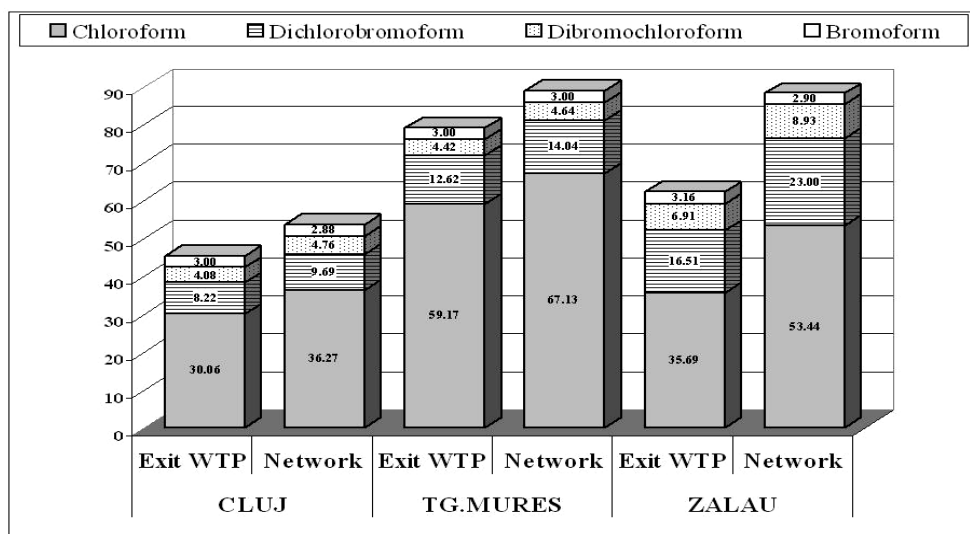
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Fig. 5. *Species of THMs in the treated and supplied water (µg/L)*

We mention once again that the highest values of residual chlorine were recorded in Tg.Mures distribution system. As a characteristic, a much higher concentration of dichlorobromomethane, dibromochloromethane and bromoform appears in the water exiting Varsolt/Zalau WTS in comparison with the other localities, due to bromates' content in the raw water (Varsolt reservoir). Differences for dichlorobromomethane and dibromochloromethane between Cluj-Napoca-Tg.Mures and Tg.Mures-Zalau were observed. It is notable that in Zalau city distribution system, besides the highest concentrations of total THMs to be recorded and samples that exceeded the maximum admitted concentration, the dibromochloromethane which is a compound frequently associated with carcinogenesis, also recorded the highest concentrations between 4-10.70 µg/l. The most important parameter involved in the dynamic generation THMs in an aqueous medium, is the concentration of residual chlorine, which varies according to other parameters such as temperature, pH or concentration of natural organic substances. Thus, typically high chlorine concentrations determine large amounts of chloroform. The relationship between the formation of THMs compounds (specifically chloroform) and chlorine was studied by laboratory kinetic experiments. The results demonstrated that the chlorine dose added directly and linearly in the water influences the rate of chloroform generation. A 2.5 mg/l chlorine dose increased the chloroform concentration to 28.0 – 31.0 µg/L. (Ristoiu et al., 2008).

The decrease of formation of THMs is the most important way to reduced the human exposure from this by-products. That can be realized changing the treatment procedure: decreasing the natural organic matter and humic substances which practically means decreasing the amount of high total organic carbon also

decreases the high disinfection demand, as well as the formation of THMs. Some studies reported data about removal of humic substances using before settling and filtration different procedure like solar irradiation fallowed by granular activated carbon absorption (X Liu and C.S.B. Fitzpatrick, 2010) or Brimac media associated with granular activated carbon. (K.M. Courtnadge, A. Muir, S. Sandilands and J.Martin, 2010).

Heterogeneous photocatalysis is a promising technology in addressing the incapacity of current water technology. The best example is TiO2 nanotube photocatalytic oxidation of humic acid in water having an excellent performance in decreasing the amount of high total organic carbon and the generation of THMs. (Xiwang Zhang et al., 2009).

A method to decrease THMs is to eliminate or reduce chlorination before filtration and to reduce organic matter. Few studies were found in literature on mixing effects of chlorination by changing the chlorination point or dosage.(K. Shodhan and I. Wei, 2010). In same time some studies recommend to optimize the disinfection using other disinfectants like ozone (K. Lekkerkerker and al., 2009; Y Jaeger at al., 2009) and UV light.

In the drinking water networks the problem of balancing the need to maintain effective chlorination in the water and the effort to control THMs production still remain to be treated by the water suppliers. In Romania, as well as worldwide, water industry is currently replacing pipes with less reactive synthetic materials. Some studies (Chan at al., 2002) showed that in this kind of pipes the biofilms form when microbial cells attach to the pipe surface and multiply, forming a slime layer in the pipe. The surface biofilm may impose certain impacts on the formation of THMs during distribution, contributing to the chloroform production. Both bacterial inactivation and THMs formation exert a chlorine demand and rely heavily on the natural organic matter (as a precursor for THMs formation and as a nutrient source for bacteria). It is known that the rechlorination significantly increases the THMs production. In some cases, the potential of rechlorination to prevent biofilm re-growth may be outweighed by its potential to pose a threat downstream on THMs control efforts. We obtained results showing that under the conditions of a low content of oxidizable organic matter in water and a level of free residual chlorine below 1 mg/l, the generation of THMs continues in the distribution system. From the health risk point of view the main threat to the water production is the maintaining the THMs levels low into the drinking water network. This presumes the permanent maintenance of the network and replacement of improper pipes.

Other major factors that participate in the process of THMs formation in the water distribution system is the bacterial attachment to surfaces and bioactivity of these organisms, including the microbial regeneration process and production of extracellular polysaccharides. It seems that chlorination acts selectively on bacteria, which explains their persistence and regeneration, while promoting additional formation of chloroform.

The decreasing of THMs in drinking water can be done also/and by some control measures at home (if anyone believes that this is an important factor in their lives) like filters, aeration or boiling of drinking water and using bottled water (Gopal et al., 2007)

CONCLUSIONS

Overall, it can be stated that the three studied water sources in the central part of Transylvania frame in the A2 category for surface waters that can be processed for drinking water purposes. The investigated water sources present variable moderate characteristics regarding the chemical oxygen demand, ammonium and nitrates being influenced by the hydrological system and the upstream sources of pollution both in Gilau and Varsolt reservoirs and in Mures River. The water treatment plants in this study, through the performed technologies provide water exiting the water treatment plants that corresponds to the quality standards in terms of analyzed indicators that reflect the reduction or absence of microbiological pollution of the water. Using pre-chlorination dictated by the level of organic load in the water source created the prerequisites in obtaining drinking water with a statistically significant reduction of parameter indicators levels, but thus favoring the occurrence of disinfection by-products that can affect consumers' health.

The total concentration of trihalomethanes and the formation of individual THM species in the chlorinated water strongly depend on the composition of the raw water and mainly the presence of natural organic matter in water, on operational parameters and chlorine dose, reaction time, and in the distribution system by the pipe environment created from the occurrence of residual chlorine, and the bioactivity in biofilm. Generation of THMs takes place even at low concentrations of precursors, the level of the free residual chlorine influencing especially the formation and level of chloroform.

THMs toxicodinamics action mechanisms have negative effects on human health like genotoxicity, and carcinogenicity.

From epidemiological perspectives, exposure assessment to THMs in the three localities showed that the risk of occurrence of adverse effects (considering long-term exposure) exists, both when the measured concentrations of total THMs were high and mainly when some compounds that are mostly associated to carcinogenesis were identified at the same time.

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THE NOISE VARIATION EMITTED BY AIRBUS A 320, BOEING 737 AND ATR 42 S 500 NEAR THE INTERNATIONAL AIRPORT OF CLUJ-NAPOCA

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ABSTRACT. In the last years, it has been noticed that the number of airplanes that have „visited" the International airport of Cluj-Napoca is disturbingly increasing. The aim of the study is to show what kind of movement is noisier: the landing or the take-off. This study presents the level of sound pressure that people who live near the airport have to bear. It refers to the comparison of the emitted noise of three different airplanes, at landing and take-off, near the airport. Every measurement was taken in three places: one placed beneath the flight path and the others two on one side and another. The airplane noise was recorded for 20 seconds, time for the aircraft to cross over the measuring places at landing and take-off.

Key words: *noise pollution, aircraft noise, airport, landing, take-off, dB*

INTRODUCTION

Noise is defined as unwanted sound. Human activities have so many benefits for humanity, but it brings up pollution, and especially noise pollution for the environment. The increase in air traffic impacts urban and housing area with a high level of noise, especially for areas near runways. The issue arise when it disturbs the daily life of civilians in a large metropolitan area. The noise is considered one of the most widespread environmental issues, all over the world. Noise pollution is affecting human activities at work, and can produce health problems like hearing loss and cardiovascular problems.

Air traffic is known as the main source of noise pollution in a big city. The noise engine of every aircraft has a high intensity, large range of frequency and it can always be distinguished among the other sources of noise pollution (Gafițanu et al., 1980). But what kind of movement is noisier, the landing or the take-off? We choose three places to measure the emitted noise. The first step was to study the noise recorded from underneath the flight path. We studied how the level of noise decreases at landing and take-off as we move away from this place.

METHODOLOGY

In order to evaluate the noise pollution, three different aircrafts were chosen to be analysed. The measurements had been taken with Brüel&Kjær 2260 Investigator sound level meter. The Noise Explorer Program was used to examine the data. For every aircraft the measurement were taken in three different places: 1, 1.A, 1.B, (Fig.1) in order to see how the noise is percept on the ground. The first place was beneath the flight path and the others two on one side and another. These places are situated in the east part of the runway of International Airport of Cluj-Napoca. The length from the place beneath the flight path and the others is 170 m. The distance between the runway and the measuring place 1 is 300 m. Those places were chosen to see the differences between the level of noise beneath the flight path and the others two.

The noise was recorded for 20 seconds (with a value for every second), the time corresponding for every aircraft landing and take-off to cross over the measurement place 1. At every measurement place the noise had been recorded for at least two times, in order to eliminate the errors. In order to show the differences the L_{ASmax} parameter was recorded for every second. As it can be seen in the figures bellow (Figure 2-7), the noise increases till 10th second, when the aircraft is exactly above the measuring place 1. After that, the noise level decreases as the aircraft moves away.
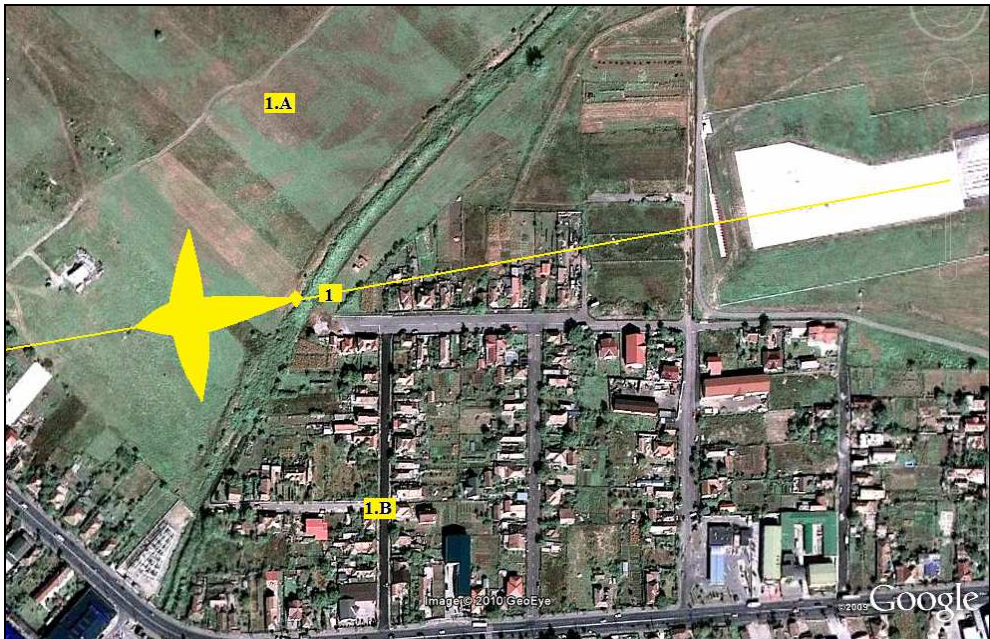
Fig. 1. *The measurement places*

RESULTS AND DISCUSSION

Data from 3 places were analyzed: 1, 1.A, 1.B (Fig.1). Three different airplanes were monitories: Airbus A 320, Boeing 737 and ATR 42 s 500.

Airbus A 320

The Airbus A 320 is a commercial passenger jet of short to medium range, narrow body and with a standard diameter. It has 37,57 meters and a capacity of 180 passengers. It is one of the most frequent airplanes that are landing at Cluj-Napoca airport.

During landing, the airplane is at 50 meters high above the measurement place. The maximum level of noise for every measuring place is: 97,74 dB for the place 1, 76,7 dB for place 1.A, and 77,86 dB for the place 1.B.
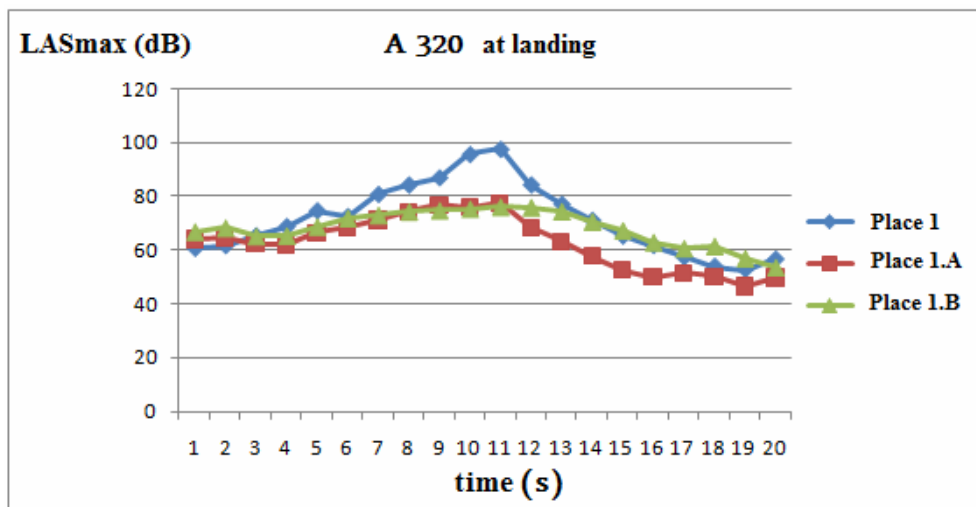
Fig. 2. *The noise variation for Airbus A 320 at landing*

As it can be seen on Fig.2. the level of noise recorded under the flight path (place 1) is higher than the others two (place 1.A and 1.B) with a maximum differenece of 20 dB. In those 20 seconds, the noise level is almost exactly in those three places untill the airplane is above the measuring point. The difference appears at place 1 where the level of noise is rapidly increasing at 9th second it reaches a maximum at 10th and 11th second and then is rapidly decreasing. The aircraft reaches that point in the 10th second, so there is a big difference between those three places.

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During take-off, Fig.3, the level of noise is stronger and is spread over a bigger area. At take-off the aircraft reaches 150 meters altitude in place 1. If at landing, the noise reached 90 dB just beneath the flight path, at take-off the noise is around the same value in all three places. As it can be seen in Fig.3, the noise evolution during take-off is almost the same with no big differences as at landing.

The difference between the maximul level of noise measured is about 5 dB. The maximum recorded was under the flight path with 95,4 dB, and in other places 91,16 dB (place 1.A) and 87,91 dB (place 1.B).
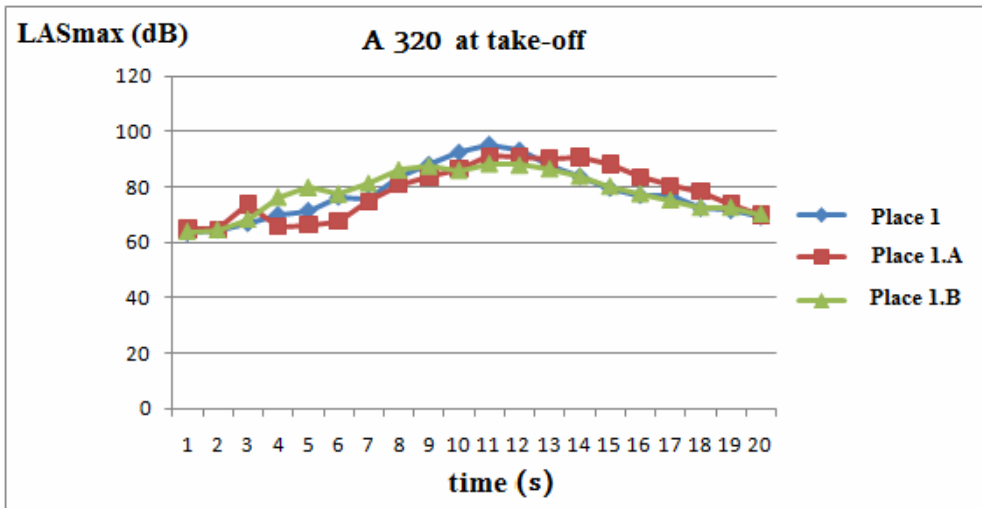
Fig. 3. *The noise variation for Airbus A 320 at take-off*

Boeing 737

The B 737 is the most used airplane over the world and it has a capacity of 116 passengers. The maximum recorded at landing was 95,59 dB in place 1 and 77,55 dB respectively 78,82 dB in the others. As it can be seen in the Fig.4 the noise evolution is the same as A 320 with an increase in noise level around 10th second in place 1.
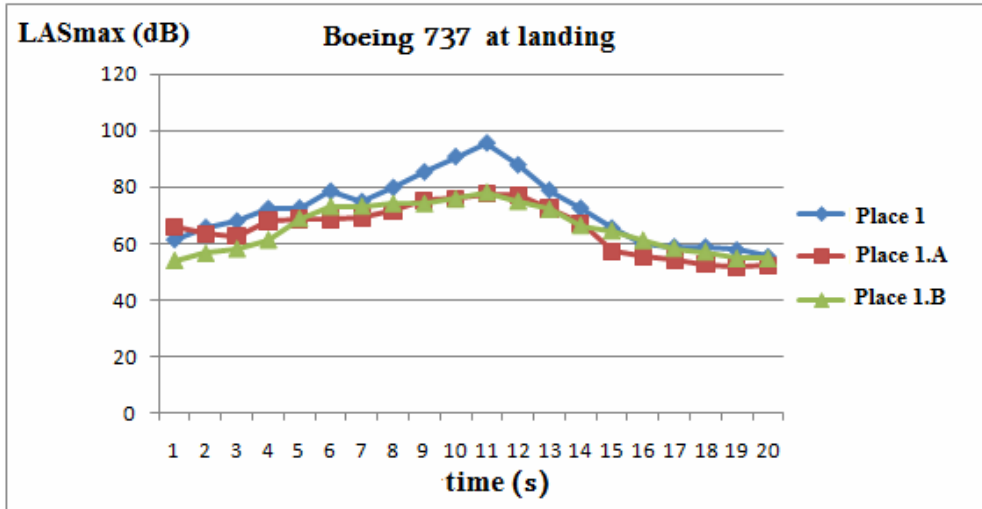
Fig. 4. *The noise variation for Boeing 737 at landing*

At take-off (Fig.5) the maximum recorded was 95,72 dB in place 1 and 87,91 dB respectively 87,66 dB. So the level of noise has no big variation between those three places.
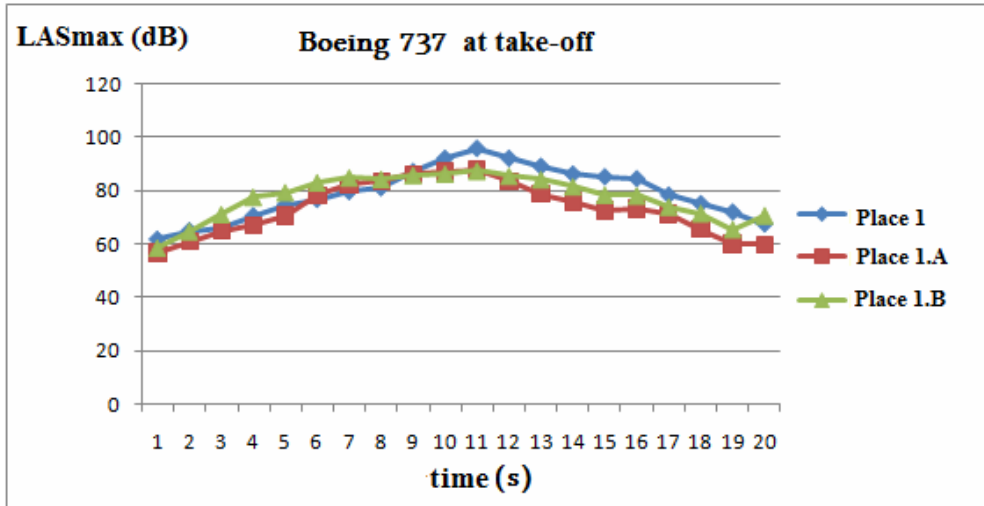
Fig. 5. *The noise variation for Boeing 737 at take-off*

ATR 42 s 500

The ATR 42 s 500 airplane is the smallest studied aircraft with 22,67 meters length and a capacity of 48 passengers.

At landing the level of noise recorded for this airplane was almost at the others aircraft with a big variation under the flight path. In place 1, the maximum recorded was 90,04 dB and 77,53 dB respectively 77,42 dB on the others two.
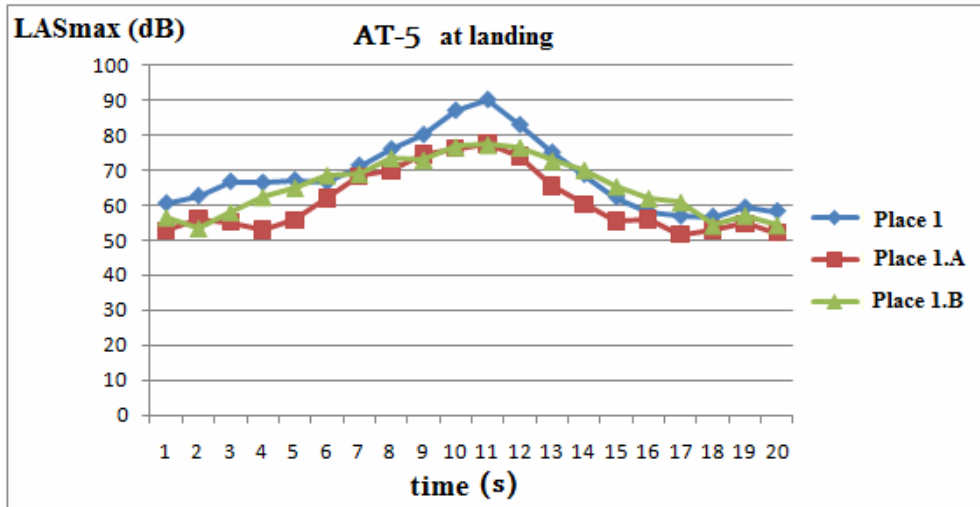
Fig. 6. *The noise variation for ATR 42 s 500 at landing*

During take-off (Fig.7) the AT-5 recorded the lowest level of noise of all the aircrafts. The maximum was under the flight path with just 79,75 dB and 74,97 dB respectively 74,17 dB on the others two. As in other two cases, we have a small difference between the level of noise recorded under the flight path and the others two (5 dB).
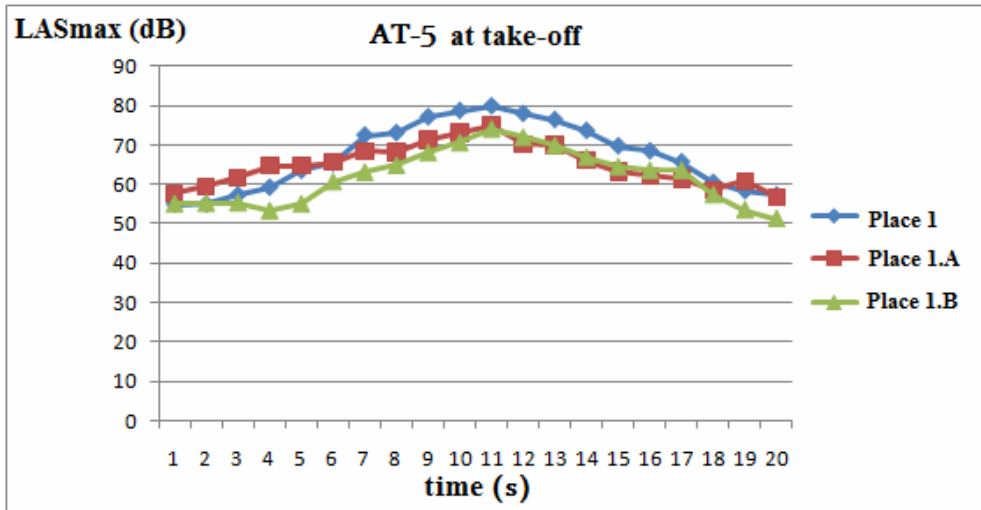
Fig. 7. *The noise variation for ATR 42 s 500 at take-off*

In Fig.8 are presented the maximum levels of noise recorded for every aircraft. As it can be seen the differences at landing are bigger no matter the type of aircraft. At take-off the differences are smaller and drop with a maximum of 5 dB in 170 meters.
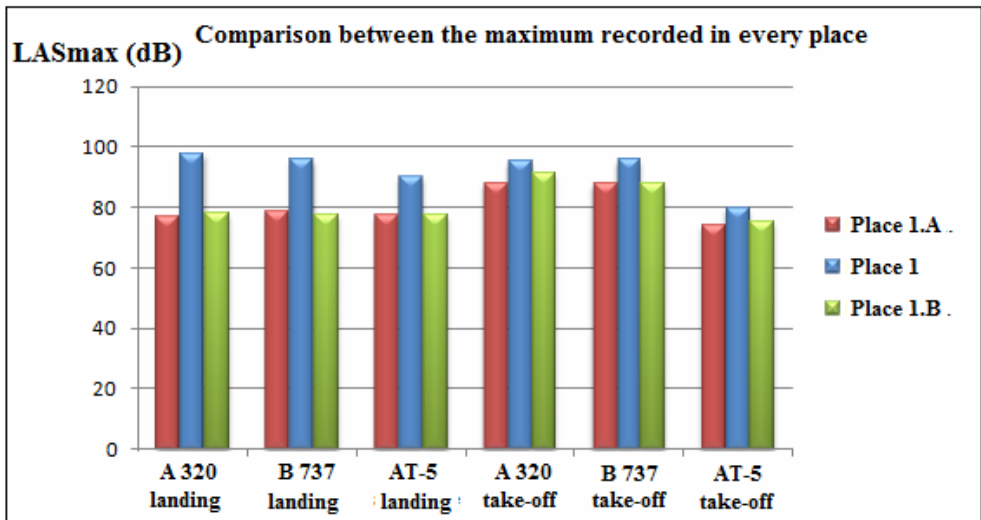
Fig. 8. *Comparison between the maximum recorded in every place*

CONCLUSION

The increase in air traffic impacts urban and housing area with a high level of noise, especially for areas near runways. The results show that people how live near the airport are exposing to a high level of noise.

The problem appears during take-off, when the noise is widely spread and is affecting many households. If noise emission from Airbus A 320 and Boeing 737 are almost the same, with values around 90 dB, the ATR 42 s 500 is less noisy with values around 75 dB.

The noise emission during landing is affecting a fewer households, because the airplane is at a lower altitude and the noise is emitted especial beneath the airplane. There are big differences between the noise level between the place beneath the flight path and the others two: 20 dB for Airbus A 320, 17 dB for Boeing 737 and 13 dB for ATR 42 s 500.

The conclusion is that the take-off is noisier. If we take the place beneath the flight path, there are no differences between landing and take-off. But if we move away from this place we can see that the take-off is noisier than the landing.

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THE PARTICULAR ASPECTS OF INDIVIDUAL DRINKING WATER CONSUMPTION IN HEALTH RISK ASSESSMENT

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ABSTRACT. The volume of cold tap water consumed is an essential element in quantitative toxicological and microbial risk assessment. Drinking water consumption studies have been carried out for several purposes: to determine possible relationships between drinking water quality and human health, to determine the fraction that drinking water comprises of the individual's total liquid consumption or just to calculate the amount of water ingested in relation to other uses of drinking water in households.

The present paper discusses the individual drinking water daily consumption and the main variables involved in the public perception of drinking water quality. Research on this topic suggests that perceptions of water quality result from a complex interaction of diverse factors. In many circumstances, the estimation of water quality is mostly influenced by organoleptic properties, in particular flavor. The area of study is represented by 3 large cities: Cluj-Napoca, Targu Mures and Zalau, each city having a different drinking water supply system. Realistic exposure estimates of contaminants in drinking water require detailed information on amounts and frequency of drinking water consumption during a day. Data on total daily amounts consumed, number of drinking occasions and the average water consumption per day, type of water drunk at home and at work show larger between-subjects variation. Statistically significant associations were also observed between drinking water consumption patterns and participants' ages, sex, education and the locality in which these participants live.

Key words: *drinking water, water source, questionnaire, water consumption, trihalomethanes*.

INTRODUCTION

Why should we be concerned about drinking water consumption?

Water is a fundamental and indispensable constituent of the human body and it can have a major influence on health status. Water plays multiple functions in the human body: first, it has a structural function, being the main component of the organism; it integrates the reaction medium for all metabolic processes necessary for the body to function in normal parameters.

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Despite more stringent regulations concerning drinking water quality, the public is increasingly concerned about the safety of municipal tap water (Proux et al., 2010). Old infrastructure, loss of drinking water from pipes and external contamination affect significantly the drinking water quality. Public health depends largely on the contamination protection and prevention of the drinking water. Since 1974, more than 2,100 drinking water contaminants have been discovered, hence over 190 are suspected to cause adverse health effects.

In Romania, in 2009 there were 1,398 drinking water treatment plants. 25% of the small water treatment plants, and 10% of the large ones supplied improper drinking water in terms of the quality required by legislation. In 21% of urban localities (12.5% of urban population supplied with drinking water), the distributed drinking water was being interrupted more than 8 hours per day. During the same year, the average daily drinking water consumption in urban areas was 123.2 liters/person, less than in 2008 (124.9 liters/person).

The decrease tendency in the drinking water consumption from municipal networks requires to be studied on the use of drinking water in localities connected to the public water system. Through this study it is required to establish the possible connection between drinking water quality and human health, to determine the percentage of drinking water consumed by an individual in relation to the total daily liquids consumed and the amount of water intake in relation to other uses of drinking water in the household.

Realistic exposure estimates for types of contaminants in drinking water require detailed information on amounts and time of consumption for each drinking occasion during a day (Barraj et al., 2009).

The purpose of this paper is to assess the individual daily drinking water consumption and the main variables involved in the public perception upon the drinking water quality.

MATERIAL AND METHODS

The study was developed during 2009. On the basis of a questionnaire 629 subjects were investigated from three cities in the study: Cluj-Napoca (211 subjects), Targu-Mures (209 subjects) and Zalau (209 subjects). Study participants were chosen randomly, the criterion for inclusion being residence in the locality for at least 10 years. The questionnaire included questions about habits of using water for drinking and for other purposes at home and at work. Databases and data processing were performed by using Excel program.

RESULTS AND DISCUSSION

In the present paper we refer only to the drinking water consumption at home, according to the answers in the questionnaire.

Table 1 shows the period of residency for the respondents to the questionnaire, where a rate of approximately 80% has lived in the same town for 20 years. Targu-Mures city has a proportion of the residents of 87.6%, 80.1% for Cluj-Napoca, and for Zalau the percentage increases to 83.7%. Other categories, those under 10 years of residence in the city and those who have lived there for the last 10-15 years are in insignificant proportion.

Fig.1 shows that the average age for the 629 subjects was 42 y.o, with a minimum of 40.6 y.o. in Targu-Mures city and a maximum of 43.4 y.o. in Cluj-Napoca city. The proportion of those younger than 30 years old and older than 59 years old is not significant, being 16.5% and 6.8%, respectively.

Table 1.*General information about residence of subjects in locality.*

Locality	N	Residence in locality					
		<10 yrs.		10-20 yrs.		>20 yrs.	
		n	%	n	%	n	%
CLUJ	211	26	12,3	16	7,6	169	80,1
TG.MURES	209	13	6,2	13	6,2	183	87,56
ZALAU	209	13	6,22	21	10	175	83,73
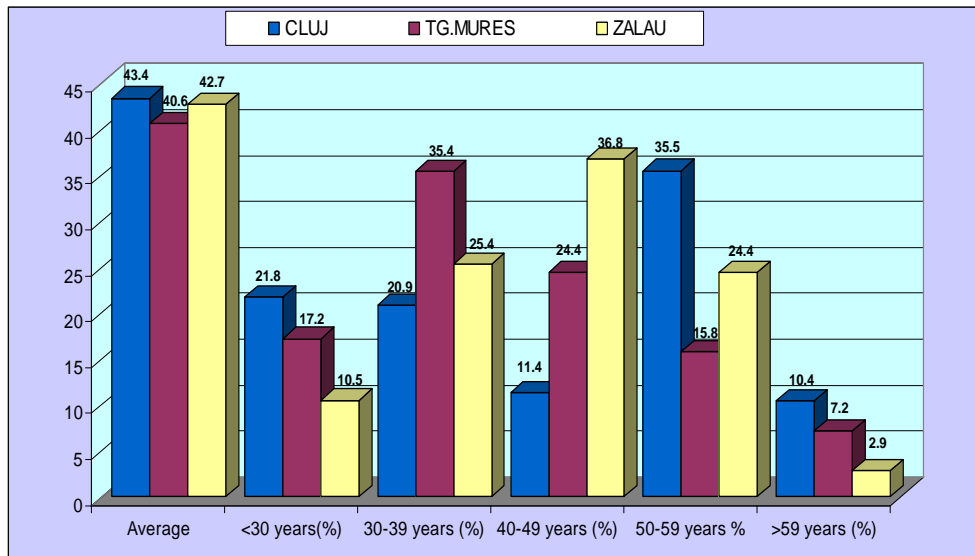
Fig. 1.*General information on the age of subjects.*

Regarding the gender of the subjects questionnaire respondents, females represents a higher percentage of 64% from the 629 total subjects who responded to the questionnaire, while men 36% as an average over the three cities in study. As shown in Table 2, the lowest number of male respondents, 27.8% is from Zalau city, and the highest number of 40.8% is from Cluj-Napoca. In all three cities the majority of people participating in the study has secondary and higher education. Women have shown a greater interest regarding the issues covered by the questionnaire and a greater willingness to participate in the study, consequently most respondents were women with secondary and higher education.

People use tap water mainly to prepare food and certain drinks (tea, coffee, homemade fruit syrup), but bottled water is used for individual consumption, less than tap water (Fig. 2).

Table 2. *General information on gender and education of subjects.*

Locality	N	GENDER				EDUCATION					
		male		female		General		Second ary		Superior	
		n	%	n	%	n	%	n	%	n	%
CLUJ	211	86	**40,8**	125	**59,2**	35	**16,6**	48	**22,7**	128	**60,7**
TG.MURES	209	81	**38,8**	128	**61,2**	13	**6,2**	75	**35,9**	99	**47,4**
ZALAU	209	58	**27,8**	151	**72,2**	38	**18,2**	79	**37,8**	95	**45,5**
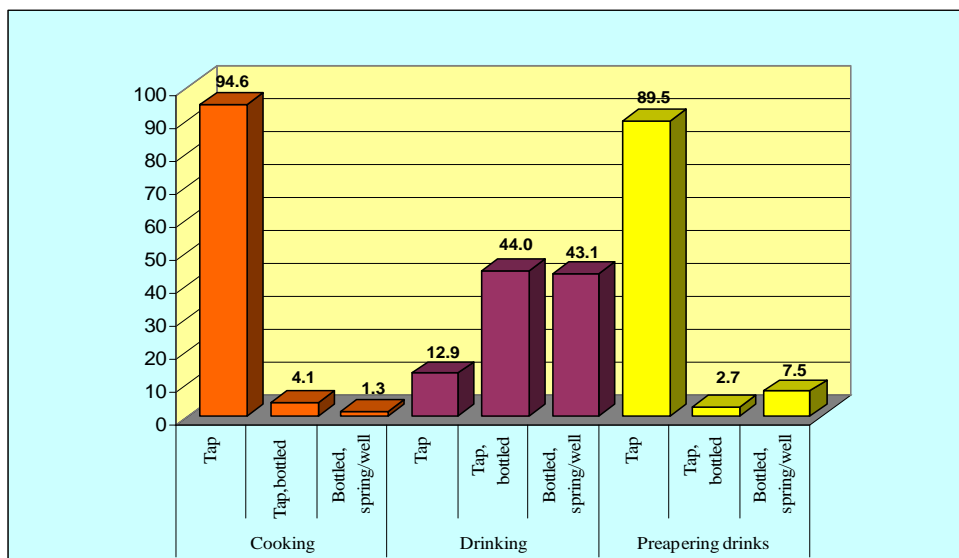
Fig. 2. *General information on use of water in households.*

The average water consumption is 1-1.9 liters/person/day (58%) and 34% of the population has a drinking habit of more than 2 liters/person/day.

In terms of gender differentiation of subjects, it is observed that for men the daily water consumption is higher in comparison to women in all three cities in study.

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No significant differences are observed in terms of total water consumption according to age, although a larger quantity is consumed around 30-50 years old, decreasing slightly in average towards 60-70 years old (Table 3) .

Regarding the organoleptic properties of drinking water (taste, smell) in Cluj-Napoca over 80% of respondents declare that water has no taste and no specific odor of chlorine, while in the other two cities, Targu-Mures and Zalau the proportion decreases, over 30% of the population decline the water consumption because of the smell or taste of chlorine (Fig. 3).

Table 3. *Total water consumption person/day – differentiation on age.*

Locality	N	min	max	AGE											
				average		<30 yrs		30-39 yrs		40-49 yrs		50-59 yrs		>59 yrs	
				X	D.S	n	%	n	%	n	%	n	%	n	%
CLUJ	211	21	70	**43,4**	**13,5**	46	**21,8**	44	**20,9**	24	**11,4**	75	**35,5**	22	**10,4**
TG. MURES	209	21	69	**40,6**	**11,4**	36	**17,2**	74	**35,4**	51	**24,4**	33	**15,8**	15	**7,2**
ZALAU	209	20	62	**42,7**	**10,2**	22	**10,5**	53	**25,4**	77	**36,8**	51	**24,4**	6	**2,9**
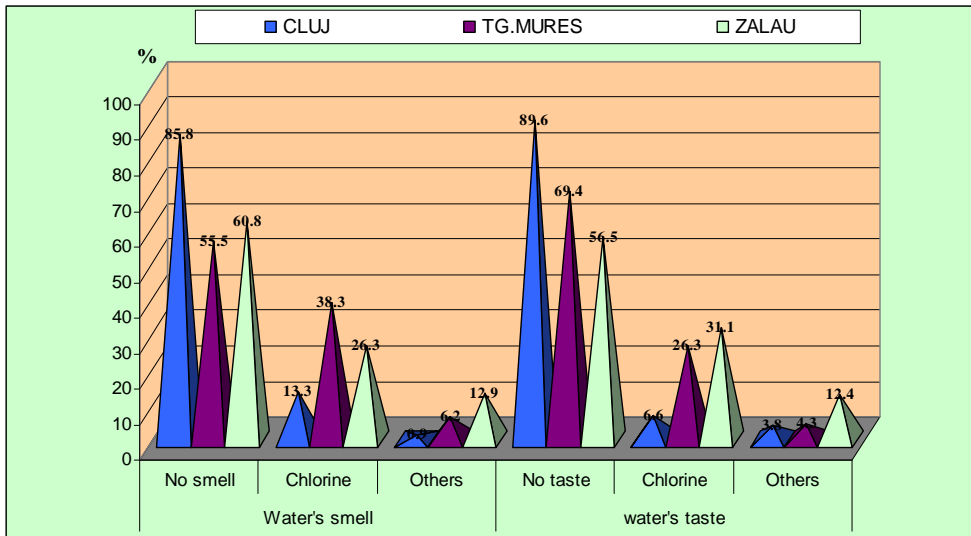
Fig. 3. *Information on the smell and taste of tap water.*

Water disinfection by chlorination is the final step in the drinking water treatment process for public health protection. The necessity of using chlorination for drinking water treatment depends largely on the quality of the raw water source. In the case of a groundwater source, the necessary amount of chlorine reduces significantly in comparison with the chlorination of water from a surface source. Chlorine is used as an initial disinfectant, due to reduced costs involving water purification. But after chlorination, disinfection byproducts (DBP) result, mainly due to the existence of precursors in water, necessary for the formation of these byproducts: organic natural substances (NOM) and chlorine. These byproducts are halogenated-compounds-type (TOX), with different degrees of volatility. Of the total halogenated compounds generated by chlorination, a proportion of about 30% is represented by trihalomethanes (THMs).

Trihalomethanes are organic compounds derived from methane by replacing three atoms of hydrogen with halogens. THMs are on the list of priority dangerous substances in water with serious effects on health, cancer (liver, bladder, intestine) and reproductive effects (premature births, miscarriages, congenital malformations). Usually, there are four types of trihalomethanes in water: chloroform, bromodichloromethane, dibromochloromethane and bromoform. The level of maximum accepted concentration in drinking water (Directive 98/83/EC transposed in Law 458/2002 and Law 311/2004) - 100 µg/l (sum of the concentrations of the four individual compounds).

Organoleptic characteristics (taste and odor) were directly correlated with increasing concentration of trihalomethanes (Table 4). Relative risk (RR) of smell or taste occurrence increases along with increasing the concentration of THMs (Table 5, 6). Probability (OR) of unpleasant smell or taste occurrence is noted at concentrations of THMs higher than 70 µg/L (risk of smell occurrence is 4.40 times higher when the concentration of THMs is higher than 70 µg/L and 5.62 times higher in event of unpleasant taste occurrence).

Table 4. *Concentrations of THMs depending on unpleasant odor and taste of water.*

Trihalomethanes	N	Unpleasant odor(%)	Unpleasant taste(%)
<70µg/L	209	13.88	10.05
>70µg/L	418	41.87	40.19

Table 5. *Relationship between unpleasant odor of water and concentration of THMs.*

Risk of unpleasant odor of the water network in relation to concentrations of THMs			
	RR	OR	RA %
(<50) – (50-70) µg/L	1.07	1.08	6.36
(<70) – (70-100) µg/L	**2.99**	**4.40**	**66.57**
(<70) - (>70) µg/L	3.02	4.47	66.86

Table 6. *Relationship between unpleasant taste of water and concentration of THMs.*

Risk of unpleasant taste of the water network in relation to concentrations of THMs			
	RR	OR	RA%
(<50) – (50-70) µg/L	1.01	1.02	1.43
(<70) – (70-100) µg/L	**3.84**	**5.62**	**73.94**
(<70) - (>70) µg/L	4.00	6.02	75.00

Tables 4, 5 and 6 show a positive significant correlation between the presence of trihalomethanes in water and its unpleasant taste or smell.

An important finding is that two key variables (taste and smell) linking a person's health perceptions regarding tap water quality are significant factors leading to the choice of bottled water over tap water (Dupont et al., 2010).
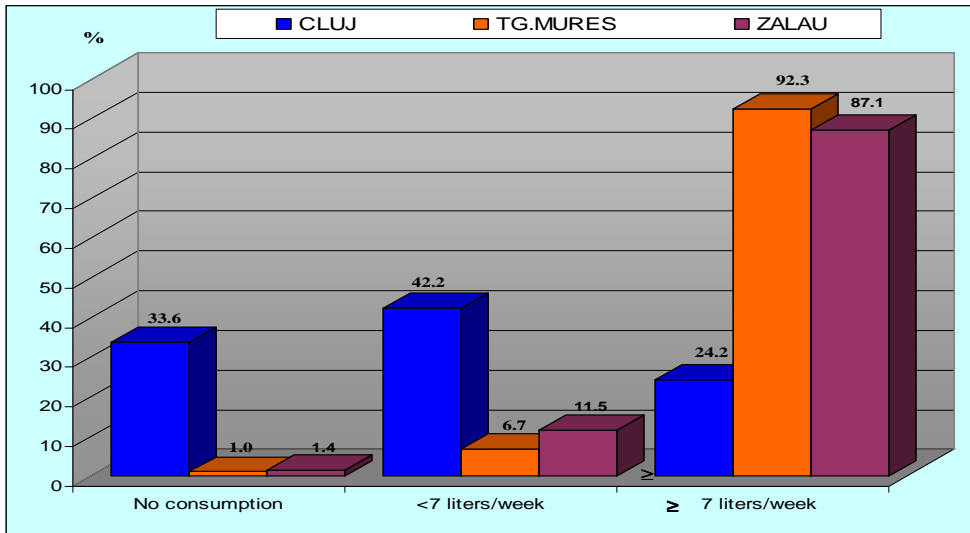

Fig. 4. *Bottled water consumption.*

As a result of the drinking water organoleptic properties altered after chlorination, consumption of bottled water is increasing over 7L/week - 92.3% in Targu Mures and 87.1% in Zalau (fig.4).

Table 7. *Water consumption depending on population education.*

		N	average	st.dev.
	Primary ed.	35	**2.66**	**3.37**
	Secondary ed.	48	**3.35**	**3.50**
CLUJ	Higher ed.	128	**4.88**	**5.22**
	Primary ed.	13	**7.62**	**3.73**
	Secondary ed.	97	**8.89**	**3.97**
TG.MURES	Higher ed.	99	**7.02**	**3.73**
	Primary ed.	38	**5.18**	**1.92**
	Secondary ed.	76	**5.70**	**2.75**
ZALAU	Higher ed.	95	**7.34**	**3.94**
	Primary ed.	86	**4.52**	**3.35**
	Secondary ed.	221	**6.59**	**4.12**
TOTAL	Higher ed.	322	**6.26**	**4.57**

The consumers' education level was not correlated with the bottled water consumption, example being Targu Mures city, where the highest consumption of bottled water is observed without significant differences related to the subjects' education level. In the case of Zalau city, bottled water consumption was significantly higher in people with higher education.

Based on the trend of decreasing the water consumption at home, studies in literature have focused on determining the causes of not using network water for the daily consumption and population preference for bottled water. We investigate the factors that influence these choices and whether choosing drinking water is linked to perceptions of health concerns with respect to tap water (Dupont et al., 2010). In order to explain the choice of the drinking water type for consumption, the differentiation of subjects by gender, age, education and the purpose of water use was applied in the questionnaire analysis. Consumption of drinking water via liquid and food was assessed as well as the type of water consumed (tap, bottle or filtered water) and place of consumption (home or away from home) (Levallois et al., 2010).

Perceptions of water quality result from a complex interaction of diverse factors. Trichloramine (NCl_3) is one of the major causes of the chlorine odor in drinking water (Kosaka et al., 2010). The smell and the taste are the factors yielding higher probabilities of a respondent being primarily a bottled water drinker (relative to the choice of tap water) include: higher income, unpleasant taste experiences with tap water (Dupont et al., 2010).

CONCLUSIONS

Realistic exposure estimates of contaminants in drinking water require detailed information on amounts and frequency of drinking water consumption during a day. Data on total daily amounts consumed, the average water consumption per day, type of water drunk at home show larger between-subjects variation. Statistically

significant associations were observed between drinking water consumption patterns and participants' ages, sex, education and the locality in which these participants live. In many circumstances, the estimation of water quality is mostly influenced by organoleptic properties, in particular flavor.

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PARTICULATE MATTER, HEAVY METALS AIR POLLUTION AND INTENSITY OF THE URBAN TRAFFIC. STUDY CASE - CLUJ-NAPOCA CITY

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ABSTRACT. An ambient air quality study was undertaken in Cluj-Napoca city from October 2004 to September 2005. The data were obtained from three urban monitoring sites, with different traffic volume. The purpose of the study was the monitoring of some air pollutants emissions caused by car traffic, especially the particulate matter and heavy metals.

The results showed that the highest PM 2.5 and heavy metals concentrations occurred in the area with the largest traffic volume in cold season for PM 2.5, respectively in summer for heavy metals.

Key words: *air, heavy metals, air pollution, urban atmosphere, particulate matter, PM2.5*

INTRODUCTION

Urbanization is a process of relative growth in a country's urban population accompanied by an even faster increase in the economic, political, and cultural importance of cities relative to rural areas. There is a worldwide trend toward urbanization.

Environmental pollution, especially air pollution is one of the consequences of the urbanization increase. The potential for serious consequences of exposure to high levels of ambient air pollution was made clear in the mid-20th century, when cities in Europe and the United States experienced episodes of air pollution, such as the infamous London Fog of 1952 and Donora Smog of 1948, which resulted in large numbers of excess deaths and hospital admissions [Cohen et al. 2004]. Subsequent clean air legislation and other regulatory actions led to the reduction of ambient air pollution in many regions of the world, and particularly in the wealthy developed countries of North America and Europe.

EXPOSURE TO URBAN AIR POLLUTION FROM COMBUSTION SOURCES

Combustion of fossil fuels for transportation, power generation, and other human activities produces a complex mixture of pollutants comprising literally thousands of chemical constituents. The precise characteristics of the mixture in a given locale depend on the relative contributions of the different sources of pollution, such as vehicle traffic and power generation, and on the effects of the local geo-climatic factors.

Motor vehicle traffic is a major source of air pollution in the big cities. In half of them it is the single most important source. It is a major source of four of the six major air pollutants: carbon monoxide, nitrogen oxides, hydrocarbons and lead - and contributes to the SPM (Suspended Particulate Matter) concentration as well. The pollutant mixture also contains carcinogens such as benzo(a)pyrene, benzene and 1,3-butadiene. When petrol contains lead (Pb), as is still the case in many developing countries, this element is a common constituent of the pollution mix [Cohen et al. 2004, Duruibe et al. 2007].

A. Particulate Matter (PM) air pollution

Particulate matter consists of tiny particles in the atmosphere that can be solid or liquid (except for water or ice) and is produced by a variety of natural and manmade sources. These particles vary greatly in size, composition, and origin.

The amount of suspended particulate matter, usually measured in micrograms per cubic meter of air, is one of the most important indicators of the quality of the air that people breathe. According to the World Health Organization's air quality standards, the concentration of suspended particulates should be less than 90 µg/m^3. In many cities, however, this number is several times higher.

High concentrations of suspended particulates adversely affect human health, causing a wide range of respiratory diseases and exacerbating heart disease and other conditions.

These solid and liquid particles come in a wide range of size. Total Particulate Matter (TPM) are considered to be airborne particulate matter with an upper size limit of approximately 100 micrometers (µm) in aerodynamic equivalent diameter. Total Particulate Matter present in air are divided in two categories depending on the size of the particles:[Ghose et al. 2005, Haiduc et al. 2005]

- *Settle Particulates*: have more than 50 microns in diameter, this particulates tend to out of the air.
- *Suspended Particulates* : particulate diameter range from 0 – 50 microns:
  - *PM 0.1* (ultra fine particles): particles up to 0.1 microns in diameter
  - *PM 2.5* (fine particles): are particles up to 2.5 microns in diameter can enter lungs through nose. PM 2.5 contain many toxic organic compounds and heavy metals. Fine particles are mainly coming from activities like driving automobiles, burning plants (brush fires and forest fires or yard waste)
  - *PM 10* (coarse particles): particles up to 10 microns in diameter, can enter lungs through mouth. Coarse particles are mainly produced by the mechanical break-up of even larger solid particles. Examples of coarse particles include dust, pollen, spores, fly ash, and plant and insect parts.
  - *PM 10 – PM 50* – too large for respiratory system

The smaller particles are lighter and they stay in the air longer and travel farther. PM10 particles can stay in the air for minutes or hours while PM2.5 particles can stay in the air for days or weeks. PM10 particles can travel as little as a hundred yards or as much as 30 miles. PM2.5 particles go even farther; many hundreds of miles [Jones and Harrison 2006].

A.1. Sources of Particulate Matter

Particulate matter can come from many sources. Generally, any activity which involves burning of materials or any dust generating activities are sources of PM.

Some sources are natural, such as volcanoes and water mist. Humans create huge quantities of particulate and many of these are regulated, such as smoke stacks at factories, power plants, and auto paint shops. However, there are many sources that are not regulated and our home is one of them.

PM may be classified as primary or secondary, depending on the compounds and processes involved during its formation. Some particles are directly emitted into the air from a variety of sources, such as vehicles, factories, construction sites, farming, unpaved roads, burning wood, and blowing sand and dust in desert environments. These particles are called "Primary" particles. Other particles may be formed in the air when gases from burning fuels chemically react with sunlight and water vapor. These are the "Secondary" particles, and they can result from fuel combustion in motor vehicles, at oil fields and refineries.

Combustion of fossil fuels for transportation, power generation, and other human activities produces a complex mixture of pollutants comprising literally thousands of chemical constituents. Exposure to such mixtures is a ubiquitous feature of urban life.

All combustion processes produce particles, most of which are small enough to be inhaled into the lung either as primary emissions (such as diesel soot), or as secondary particles via atmospheric transformation (such as sulfate particles formed from the burning of fuel containing sulfur) [Lonati and Giugliano, 2006].

A.2. Chemical composition

The chemical composition of particulate matter may vary within a broad range according to the sources of the particles, the conditions of their dispersion, location, time of year, and weather.

This complex mixture includes both organic and inorganic particles, such as dust, pollen, soot, smoke, and liquid droplets.

Urban PM10 contains at least seven broad classes of chemicals: sulphates, nitrates, ammonia, elemental carbon, organic carbon, minerals and salts. Emissions from traffic typically result in particles composed of organic matter and nitrates, domestic heating and industrial activities in sulphates, building work results in mineral dust and agriculture in ammonium [Cohen 2t al. 2004].

B. Heavy metals air pollution

Heavy metals are natural components of the Earth's crust. They cannot be degraded or destroyed. To a small extent they enter our bodies via food, drinking water and air. As trace elements, some heavy metals (e.g. copper, selenium, zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metal poisoning could result, for instance, from drinking-water contamination (e.g. lead pipes), high ambient air concentrations near emission sources, or intake via the food chain [Ghose et al 2005].

Heavy metals are dangerous because they tend to bioaccumulate.

EXPERIMENTAL DATA

In 2004 – 2005 in Cluj-Napoca was made a study, the purpose was the monitoring of the urban air pollution from Cluj-Napoca, caused by fine particulate matter (PM2.5) and heavy metals from airborne dust. The town is situated in a depression area, his microclimate disfavoring the particulate matter dispersion.

The monitoring network used for particulate matter and heavy metals determination was made from 3 areas from Cluj-Napoca with different traffic volume:

1_ P-ta Unirii – very intense traffic
2_Pavlov -V.Alecsandri crossing – intense traffic
3_1Decembrie1918-Petuniei crossing – medium traffic

Monitoring daily programming time was between the:
- 06.00-09.00 AM
- 02.00-05.00 PM
- 09.00 -00.00 PM
- 02.00-04.00 AM

For PM2.5 determination was used a MIE detector, witch allow the sample collecting by drawing tide variation. The particulate matter separation is made by specific sensors, and than the particulate matte rare x-ray sub sequential gravimetrical analyzed. MIE detector is made by a storage battery, a pDR-PU pump (for PM2.5 the pump debit was 4 L/min.) and a personalDataRam-1200 reading unit.

The results show that the highest fine particulate matter concentrations occurred at the main street with a large volume of traffic (1_P-ta Unirii and 2_Pavlov) (see figure 1).
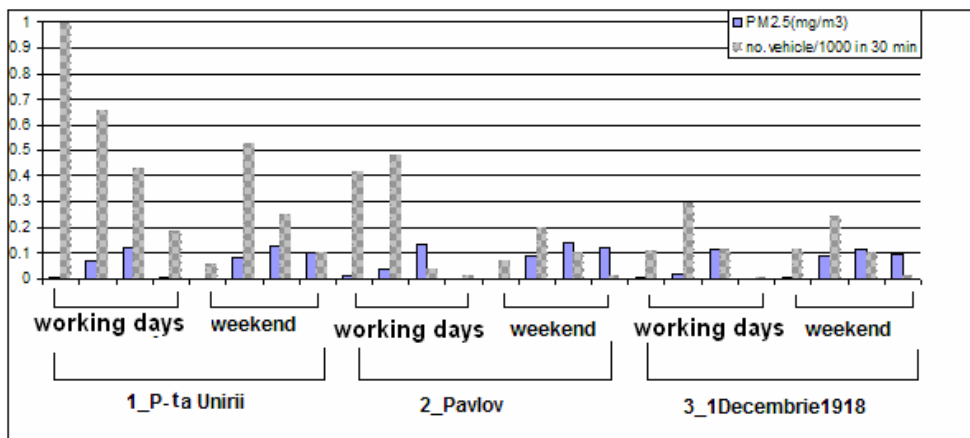

Fig.1. *Correlation between the traffic volume and the PM2.5 concentration (autumn 2004)*

Figure 2 summarizes the seasonal and daily average concentration of PM2.5 in tree areas from Cluj-Napoca, during October 2004 and September 2005:
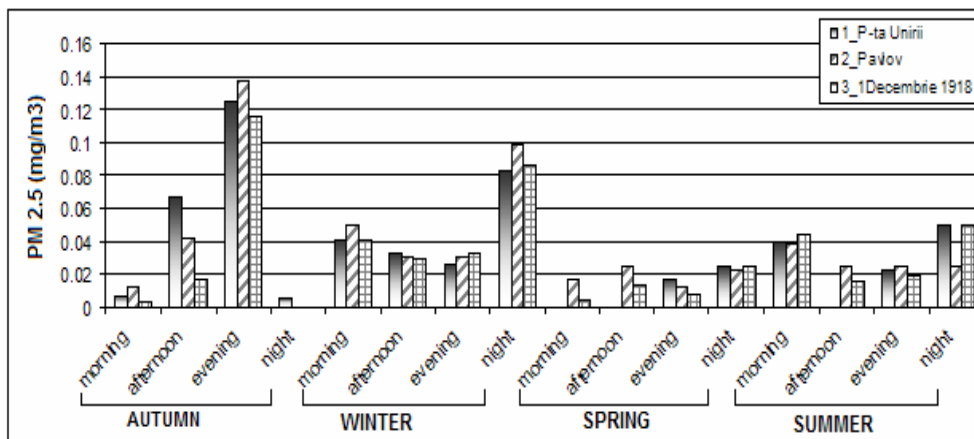
Fig. 2. *Seasonal and daily average concentration of PM2.5 in tree areas from Cluj-Napoca, during* October 2004 and September 2005

PM2.5 concentration was clearly higher during the cold season (autumn, winter) than during the warm months (spring, summer). Monthly averages PM2.5 concentrations are related to temperature, wind speed and relative humidity. In general there is a higher concentration of PM2.5 along with lower temperature and wind speed, and increasing relative humidity was noted. The particulate matter concentrations registered in spring and summer were lower, most probably because of the important quantity of precipitations from this period. Temperatures were lower during autumn and wintertime, so probably most of the particles become condensed instead of volatilizing.

The comparison of seasonal data points out that in the cold season the total number of particles is about two times greater than in the warm season, both on weekdays and on Sundays

Daily average PM2.5 concentration show that generally there is a higher concentration of PM2.5 in evening and night time.

The data evaluation shown that in each month the particulate matter concentrations were under the limit value for suspended particle (0.15 mg/m^3/month-STAS 12574/87).

In our study we determined the composition of dust from buildings and from outdoor in Cluj-Napoca too. It was determined 23 heavy metals; some of these metals have a small concentration below of detectable limit (Sr, Ru, Pb, Se, Ni, Ba, Tl, Sb, Cd). The metals which can be detected are: Mo, Zr, As, Hg, Zn, Cu, Co, Fe, Mn, Cr, Sn.

The method used was fluorescence with X ray, for this it was used a Niton XL700 [Varga et al. 2006].

The determination of these heavy metals it was made in al four seasons of the year, in all places.

The most polluted intersection with heavy metals it was P-ta Unirii, the area with the most intense traffic, figures 3 and 4.

Fig. 3. *Heavy metals concentration in P-ţa Unirii (outdoor)*
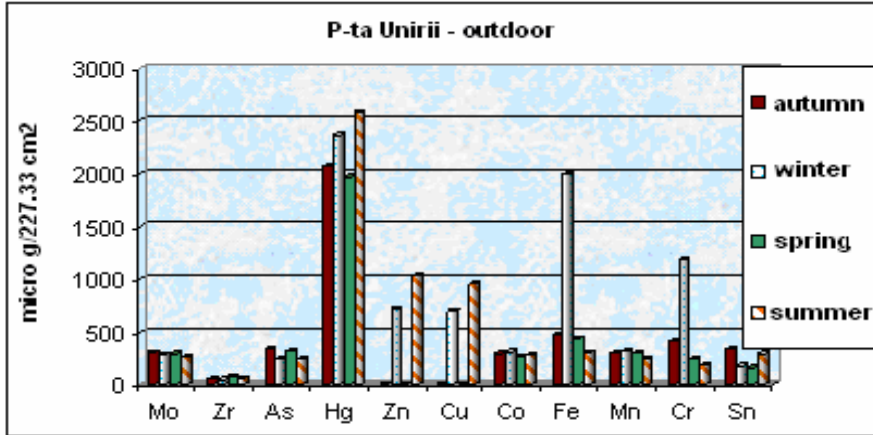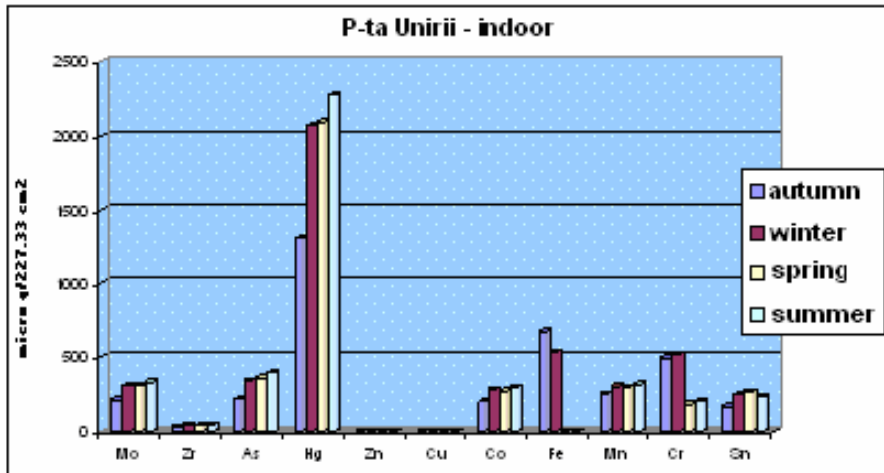

Fig. 4. *Heavy metals concentration in P-ţa Unirii (indoor)*

The heavy metal with the biggest concentration in the studied areas is mercury, in all tree intersections. This have a big concentration in interior dust and also in exterior dust and the negative impact of this metal is determined by the chemical form of this.

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The concentration of heavy metals is influenced by season. We observe that the concentration of heavy metals is bigger in summer, and this increase of concentration is influenced by the small number of precipitations.

The reality from our day is, that is impossible to not be expose to heavy metals daily, but the essential problem is, how much, in what concentration and the source of pollution.

The biotoxic effects of heavy metals refer to the harmful effect of heavy metal to the body when consumed above the bio-recommended limits.

Mercury is toxic and has no known functions in human biochemistry and physiology. Inorganic forms of mercury cause spontaneous abortion, congenital malformation. Poisoning by its organic forms, which include monomethyl and dimethylmercur presents gingivitis, stomatitis, neurological disorders, total damage to the brain and congenital malformations [Frankel et al. 2004].

CONCLUSIONS

The results of this study showed that the highest fine particulate matter concentrations occurred at the main street with a large volume of traffic (1_P-ta Unirii and 2_Pavlov). The comparison of seasonal data points out that in the cold season the total number of particles is about two times greater than in the warm season, both on working days and on Sundays. Daily average $PM_{2.5}$ concentration show that generally there is a higher concentration of $PM_{2.5}$ in evening and night time. The data evaluation shown that in each month the particulate matter concentrations were under the limit value for suspended particle (0.15 mg/m^3/month- STAS 12574/87).

The most polluted intersection with heavy metals it was P-ta Unirii. The heavy metal with the biggest concentration in the studied areas is mercury, in all tree intersections. This have a big concentration in interior dust and also in exterior dust and the negative impact of this metal is determined by the chemical form of this.

The concentration of heavy metals is influenced by season. We observe that the concentration of heavy metals is bigger in summer, and this increase of concentration is influenced by the small number of precipitations.

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LEGISLATIVE IMPLICATIONS OF MINE CLOSURE IN ROMANIA

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ABSTRACT. Environmental protection legislative regulations issued at European Union level for the mining sector, are trying to get some answers to problems caused by mining activities that generate negatively impact on environmental factors. Because of this, the legislation is very broad, and transposing European Directives into the Romanian legislation arises slowly. The most important national laws governing mining activities with the aim of sustainable development and environmental protection are the Environmental Protection Act, Mine Act and Water Act. Laws in force require the achievement of mine water treatment, but this process is not possible in municipal water treatment stations existing in our country.

After closing the mines, the Romanian Government has emitted the GD 1403/2007 legislative statement regarding the necessities of remedial and/or ecological reconstruction of geological environment and terrestrial ecosystems affected by the mining activities.

In this paper are presented several aspects of legislative implementation measures concerning the green mines closing, a case study of mine Larga de Sus (Zlatna) from Alba County.

Key words: *mining industry, mine closure, Zlatna*

INTRODUCTION

In 1987 Brundtland Commission (World Commission on Environment and Development – WCED) issued Brundtland Report called „*Our Common Future*" in which was defined the synthetic term „sustainable development" as „*development that meets the needs of present generations, without compromising the ability of future generations to meet their own needs*" (Bejan and Rusu, 2007b). From that moment, the prosperity of future generations by maintaining reserves of minerals as large quantities as possible, has become a priority concern of mankind. Within the meetings that are taking place globally are always discussed topics about the optimal development of human society while damages of natural environment are minimal. The effort to protect the renewable resources is lower than the necessary endeavour to create the proper protection of non-renewable resource.

Mining is seen as a set of businesses which use non-renewable natural resources as raw materials, and this is why it must be conducted in an organized framework governed by policies that reflect the rational use of these resources. The science evolution enables the development of techniques and technologies able to

solve many problems encountered in increasingly complex mines. Economical exploitation of reserves can be achieved by higher quality processing of minerals and the recovery of secondary products, including wastes resulted in the mining technology. Minimizing the negative impact caused by exploration, exploitation and processing of minerals is reflected by the protection of natural support systems of life – water, air, soil, flora and fauna.

Mining industry in Romania has experienced a flourishing period before the current downturn. The assiduous exploitation of natural resources in the communist period led to achieve the maximal pollution of environmental factors. The natural ecosystems prejudices caused by mining and quarry workings, building of settling ponds (such as the V. Seşei – Arieş River Basin, built on the site of the village Geamăna), breaking the dams of ponds (Lake Novăţ - March 10, 2000), storing of gangue material in dumps, can be classified as environmental disasters. The judicious exploitation of natural resources induces internationally negative impact. It is therefore imperative necessarily, the remediation of disused mining sites and revamping the mining objectives in working order.

MINES CLOSURE – LEGISLATIVE IMPLICATIONS

In the early '90s it was aware for the first time the internationally negative environmental impact produced of mining industry, being issued a series of legislative measures to regulate the situation. In 1991 in Berlin took place a meeting as an *„International Round Table on Mining and Environment*" in which were established the *„The Principles from Berlin*", to implement environmental protection measures.

The EU legislative regulations for the mining sector regarding the protection of environmental factors relate to solving problems of negative impact caused by the exploration, exploitation and minerals processing. For this reason this legislation is very broad, and transposition of European directives into the Romanian legislation arises slowly.

In the Directive 2006/21/EC on waste management in the mining industry, were established major objectives to be met by Member States of the European Union to minimize, treatment, recycling and disposal of all waste associated with mining operations. In this directive are presented guidance on waste management plan creation and its application methods. Article 3 (14) of Directive 2006/21/EC, mine water are considered hazardous waste due to the high loading of dangerous substances for natural ecosystems and human health. Competent authority together with the operator must take necessary measures to meet environmental standards set out in Directive 2000/60/EC on the retention of the status „good" or „very good" bodies of water and remediation of those waters that do not meet the quality.

The main national laws governing the mining activity in relationship with sustainable development and environmental protection are Mining Act (amended by Law 237/2004), Environmental Protection Act (amended by Ordinance 91/2002) and Water Act (Act 107 / 1996).

In Chapter I of GD 1403/2007 is discussed the reclamation of geological environment and terrestrial ecosystems polluted by bringing as close to natural state by cleaning measures, remediation and / or ecological restoration. The remediation consists

of removing contamination sources from polluted site, isolation and decontamination of polluted areas, limiting and eliminating opportunities for the spread of pollutants in the geological environment and achieving the permissible limit for concentrations of pollutants. Government allocate public assistance in order to achieve those objectives.

Under the Mining Act 85/2003, the owners of mines or quarries are obliged to execute and complete the works of mines conservation and closure. Within this law, the environmental cleanup in the affected area is a priority. In post-closure monitoring phase are given two types of activities needed to be done for environmental protection:

- Purification of mine water collected from the closed mines, in accordance with the provisions in force, in wastewater treatment plants built from funds provided for mine closure and cleaning;
- Stability monitoring and time reaction of materials from the dumps and tailings ponds and areas of land rehabilitated and intervene with remedial works where due to natural disasters, deterioration of performed works occurs.

Environmental Act provides that natural or legal persons who explore or exploit underground resources must rehabilitate the affected lands. The reconstruction of the geological environment and terrestrial ecosystems affected, by bringing as close to natural state, are achieved by cleaning measures, remediation and / or ecological restoration. After completion of the works through which the environment is brought in parameters that create productive conditions to support a new ecosystem, it must ensure the monitoring area. These actions are done with their financial support.

The negative effects on the environment produced by mining and quarrying can be observed without the need for sound knowledge in engineering. Local residents in the mining area, regardless of their nature, observe the natural environment changes produced by:

- Destruction of land by stockpiling the heaps of debris and by storing of equipment needed in the exploration / exploitation, development of access roads through farmland and forest destruction, etc.;
- Contamination of water sources with dust particles emitted from the cutting and grading operations of rocks, heavy metal pollution of percolation water by washing the tailing dumps or when water comes into contact with mine works;
- Air contamination with pollutants from facilities and equipment in operation, dust resulted from the operations of cutting, crushing and grading of the rock, etc.;
- Degradation of flora and fauna in the area of mine works due to contamination of environmental factors.

The most acute effects on environmental factors are imprinted by quarrying. By exploitation of natural resources in open casts, environmental factors are continuously exposed to contamination, even during the post-closure and / or rehabilitation period due to the impossibility of sealing the quarries.

Romania's integration into EU structures requires alignment of Romanian legislation with those established for the Member States. Therefore the legislative system suffers continuous changes needed to achieve the objectives laid down in European directives and standards.

CASE STUDY: MINE LARGA DE SUS (ALBA COUNTY)

Zlatna Depression – geographical and geological characterization

Exploitation of underground mining reserves has represented many centuries in a row a main sub-branch of Romanian mining industry. The complex geological structure of the Romanian territory favoured the accumulation of minerals, which allowed the continuous development of Romanian mining. Before 1990, the companies that were operating in mining industry had received state financial aid. When the financial aid was stopped, a number of operators have accumulated debts to suppliers and the state budget. This initiated a process of restructuring and closure of economically unprofitable mining works. Thus, between the 1997 and 2008 were transferred to the final closing 550 mines and quarries. According to published data in Mining strategy for the period 2008 – 2020, extraction and processing of mineral resources in 2007 has been unfolded in 25 mines, 37 quarries, 7 salt mines and 9 processing plants.

The Zlatna mining perimeter is located in the depression with the same name, a morphological unit bounded by Trascău Mountains at north and Auriferi Mountains at south. During the Miocene the Depression was a bay basin and was separated from the Ampoi – Ampoiţa Depression through a gorge carved in ophiolite. The Zlatna Depression is drained on a length of about 15 km from the Ampoi River which has imprinted the area a structure of terraces and hills. The location analyzed in this paper belongs geographically to Roatei Hill. Access is made by DN 74 road, Alba Iulia – Zlatna, then DC 113 – Roatei Hill.

From a geological point of view, the studied territory is part of the South Apuseni Mountains and it begun to operate as geosyncline area in the Alpine cycle (Mureş Geosyncline) having the substratum formed of crystalline schists. Since Cretaceous the Mureş Geosyncline has been affected by intense movements with the result of synorogene deposit formation.

Over the crystalline schists occurred the sedimentary formations on which the Hercynic and Prebaikalian magmatic products are added (represented by mica-schist, sericite and chlorite slate, crystalline limestone and dolomites).

The sedimentary cover is represented by deposits of Jurassic age belonging to the Mesozoic age (calcareous nodules that vertically pass in calcareous slabs, massive limestone, coral limestone) and to the Cretaceous (sandy silt shales and argillaceous silts weakly metamorphosed, micro conglomerates, sandstones, mudstones belonging to the lower Cretaceous age, and conglomerate and sandstone deposits – upper Cretaceous age). The terrigenous sedimentary suite consists of Faţa Băii conglomerates and Almaşu Mare gravels covered up by the globigerina tufaceous marls.

On the direction of the NW – SE system faults metalliferous genetic processes of volcanic type have developed. In Neocene magmatic eruptions have generated and driven to the surface lava giving birth to Barza quartz andesine type deposits. Mineralizations are of hydrothermal origin and are present as veins, stocks, breccia bodies and lenses. Mineralized columns have heights exceeding 300 – 400 m, sometimes reaching 700 – 800 m in case of Haneş ore (Duma, 1998). Mineralogical paragenesis consists of pyrite, chalcopyrite, blende, galena, covellite, chalcocite, tetrahedrit, antimonite, sulphonic-acid halides (petzite, calaverite, other), native gold, gangue (quartz, rhodochrosite, calcite, baryte).

a)   b)   c)
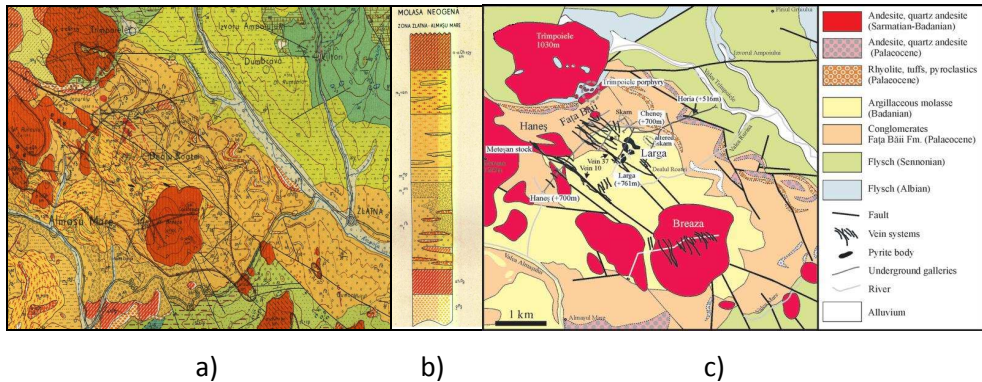
Fig. 1. *a) Zlatna Depression geology (1:10000); b) Stratigraphic column of Zlatna Depression (1:5000); c) Geological-metallogenetic map of part of the Zlatna – Stănija volcanic zone (Cook and Ciobanu, 2004).*

The gangue deposits from the area are related to igneous rocks from the second cycle of eruptions, such as the Barza quartz andesine, which outcrop over a large surface as rooted bodies and lava flows.

In Quaternary the emergent areas have been subject to intense erosion, while accumulations were reduced to formation of underwater deposits (alluviums, colluviums, adobes, etc.). The hydrographical network was completed during this period.

The history of mining activities

The Larga de Sus exploitation is the researched subject in this paper; it falls within the so-called „The Transylvanian Gold Quadrangular" that includes the perimeters of the mining areas Deva, Zlatna, Brad and Caraciu. The extraction activities of gold-silver nonferrous ores date from the Dacian-Roman period. In the XVIth century complex ores of Cu, Zn and Pb were discovered. Mining activities were concentrated mainly on Gura Barza, Baia de Arieş, Roşia Poieni, Haneş, Larga, Valea Babei and Almaş deposits.

In 1746 the first metallurgic factory of ore copper processing was built in Zlatna and in 1970 a new plant was put into operation, respectively SC Ampellum SA.

In the Zlatna perimeter the extraction of polymetallic ores enriched in gold and silver were made from Haneş and Larga mines, from their processing complex concentrates were obtained (Pb, Zn, Cu, Au, Ag) and auriferous pyrite concentrate (Cu, Au , Ag). The access gallery Larga de Sus was opened in 1962-1963.

Pressures on environmental factors have long been exercised by the S.C. Ampelum S.A. and Zlatmin S.A. Branch, which were the main source of pollution in the area. On 14/01/2004 S.C. Ampelum S.A. has ceased its activity and attracted the interruption of the activity in the Zlatmin S.A. Branch at 04/01/2004.

Mine Larga de Sus – overview

The environmental conditions in Zlatna Depression are strongly affected by complex pollution with heavy metals, air borne particles, SO_x from the mining activities and processing of non-ferrous ores. The researched perimeter, Mine Larga de Sus, is a part of the mines subject to closing and greening according to the Mining Strategy for the period 2008 – 2020. The impact on the environment exercised by the opening, operation and closure of Mine Larga de Sus is complex. The abandoned disused building, the reddish water that seeps to the bottom of the tailing heaps and the waste pile inhibits the viewer to admire the beauty of the area.

After the final closing of the galleries, disused platform is home to a pile of waste. Wastes and materials resulted either from the extraction activity or from the closing of the pit mouths have been dumped on the site in an uncontrollable way, as follows:

- Wood waste derived from supporting and reinforcing elements of mining works;

- Framework of batteries and accumulators;

- Metallic elements (elements related to mining cars, pipes, etc.).

Storage of gangue material extracted from the Larga de Sus acces gallery and Beci gallery (used as a food warehouse) is by far the most important land change that has been identified in the area (Keri et al., 2010). The two heaps are situated about 80 m from the pit mouth, encompassing 50 tons of gangue material in an area of 3.2 ha (Duma, 1998). The deposed material includes both gangue and coarse ore with high content of pyrite (FeS_2). In aerial conditions, the pyrite reacts with meteoric water that washes heaps. This reaction causes the enrichment of water in pyrites acid. Moreover, the soil pollution is produced by leakage of uncontrolled mine water discharge as well by deposition of air borne particles transported by wind from the heaps.

Liquid pollutants generated from exploration, exploitation and treatment of ores are generally known as „mine waters", which represents a mixing of meteoric waters and groundwater chemically changed. The percolation water (rainwater) infiltrates the mine through soil pores and flows within the ore through cracks and faults system. The groundwater flows through stale galleries, partial or total flooded. This mixture in contact with minerals dissolves them. Therefore, water transports in suspension material particles and in solution chemicals, becoming impure. When such water laden with pollutants is emptying into another surface body of water (lakes, rivers), may cause changes in turbidity and chemical composition of the emissary. According to Article 20 paragraph 1 of the Water Act, mine water can be discharged into watercourses only after its proper treatment. Mine water for which treatment technologies are not suitable, must be injected into the deep layers, ensuring protection against groundwater pollution.

Studies undertaken by the Duma S. (1998) and the Environmental Protection Agency Alba (2005 – 2010) on the pollutant concentration from mine water revealed the presence of Cu, Zn, Fe and Mn in amounts exceeding the maximum permissible limit (Table 1) (Duma, 1998; http://www.apm-alba.ro/index.html).

Tabel 1. *Quality analysis of water from Mine Larga de Sus*

Quality marker		Duma, 1998 (mg/L)	Environmental Protection Agency of Alba http://www.apm-alba.ro/index.html					
NTPA 001/2002 (mg/L)			Av. 2005 (mg/L)	Av. 2006 (mg/L)	Av. 2007 (mg/L)	Av. 2008 (mg/L)	Av. 2009 (mg/L)	Av. 2010 (mg/L)
*p*H	6,5 – 8,5	2,5	3,18	3,13	2,63	2,79	3,24	2,66
Mn	1,0	20,8	9,51	10,635	9,72	10,35	11,21	10,18
Zn	0,5	25,6	4,00	3,935	3,20	4,61	3,863	3,49
Fe	5,0	158,00		22,32	21,03	4,83	25,26	29,525
Cu	0,1	1,90		0,74	0,748	0,81	0,658	

*Av. = Average

Usually mine waters are collected in settling ponds or tailing ponds where the water is purified. Contrary to old mines such as Mine Larga de Sus (Romania), uncontrolled discharges of mine waters from pits and galleries are running freely into natural environment. Although mine closure was achieved in 2006, currently the mine water is flowing unimpeded in the Bloria Brook, a surface water course nearby the mine. The riverbed of Bloria was partially blocked by the material from the refuse heaps, creating a lake where untreated mine water enters. The mine water drainage channel is arranged inadequately, as it is a simple 20 – 50 cm deep trench grooved in the disused platform topsoil blanket. Water is strongly acidic (*p*H = 2.44) and present specific colour of ochre, these characteristics is due to dissolution of ore metal sulphides. This water infiltrates the soil profile, which retains heavy metals causing chronic pollution of the soil. After leaving the mining perimeter Bloria (Ruzina) Brook flows into the Trâmpoiele Brook causing the pollution of both watercourses.

DISCUSSIONS AND CONCLUSIONS

Mining industry generates continuous negative impact on the environmental factors not only in operation phases but also after cessation of mining activities. That is why environmental impact studies and monitoring assessments are needed. Once Romania has joined the European Union was necessary the alignment of Romanian legislation with the European. Therefore, the mining sector has undergone a series of transformations that have led to the transposition of European directives and standards in national laws.

After a long period in which mining and ore processing were the main concern of people from Zlatna town and the surrounding settlements, in 2004 any activity related to mining was finally stopped. Nowadays the mining activity is completely stopped at Larga de Sus, the gallery is closed with a concrete slab and the mine is undergoing the closure and ecological rehabilitation phase.

Larga de Sus Mine is located at 761 m altitude; access is done on a forest road. For this reason the rehabilitation works will be made heavy. Even though, the rehabilitation of the polluted perimeter can only be achieved through complex interventions that will improve the quality of environmental factors: water and soil. Before the implementation of any measures in order to improve environmental factors quality, it is necessary to conduct complex studies that lead to economically efficient solutions for environmental stabilization and reconstruction of tailing heaps and for construction of a mine water treatment station.

a)

b)

c)

d)
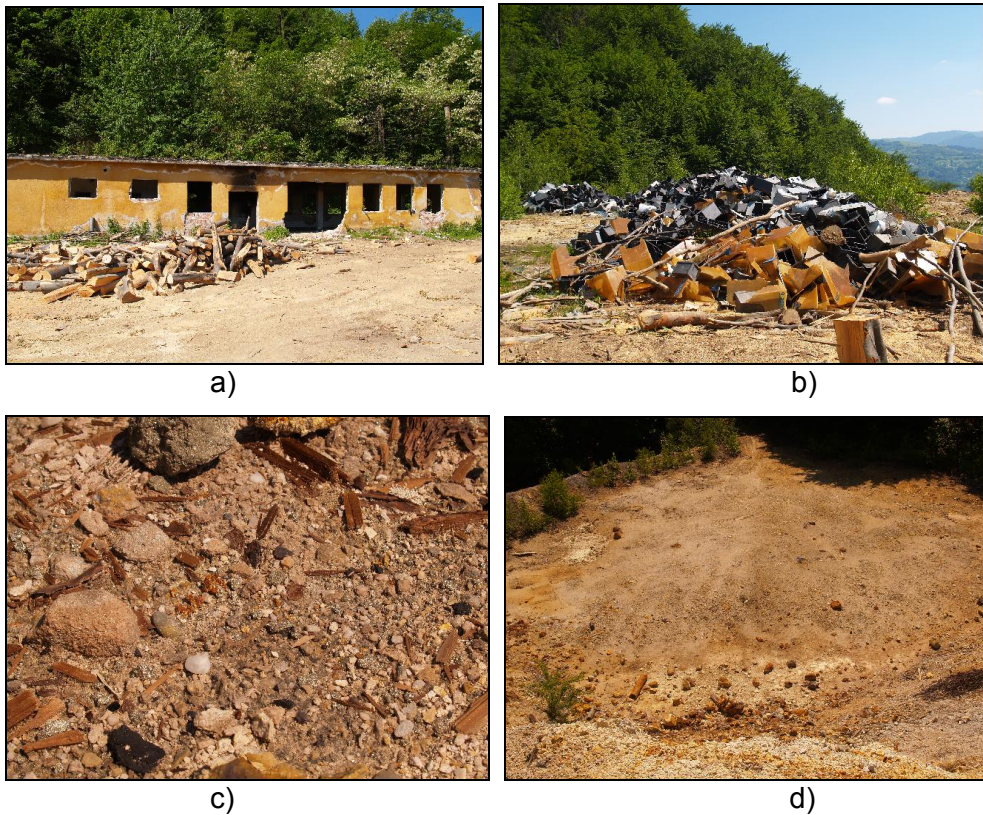
Fig. 2. *Mine Larga de Sus: a) disused building; b) pile of waste; c) deposed material (gangue, coarse ore with pyrite); d) ore deposition platform.*

If we view the mine waters as heavy metals enriched wastes, we can find methods to improve the water quality and recover the metal ions. The mine water is constant removed from mines, even after the mine is closed. In this way mine water is a continuous source of effluents enriched in metals according to the composition of crossed ore body.
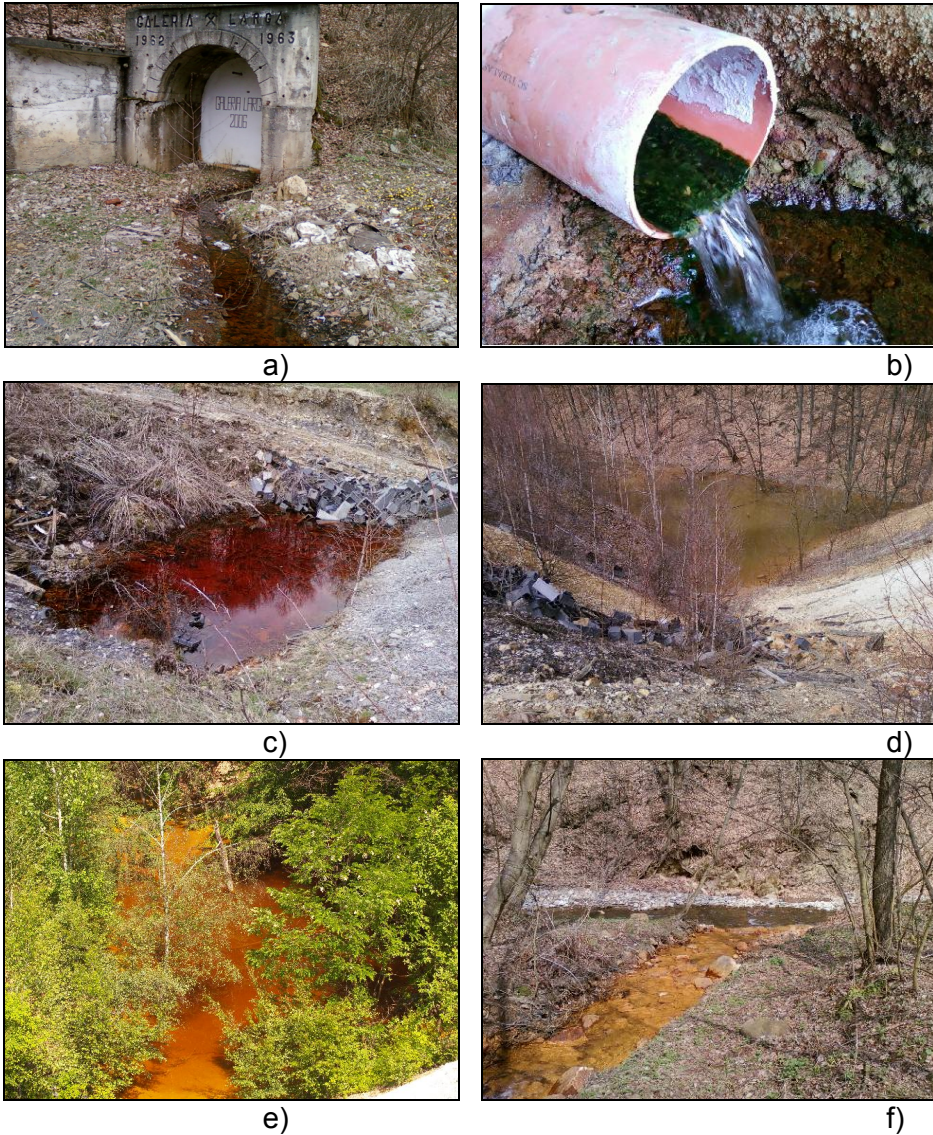
Fig. 3. *Larga de Sus – environmental aspects: a) access gallery Larga de Sus; b) mine water drainage; c) tank collection of mine water; d) view of lake formed at the bottom of the tailing heaps (April); e) view of lake formed at the bottom of the tailing heaps (June); f) junction of Bloria Brook and Trâmpoiele Brook.*

Worldwide were carried out research and were implemented pilot plants to recover metals from mine waters. Recovery of Cu^{2+}, Mn^{4+} and Fe^{2+} from acid mine water was tested on a copper pit in Bulgaria (Lazaridis, 2004). The treatment plant

building cost was estimated at $ 1.15 million and the operating costs at $ 1.76 million per year. The profit from water recycling and reuse is $ 68.000 per year, without taking into account the benefits of copper recovery.

Another method of metals recovery from acid mine drainage is stirring of a suspension composed of very fine clinoptilolite particles and liquid by air injection (Cui et al., 2006). The ion exchange capacity of some volcanic tuffs from Romania was determined for Pb^{2+}, Zn^{2+}, Fe^{2+}, Cu^{2+} (Stanca et al., 2003; Bejan et al., 2007a; Măicăneanu et. al., 2008). Tuff laden with metals can be used as additional material in fertilizer, cosmetics, ceramics, etc.

Continue development of technologies for metal elimination and recovering from liquid waste, affirm the „mine water – potential source of heavy metals" concept.

In future we propose to accomplish a complex study in order to determine the heavy metals concentration in acid mine water from Mine Larga de Sus. Zeolitic volcanic tuff will be used as filtering medium for metals purification of water. Depleted tuff will be either regenerated or used in other ways according to its metal concentration.

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HEALTH RISK ASSESSMENT OF WORKERS IN A TDI PLANT

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ABSTRACT. Diisocyanates are widely used in the manufacture of flexible and rigid foams, fibers, and coatings such as paints and varnishes, and elastomers. They are known to cause occupational asthma but little is known about the development of the disease in a cohort of workers followed prior and after the exposure occurrence. Our study is a follow up aiming to sample and monitor the air at workplaces for toluene diisocyanate (TDI) in a Polyurethane Foam Factory located in Baia Mare, Romania and assess respiratory health among participants through questionnaire responses and also to measure TDI antibodies in blood serum. In this respect, blood samples were collected from 49 workers included in the study. An interview was conducted with each participant in order to collect health data through a questionnaire. Spirometry was performed to explore the pulmonary function. Further evaluation is necessary including monitoring of the pulmonary function and serum antibodies in order to prevent or/and early identify occupational asthma among those workers with TDI exposure.

Key words: *TDI, cohort study, health questionnaire, spirometry*

BACKGROUND

Diisocyanates have wide industrial use in the fabrication of flexible and rigid foams, fibers, elastomers, and coatings such as paints and varnishes; they are manufactured for reaction with polyols (polyalcohols) in the production of polyurethanes. Polyurethanes are broadly used in high resiliency flexible foam seating, rigid foam insulation panels, microcellular foam seals and gaskets, durable elastomeric wheels and tires, automotive suspension bushings, electrical potting compounds, high performance adhesives and sealants, Spandex fibers, seals, gaskets, carpet underlay, and hard plastic parts (such as for electronic instruments). The global consumption of polyurethane raw materials is climbing, having an average annual growth rate of about 5% (Avar, 2008); this represents a rising industry, making very important the development of safer and less polluting manufacturing methods. Fully reacted polyurethane polymer is chemically inert (Dernehl, 1966), but it is a combustible solid and could ignite if exposed to an open flame for a sufficient period of time. During manufacturing procedure proper hygiene controls and personal protective equipment, such as gloves, dust masks, respirators, mechanical ventilation, and protective clothing and eyewear should be used, as well as self-contained breathing apparatus in enclosed areas (ISOPA, ***www.isopa.org).

Toluene diisocyanate (TDI) is the second highly produced diisocyanate, accounting for 34.1% of the global isocyanate market in 2000 (Randall and Lee, 2002). It is a hazardous aromatic compound synthesized in six steps (Randall and Lee, 2002), in which phosgenation of corresponding amines represents the main technical process for the manufacture of isocyanates. The amine raw materials are generally manufactured by the hydrogenation of corresponding nitro compounds; in this case, toluenediamine (TDA) is manufactured from dinitrotoluene, which then converted to toluene diisocyanate (TDI).

Isocyanates are known skin and respiratory sensitizers, and proper engineering controls should be in place to prevent exposure to isocyanate liquid and vapor; exposure to TDI vapors is well documented to increase asthma risk (Allport et al., 2003). Occupational asthma and hypersensitivity pneumonitis as a direct result of introduction to isocyanates in general and TDI in particular have been extensively researched, predominantly in last 10 to 15 years (Ott et al., 2007; Aul et al., 1999). Other forms of hypersensitivity manifestation have also been linked to diisocyanates and TDI professional contacts (dermatitis – Estlander et al., 1992; eye - conjunctiva, mucosal irritation – Omae et al., 1992; Littorin et al., 2007).

PURPOSE

The study focuses on the association between bronchial asthma and TDI exposure of workers from a Polyurethane Foam Factory located in Baia Mare, Romania.

METHODOLOGY

A group of presumably unexposed new workers has been initially evaluated through out a health questionnaire, pulmonary function tests, serum TDI antibodies and individual polymorphisms, as well. As a 6 months follow up, lung function tests and blood sampling were repeated, while the questionnaire was reapplied to the subjects. Workplace air TDI measurement were performed by direct readings and GC-MS, and dust wipes qualitative approach have been used to assess skin contact. TDI antibodies and individual polymorphisms are not included is this paper.

The TDI workplace concentration was measured in three locations, taking into account the technology and work activities. Meanwhile personal monitoring was performed for three representative workers. The measurements were conducted in three departments of the plant (foaming hall, cutting area and sponge pillows department), following the same protocol.

Air sampling was performed with a flow rate of 0.3 liters/minute for 2 hours. The questionnaires were filled in individually by a trained interviewer. Questions were aimed to record respiratory health problems and allergic background in specific details (such as: asthma, chronic bronchitis, emphysema, respiratory symptoms, rhinitis, dermatitis, previous atopy tests,). Smoking habits and close contact with pets or other animals, as well as home environment, were briefly asked in the questionnaire, while a special attention was paid to the work practice – personal protective equipment, and exposure control measures such as ventilation and hygiene conditions, along with questions on workers' compliance to safety rules. A matter of interest was the

issue of previous contacts with polyurethanes, explicitly TDI and other diisocyanates; sections of the questionnaires covered information about pre-employments and exposure to insulating construction foams or sprayed paints.

The lung function tests were performed with PC Portable Microlyser (a combined portable audiometer and spirometer) and their results were interpreted by an occupational healthcare professional. Several parameters (FVC, FEV[1], PEF, TIF, MMEF, M75, M50, M25 and MMEF/FVC) were automatically chosen by the spirometer from technically acceptable maneuvers, considering predicted values as pointed by generally accepted charts (calculated based on regression equations). The device automatically corrected results to surrounding air pressure and humidity; amending individual factors (gender, age, height, weight) were introduced by the technician.

For statistical procedure, the Chi-square test was primarily used, as it was necessary to assess whether paired observations on variables, expressed in contingency tables, are independent of each other. Chi-square (noted χ2) is generally considered the statistical indicator of differences among proportions (percentages) and it can reduce the foregone conclusions emerged from comparing non-homogenous factions.

RESULTS

Of 52 subjects originally enrolled, 49 were completely evaluated in the first stage (at employment); at this moment, the group considered for second phase evaluation is comprised of 44 persons. The second questionnaire only refers to events occurred during the six months interval (e.g. newly diagnosed lung disease, allergy, new exposure to TDI outside the working place).

Questionnaires responses

Table 1 summarizes the frequency of positive answers in three departments with diverse levels of assumed exposure. Categories listed below reflect the main lines of interest in projected finales.

Table 1. *Positive answers percentage in departments*

"Yes" answers (%)	I (Foaming)		II (Cutting)		III (Administrative)		TOTAL	
Questionnaires	Q 1	Q 2	Q 1	Q 2	Q 1	Q 2	Q 1	Q 2
Respiratory disease	0.00	0.00	0.00	0.00	0.00	2.27	**0.00**	**2.27**
Respiratory symptoms	4.08	0.00	8.16	4.54	6.12	2.27	**18.36**	**6.81**
Recent lungs ailment	0.00	2.27	6.12	11.36	4.08	2.27	**10.2**	**15.9**
Hypersensitivity	2.04	0.00	2.04	0.00	2.04	0.00	**6.12**	**0.00**
Allergic symptoms	0.00	2.27	0.00	4.54	0.00	6.81	**0.00**	**13.63**
Smoking habits	12.24	11.36	16.32	15.9	12.24	13.63	**40.81**	**40.9**
Other TDI contacts	22.44	4.54	22.44	4.54	22.44	9.09	**67.34**	**18.18**
Protection equipment	26.53	22.72	36.73	36.36	24.48	31.81	**87.75**	**90.9**
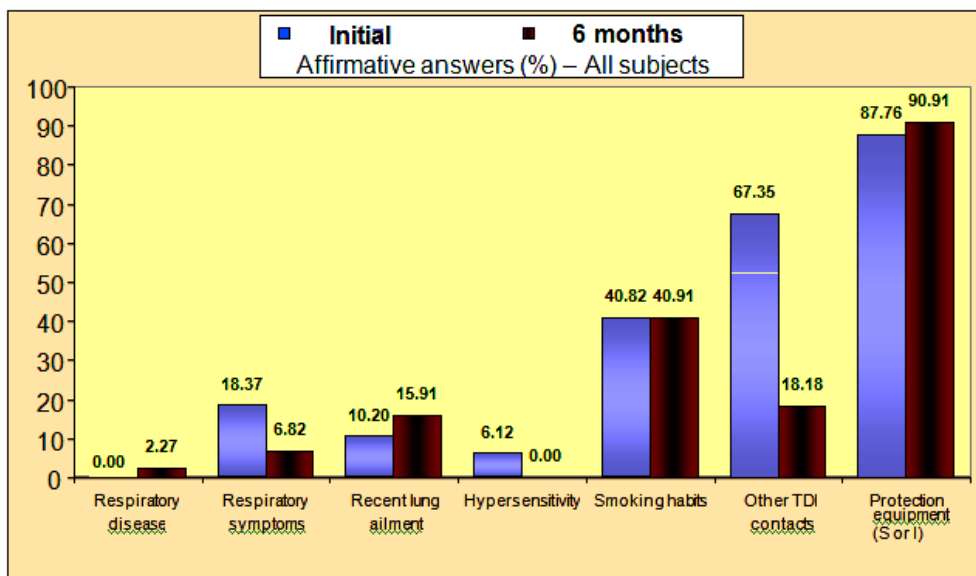
Fig. 1. *Positive answers percentage in all categories*

This chart presents percentages of each group (N¹=49; N²=44) of subjects which responded positively to the following categories in the questionnaires:

1 – Diagnosed (by physician) respiratory diseases
2 – Respiratory symptoms (cough, wheezing, dyspnea, chest tightness)
3 – Recent respiratory ailment (previous month to the questioning)
4 – Hypersensitivity (diagnosed; skin prick test or serum testing)
5 – Allergy symptoms (pruritus, excessive eye watering, rhinorrhea)
6 – Smoking habits
7 – Other TDI contacts (outside working environment; e.g. isolating foams, spray paints)
8 – Equipment (subjective satisfaction level, compliance to protection regulations)

For increased relevance of this analysis, the cohort of subjects was divided into three levels of possible exposure at the working station, ranging from level I (the most significant) to level III (least potential exposure); these subgroups will be identified as "departments" in further figures.
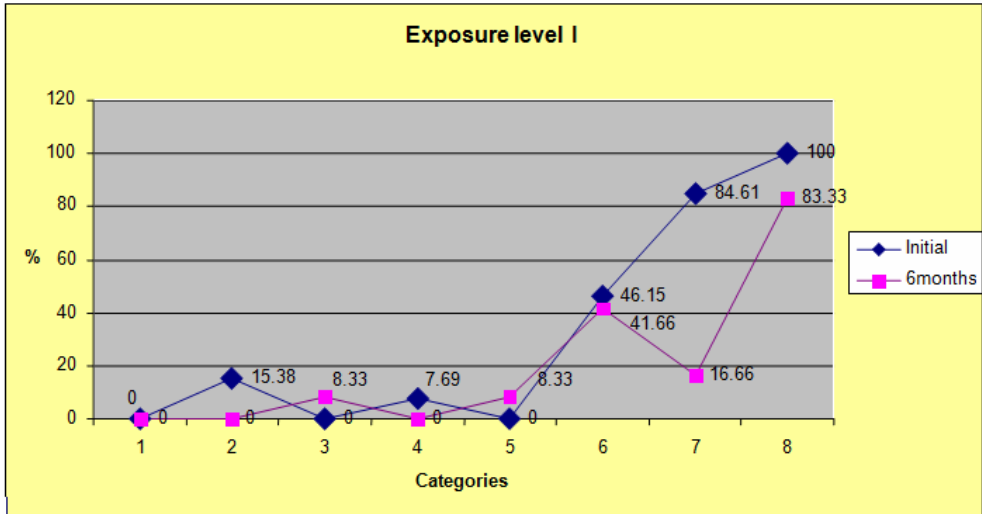
Fig. 2. *Positive answers in exposure level I*

This diagram pictures the same data range for the potentially most exposed group (exposure level I; n¹=13, n²=12) the Foaming hall department.

In following figures, all percentages are calculated relative to exposure level group, counting number of subjects within "department" and comparing level exposure groups in time.
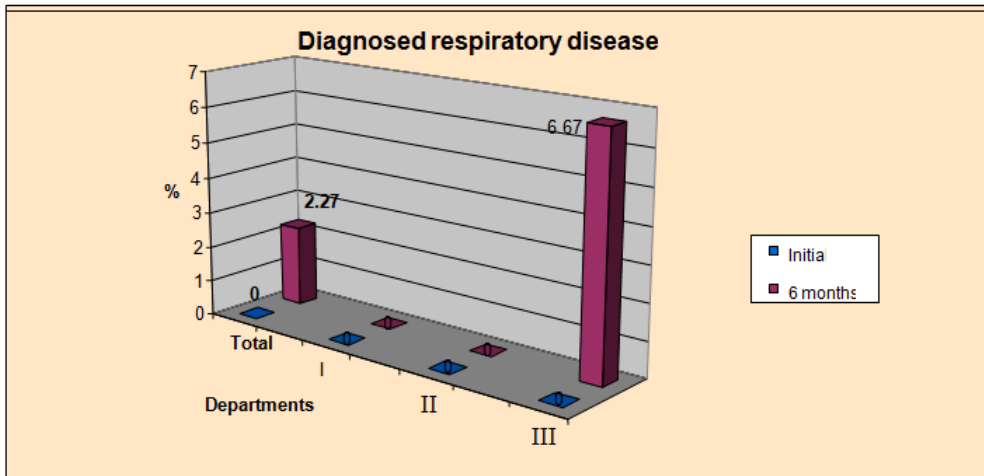
Fig. 3. *Diagnosed respiratory disease*

This part of the questionnaires refers to respiratory apparatus affections diagnosed by healthcare professionals; the only positive answer received involved an acute illness (pharyngitis).
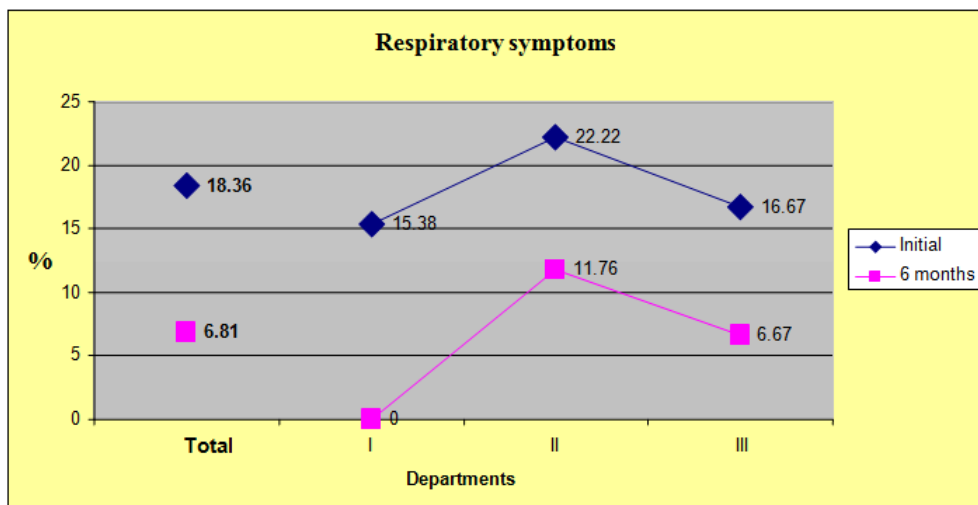

Fig. 4. *Respiratory symptoms*

Figure 4 is describing more questions concerning symptoms such as cough, dyspnea, wheezing, as perceived by the subjects in terms of occurrence, intensity, and duration. The presumably large disparity in terms of declared symptomatology it is more likely related to time limitation of the questionnaires (meaning incidence in entire previous life versus events during six months prior to examination). However, application of statistical indicator calculation χ2 reveals no significance in these terms (p ≈ 0.097).

Figure 5 analyses the answers regarding respiratory diseases arisen in the preceding one month, whether diagnosed and professionally treated, or not. The emerging problems were mild disorders, such as simple influenza or common cold. The slight variation between groups in time could be influenced by seasonal periodicity of these ailments. There is no statistical significance (p ≈ 0.4).

The 6 month follow-up shows no records for new cases of hypersensitivity. The presence of allergic-type symptoms was not verified in the first round of questionnaire application. Even under these circumstances, the statistical testing proves no significance (p ≈ 0.095).

Drastically fewer new exposures to diisocyanates had occurred in the 6 months interval; the initial set of questions involved references to any previous contact with construction materials (isolating foams, anti-moisture foams) or painting dyes. This comparison has statistical significance (p ≤ 0.05) on the χ2 test, both when considering all subjects and for each of the three departments.
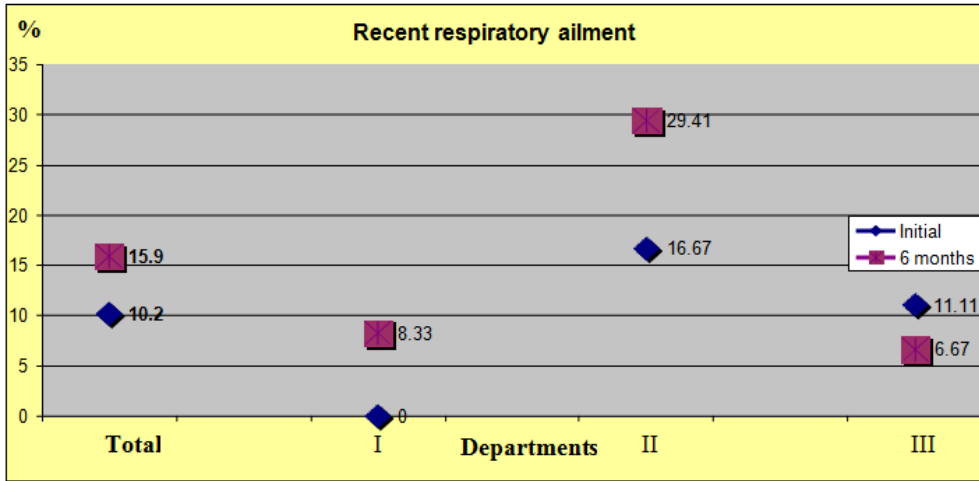
Fig. 5. *Respiratory disease (acute) – one month prior to questioning*
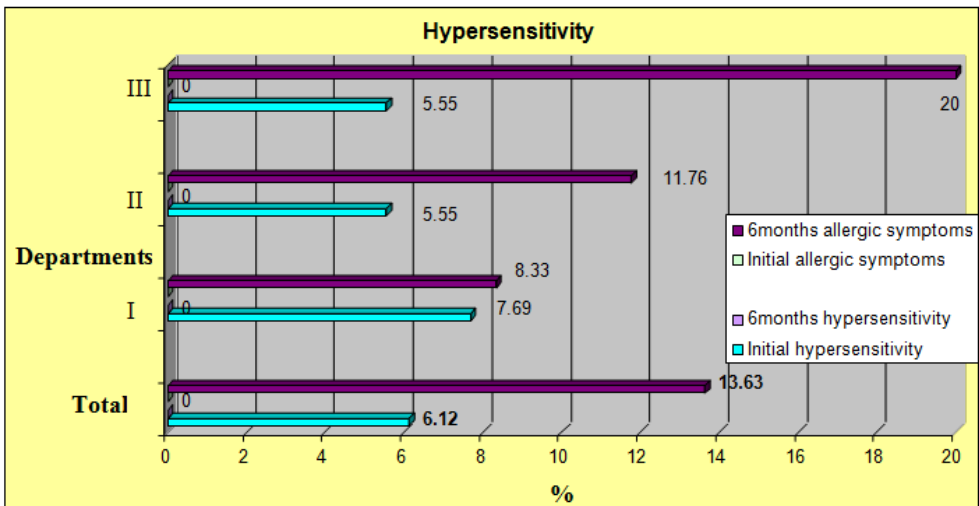
Fig. 6. *Hypersensitivity and declared allergy symptoms*
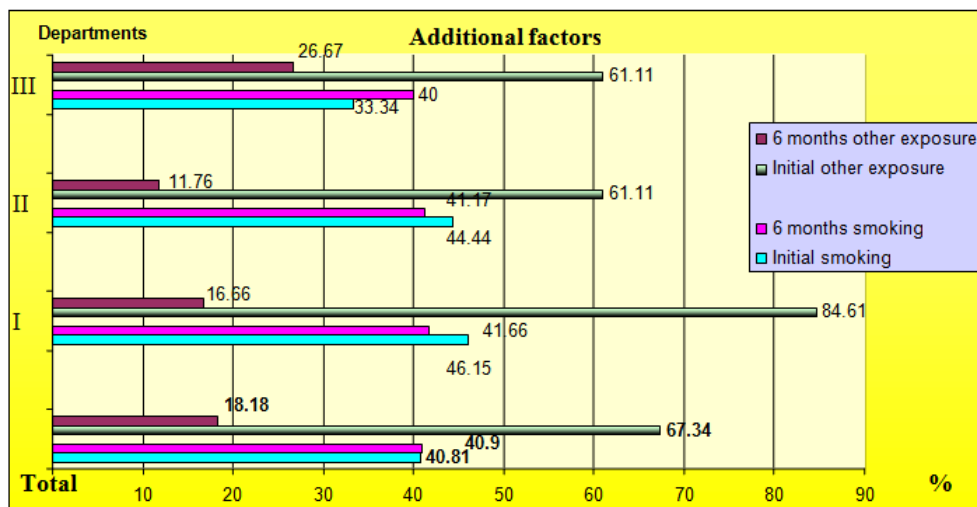
Fig. 7. *Smoking habits and other polyurethanes exposure*

The smoking habits have known very little change during six months intermission.

Table 2. *Percentages of smokers and other polyurethanes contacts*

Subject group	Smoking habits (%)			Other exposures (%)	
	Initial	6 months		Initial	6 months
Total	**40.81**	**40.9**		**67.34**	**18.18**
Exposure level I	46.15	41.66		84.61	16.66
II	44.44	41.17		61.11	11.76
III	33.34	40		61.11	26.67

The percentages represent amount of people who did not always comply with the safety rules, or who were not satisfied by supplied equipment components when subjectively considering the potential level of exposure. As seen above, the overall level of conformity has perceivably increased over time in the administrative department; meanwhile, the confidence of more exposed groups in provided paraphernalia has somehow deteriorated. With a $p = 0.6$ there is no statistical relevance on this analyzed category either.
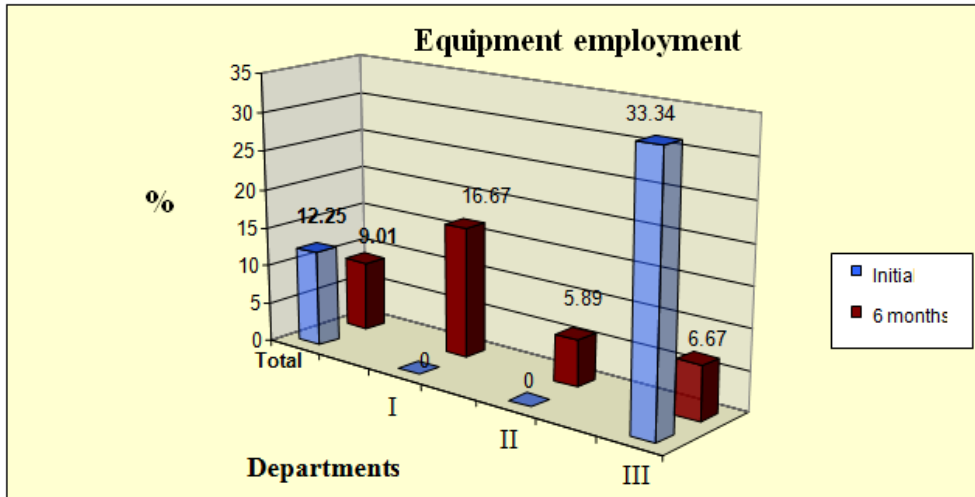
Fig. 8. *Equipment usage and compliance to safety regulations*

PULMONARY FUNCTION TESTS

The subsequent results concern only the second group of study, namely the pulmonary function evaluation in this presentation has been considered for subjects after six months of occupational exposure.

In the group of 44 valid lung function tests, 39 (88.63%) were considered within physiological limits while five (11.37%) persons were diagnosed with mild to moderate peripheral obstructive ventilatory dysfunction. The mean prevalence of obstructive dysfunction is considered to be around 12% in general population (Weaver et al., 2009; Kogevinas et al., 1999).

In order to control lung function tests for confounders the subjects were considered into three generic subgroups: "Foaming", "Cutting" and "Administrative", with the most tainted environment ranging from first toward the last.
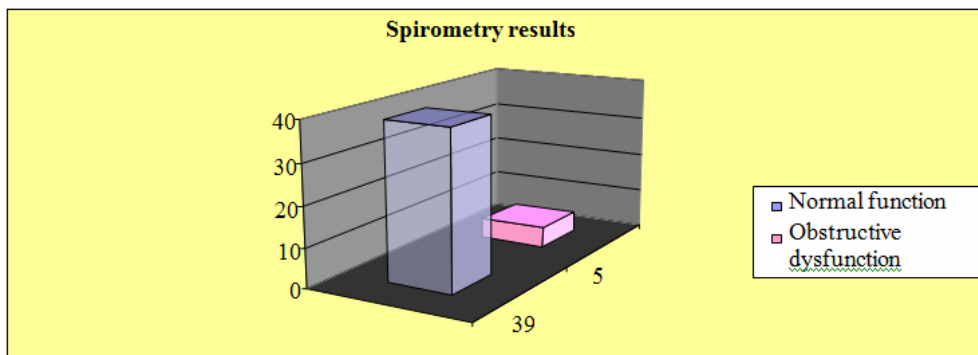
Fig. 9. *Lung test results*
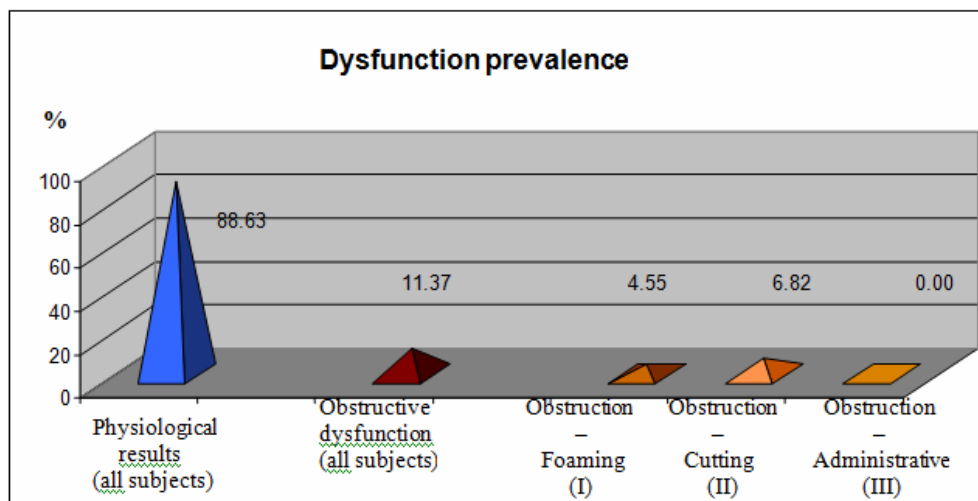
Fig. 10. *Obstructive dysfunction occurrences*

As seen from the picture, 4.55 % of the subjects that presented obstructive dysfunction were in the first group, 6.82 % were from the "medium exposure" subgroup and none from the Administrative section.

FVC stands for Forced Vital Capacity and is the amount of air that can be forcibly exhaled from the lungs after taking the deepest breath possible (forced maximal inhalation). FVC (%) represents percentage of the value obtained by one subject from a mean reference value (100%); the last comes from an internationally accepted chart of values calculated on regression equations and depending upon physiological factors (age, height, weight, gender). This reference value is typically referred to as the "prediction".

This diagram shows how percentage of people failing to achieve the reference value is lower in least exposed areas (the middle and right sets of data); the difference between "departments", computed in pairs of two, is not statistically significant (lowest p ≈ 0.12).
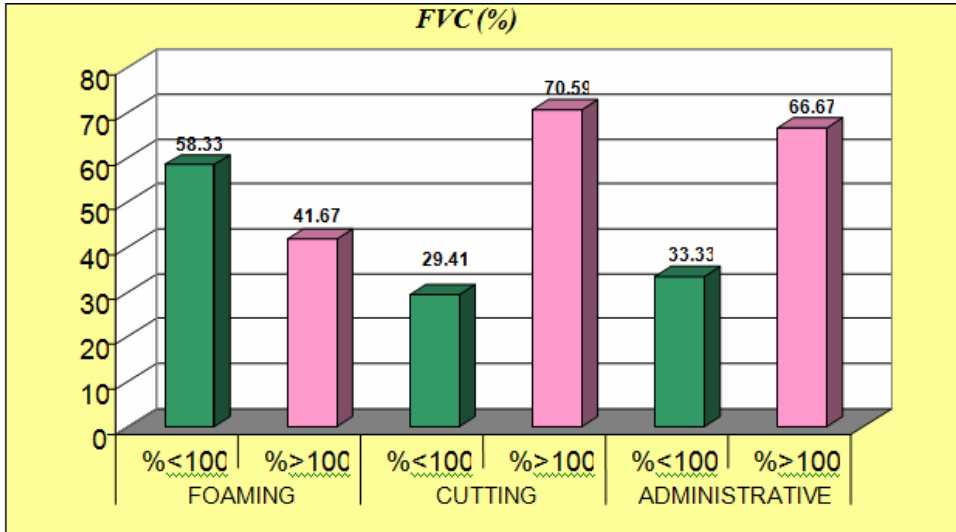
Fig. 11. *Forced vital capacity results*

FEV¹ (Forced Expiratory Volume) means the amount of air which can be forcibly exhaled from the lungs in the first second of a forced exhalation following a maximal inhalation. FEV¹ (%) is, same as above, the percentage from a predicted reference value (considered 100%).
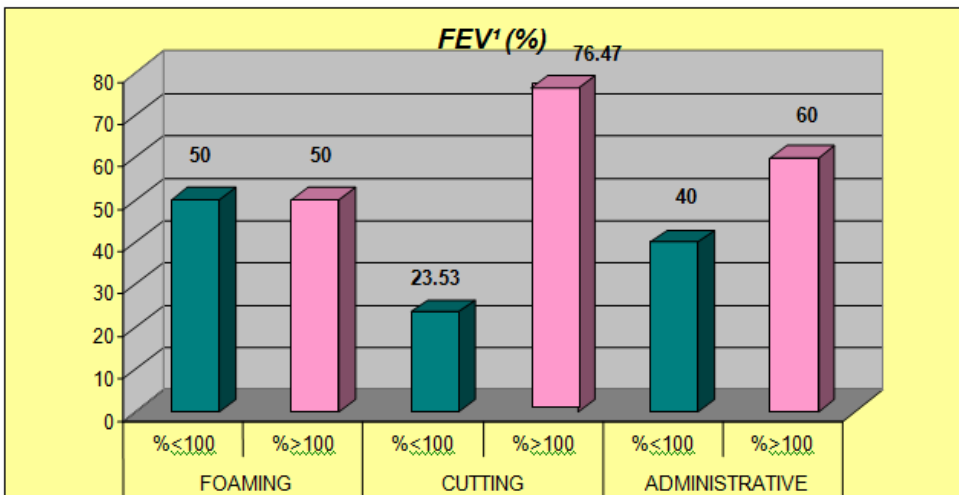
Fig. 12. *Forced expiratory volume results*

65

Although this is not a statistically significant difference ($p \approx 0.14$), nor has medically diagnostic importance in itself, it can be seen from the picture that number of subjects not reaching mean reference point is subtly greater in the Foaming group relative to the other two departments.

PEF, abbreviated from Peak Expiratory Flow, is the maximum airflow during a forced expiration beginning with the lungs fully inflated; the PEF is reduced in proportion to the severity of the airway obstruction. PEF (%) is defined as in cases above.
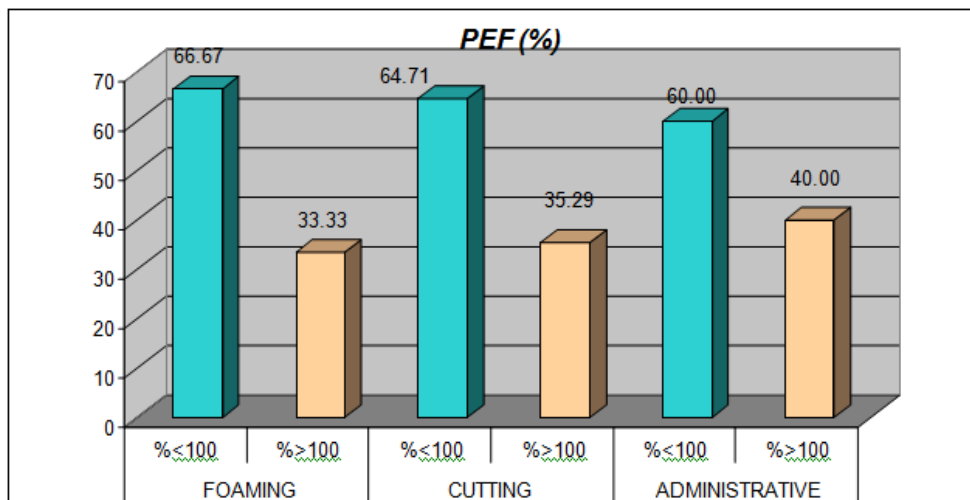
Fig. 13. *Peak expiratory flow (percentage) results*

In this case, the figure reveals a very similar situation in all three departments ($p \approx 0.7$); with vaguely better results towards Administrative section. Daily variations in PEF are physiological (Higgins et al., 1989; Aggarwal et al., 2000) and tend to be even higher in workers exposed to TDI (Lee and Phoon, 1992). In this research, the time of measurements or hours relative to work and other activities were not traced; spirometry recordings are random across the group.

TIF stands for Tiffeneau Index, being calculated as the FEV^1 / FVC ratio multiplication by 100. It is regularly considered normal at values above 75%. TIF (%) represents percentage of the predicted value for the subject, accordingly to his/her characteristics.

Table 3. *Percentage of Tiffeneau index distribution in departments*

Functional parameter	FOAMING (I)		CUTTING (I)		ADMINISTRATIVE (III)	
	%<100	%>100	%<100	%>100	%<100	%>100
TIF (%)	16.67	83.33	29.41	70.59	20.00	80.00

Allocation is reasonably similar among considered sections of the factory (p ≈ 0.43, no significance).

MMEF or MEF stands for maximal (mid-) expiratory flow and is the peak of expiratory flow as taken from the flow-volume curve and measured in liters per second. It should theoretically be identical to PEF, the latest being however measured in liters per minute.

While for most of the subjects in Cutting the measured MEF% was within or above predicted values, for workers in Foaming and Administrative departments MEF% was mostly below the predicted, even though not significantly (p ≈ 0.21).

Table 4 *Percentage of MEF (%) allotment*

Functional parameter	FOAMING (I)		CUTTING (I)		ADMINISTRATIVE (III)	
	%<100	%>100	%<100	%>100	%<100	%>100
MEF (%)	58.33	41.67	35.29	64.71	53.33	46.67

M75 (also known as FEF75) – this measurement describes the amount of air that was forcibly expelled in the last 25 % of the total forced vital capacity test.
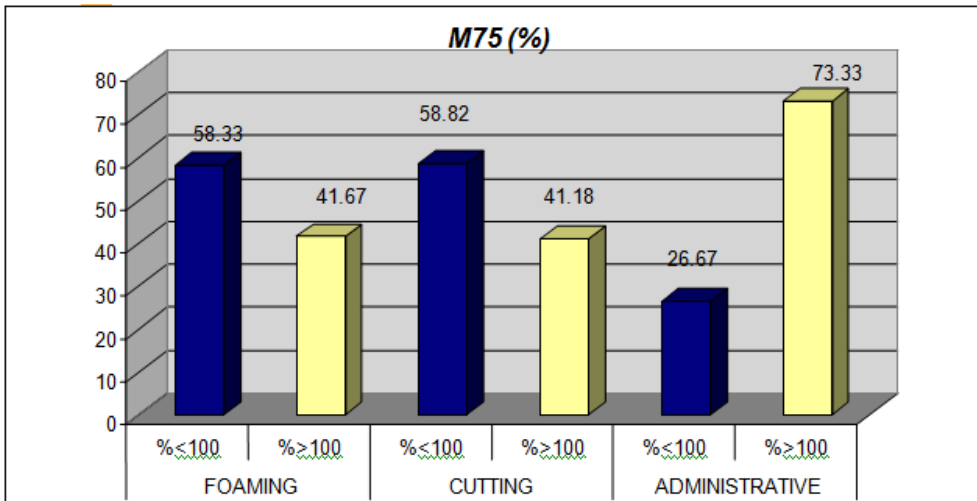
Fig. 14. *M75 (percentage) results*

As seen from picture better results were obtained in presumably the least exposed subgroup (Administrative), although the distinction is not statistically significant (most noteworthy p ≈ 0.06).

M50 (FEF50) – this measurement describes the amount of air expelled from the lungs during the first half (50%) of the forced vital capacity test.
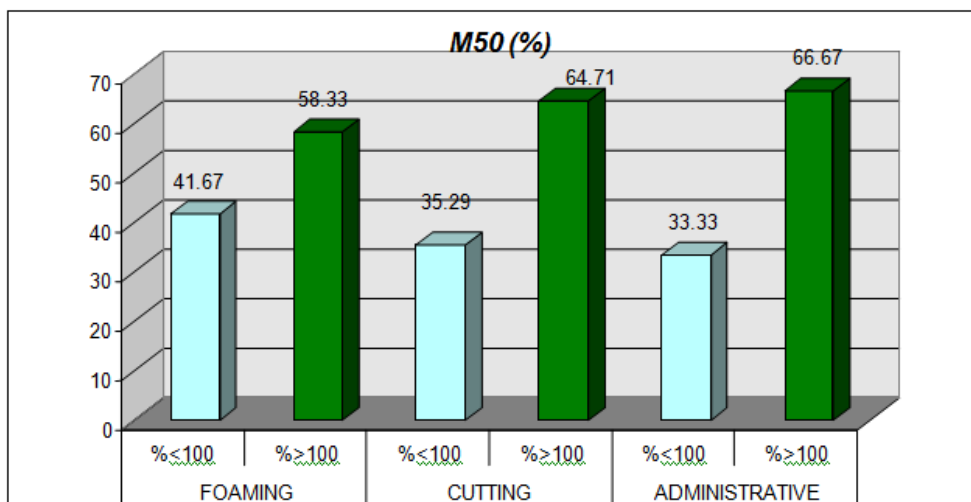
Fig. 15. *M50 (percentage) results*

Although slightly better results were obtained as the level of potential exposure proportionally decreases, the data does not hold statistical significance ($p \approx 0.6$).

M25 (FEF25) represents the forced expiratory flow at 25% of Forced Vital Capacity. This measurement describes the amount of air that was forcibly expelled in the first 25% of the total forced vital capacity test.

Table 5. *M25 (%) distribution*

Functional parameter	FOAMING (I)		CUTTING (I)		ADMINISTRATIVE (III)	
	%<100	%>100	%<100	%>100	%<100	%>100
M25 (%)	83.33	16.67	35.29	64.71	73.33	26.67

Once more, the higher percentage of subjects exceeding predicted value was found in Cutting area; the statistical significance ($p \approx 0.01$ and $p \approx 0.03$) was found only when departments were considered two by two (first versus second and second versus third, respectively). Failure to achieve a linear improvement as the exposure level supposedly decreased disqualifies these results as significant, pointing rather toward an acceptable random bias.

MMEF / FVC ratio is the maximum expiratory flow over the middle half of the FVC. It is sometimes used as an index of airway obstruction, but this is fraught with hidden menaces.

Table 6. *MMEF / FVC (%) allocation*

Functional parameter	FOAMING (I)		CUTTING (I)		ADMINISTRATIVE (III)	
	%<100	%>100	%<100	%>100	%<100	%>100
MMEF / FVC (%)	58.33	41.67	41.18	58.82	60.00	40.00

The calculated MMEF / FVC (%) pointed out similar values as referred to predicted ones without statistical significance between departments (p ≈ 0.28).

Affirmed symptoms and spirometry outcomes relationship

In order to establish an indication of patterns to be observed in further analysis as more data accumulates, we tried to make a direct comparison between frequencies of declared respiratory symptoms and objective spirometry results. Tables below present this cumulated information.

Table 7. *Connection between respiratory symptoms and dysfunction*

(%)	*Initial Respiratory symptoms*	**6 months Respiratory symptoms**	**Obstructive dysfunction**
Total	*18.36*	**6.81**	**11.37**
I	*4.08*	**0.00**	**4.55**
II	*8.16*	**4.54**	**6.82**
III	*6.12*	**2.27**	**0.00**

Differences between first two columns have proved no statistical significance, as already stated through total questionnaires investigation; however, a fairly strong correlation has been brought forward when initial and follow-up declared symptoms were set beside diagnosed obstructive dysfunctions.

Table 8. *Correlation marker "r"*

	Initial	*6 months*	*Obstructive dysfunction*
Initial – Respiratory symptoms	1		
6 months – Respiratory symptoms	0.91	1	
Obstructive ventilatory dysfunction	**0.82**	**0.74**	1

Regression Statistics	
Multiple R	0.824007
R Square	0.678988
Adjusted R Square	0.518481
Standard Error	4.40124

Figure 16th shows the simple linear regressions for the aforementioned factors, pointing out a similar ascendant trend and a better correlation of total lifetime responses (initial questionnaire) with the resulted affections. Regression equations may be found in the image.

Nonetheless, as seen from the picture, the parallel is not conforming to the arrangement of departments in presumed exposure order; most asserted symptoms are in the second group, both initially and at follow-up.
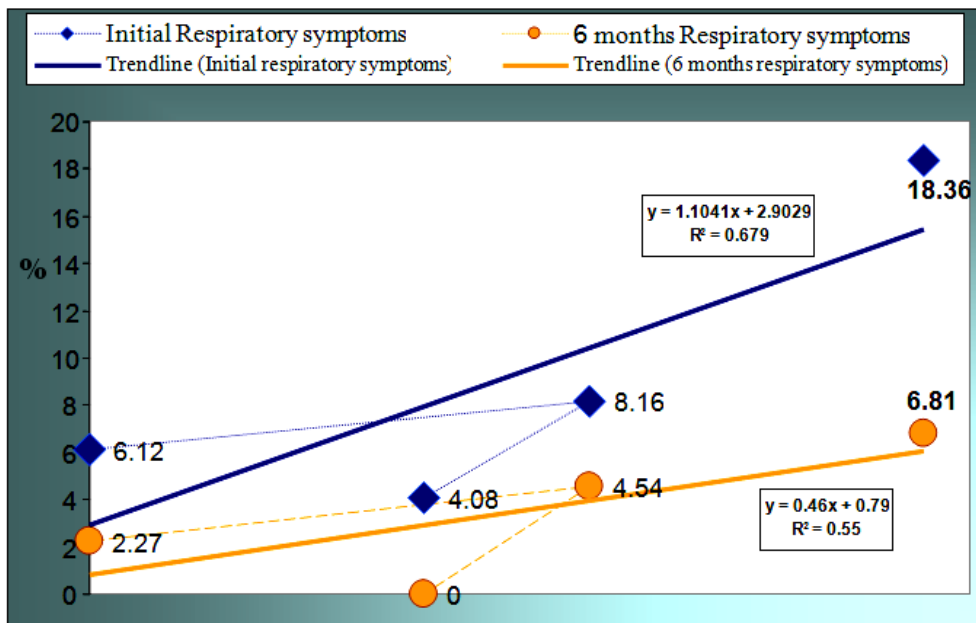
Fig. 16. *Regression curves*

These records are still too inadequate to make a significant assumption based on it, however the correlations should be remembered and same analysis re-applied in the moment more results would become available.

CONCLUSIONS

When considering the questionnaires, overall, the largest visible differences between the two time-lines emerged in terms of respiratory symptoms, recent respiratory ailments, diagnosed hypersensitivity or allergic symptoms and probably the most striking dissimilarity, exposure to polyurethanes outside the respective working station. The most credible explanation is that these discrepancies originated from the periods of time covered by the questionnaires. While the initial set of questions was aimed at establishing all previous illnesses or exposures (data collected for entire life of the subject), the follow-up was soliciting only information regarding previous six months.

On the topic of pulmonary function testing, for the parameters used in analysis there seems to be an apparent distinction in performance between the three subgroups; the reference values achievement appears to be the lowest in presumably the most exposed group, while better routine was exhibited by the least exposed set of subjects. This impression doesn't stand to an in dept scrutiny for several reasons: the three subgroups are not analogous in terms of size and, most important, constituents (gender distribution across sets of subjects), which seriously affects the significance of findings from a statistical point of view. Second, from a medical stance, the numeric

value of a spirometry factor is considered within limits down to 80 % of the established reference average, so failing to reach 100 % does not have diagnostic authority. The most that can be drawn from these data is a suspected tendency towards diminished physical performance in reverse association with the presumed exposure level, without any statistical significance at this moment. This matter should be tagged along in the years to come.

Medically diagnosed obstructive dysfunction was attained for 11.37 % in tested group with 4.55% prevalence in the presumably most exposed department, a 6.82% rate in the intermediate exposure cluster and no cases in the administrative section. 88.36% of the tested group's results were considered within physiological range. Incidence of this disorder cannot be considered different from the general population, knowing that occurrence of obstructive ventilatory dysfunction is situated around 12%.

Correlations have been established connecting declared respiratory symptoms and unbiased spirometry results, a stronger relationship existing between the responses for entire life and lung tests outcomes. Nevertheless, these sets of data are not further more associated with working place environment – the presumed level of risk considering chemical exposure.

Keeping in mind that these collected data are intermediary and situated at a very early point in terms of relevance, we can say that so far no statistically significant association between exposure levels to toluene diisocyanate and occupational health outcomes could be established.

Future sets of testing, both subject based and environmental measurements, will take place for the next three to four years at an estimated frequency of twice a year (approximately at six months).

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FORMALDEHYDE EXPOSURE ASSESSMENT IN A COMMUNITY LIVING IN THE SURROUNDINGS OF A WOODEN PRODUCTS FACTORY

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ABSTRACT. Inhalation is an important pathway for human exposure to contaminants that exist as atmospheric gases and inhalation exposure frequently occurs as a result of direct release of such gases from an on-site facility. Formaldehyde is a chemical used widely by industry to manufacture building materials and numerous household products. It is also a by-product of combustion and certain other natural processes. This study addresses the assessment of formaldehyde exposure in a population group living in the surroundings of a wooden products factory using formaldehyde in the technological process.

Simultaneous formaldehyde concentrations measurements controlled for weather conditions were performed at the plant level, outdoor and indoor for ten households in the surroundings of the plant. A health questionnaire was filled in by the study participants. Spirometry was also performed to investigate the pulmonary function of the subjects participating in the study.

Exposure doses were calculated using the ATSDR (Agency for Toxic Substances and Disease Registry from CDC - Center for Disease Control and Prevention) Dose Calculator.

In the worst case scenario, the additional estimated cancer risk, as a result of formaldehide exposure of the investigated population group in the surroundings of the plant, were between 10^{-6} and 10^{-3} as orders of magnitude.

Key words: *formaldehyde, exposure dose, wooden products factory, respiratory health status*.

INTRODUCTION

Formaldehyde is one of the most widely used organic compounds and is an indispensable chemical in many industries.

Commercially manufactured for over 100 years, formaldehyde production in USA was 11.3 billion pounds in 1998.

International formaldehyde production was over 46 billion pounds in 2004 and growing fast.

Formaldehyde is used in the production of pressed wood products, plastics, dyes, paint, paper products, glues and adhesives, disinfectants, cosmetics, shampoos, hair conditioners, pharmaceutical products, air fresheners, household antiseptics, carpet cleaners, mouth washes, etc (EPA, 2010). The list of household products with formaldehyde can be unending. According to recent studies, formaldehyde is

present in both indoor and outdoor air at low levels (Department of Health and Human Services, 2008). Most of the materials with formaldehyde content release formaldehyde gas into the atmosphere. Formaldehyde emissions are highest when products are new, and decline over time. Heat and humidity increase release rates of formaldehyde from household products.

A major outdoor source of formaldehyde exposure is smog, especially in heavy traffic corridors, so the outdoor air in rural regions has much lower concentrations than urban areas (Department of Health and Human Services, 2008).

Formaldehyde is heavily and widely employed in agriculture for seed treatment, stored crop fumigation, and soil disinfection. Many slow-release fertilizers are based on urea-formaldehyde (EPA, 2010).

It is added to animal feed as a preservative, and to improve handling characteristics of animal fat and oilseed cattle food mixtures.

Formaldehyde have a short half-life in air, about 8 to 12 hours, where sunlight accelerates decomposition by photolytic oxidation, thus proximity to sources is the main determinant of outdoor air levels.

Continuous off-gassing indoors, where photolytic oxidation is absent, can result in long term elevated levels.

Formaldehyde has a short half life in water, making water a negligible contributing source.

OBJECTIVE

The study addresses the assessment of formaldehyde exposure in a population group living in the surroundings of a factory producing pressed wood products made using adhesives that contain urea-formaldehyde resins.

METHODS

Formaldehyde – sampling and analysis

Formaldehyde was simultaneously measured in three locations: at the factory producing pressed wood products, inside and outside the houses in the area of influence of the factory.

In order to measure formaldehyde, air samples were collected for 60 minutes on tubes (SCK 226118) containing 2-hidroxymethil piperidine, using an aspiration pump calibrated at 0.250 l/minutes, as sampling flow. After 60 minutes sampling time, the samples were stored at 4°C for transportation and were taken to the lab to be analysed. The formaldehyde collected on the SCK 226118 tubes was extracted on an ultrasounds bath for 60 minutes using toluene. The extract was transfered into a cromatographic vial of 1.5 ml and the analysis was performed using a gas cromatograph coupled to a mass-spectometer (GC-MS Shimadzu QP 2010 Plus). The method used is called **S**elected **I**on **M**onitoring (SIM) and has a better detection limit as the compound is measured based on the unique mass specter. The concentration of the compund is read on the calibration curve.

Questionnaire survey and Pulmonary Function Test (Spirometry)

An interview was conducted with each participant in the study and information was collected based on a questionnaire. The questionnaire included questions on personal data (age, gender, residence), socioeconomic factors (level of education, employment), diagnosed occupational diseases, respiratory symptoms, chronic respiratory diseases, allergic diseases, smoking.

The pulmonary function of each participant in the study was tested by measuring how much air the lungs can hold and how well the respiratory system is able to move air into and out of the lungs, using a portable spirometer (MicroMedical MICRO GP), with disposable mouth piece. Individual parameters (gender, height, age, race) were entered by the person who performed the test, before starting it. The following parameters were measured: *Peak Expiratory Flow* (PEF) which is the highest value of the air flow as a result of a maximal forced exhalation coming after a maximal inspiration; *Forced Vital Capacity* (FVC) which is the volume of air that can be forcibly expelled from the lung from the maximum inspiration to the maximum expiration; *Forced Expiratory Volume in 1-st Second* (FEV_1) which is the volume of air that can be expelled from maximum inspiration in the first second.

Data analysis

The data analysis was performed using the ATSDR (Agency for Toxic Substances and Disease Registry from CDC - Center for Disease Control and Prevention) Dose Calculator.

The exposure dose and the additional cancer risks as a result of the exposure to formaldehyde for a period of 10 and 35 years respectively, were calculated based on standard input parameters for adults and based on the formaldehyde concentration measured inside and outside the houses in the study area.

Also, for the 38 subjects investigated in the study area, individual exposure doses and additional cancer risks as a result of the exposure to formaldehyde for a period of 10 and 35 years respectively, were calculated in the worst case scenario, considering the amount of air inhaled and individual weight, and using the following equations:

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

In the above described worst case scenario, the amount of air inhaled per 24 hours was calculated as the sum of the amount of air inhaled per 14 hours (assuming this 14 hours as the active period of the day) and the amount of air inhaled per 10 hours (assuming this 10 hours as the rest period of the day) where the amount of air inhaled per 14 hours was calculated as: air inhalate/14hours= FVC*4*14*60 and the amount of air inhaled per 10 hours was calculated as air

inhalate/10 hours= FVC*2*10*60 where FVC is the Forced Vital Capacity parameter and assuming that 4 is the number of forced respiratory cycles per minute during the active period of the day and 2 is the number of forced respiratory cycles per minute during the rest period of the day.

The additional cancer risk was calculated according to the equation: Theoretical cancer risk= dose*IUR, where IUR=inhalation unit risk

RESULTS

The population sample and the descriptive analysis of the questionnaire and spirometry data

The investigated population sample included 38 subjects, males (15 of them) and females (23 of them), with ages ranging between 20 and 77 years (45% of the subjects between 20-40 years), living in the area of influence of of a factory producing pressed wood products made using adhesives that contain urea-formaldehyde resins. (Table 1-2).

Table 1. *Distribution by gender of the investigated subjects*

Gender	Frequency	Percent %
Women	23	60.53
Men	15	39.47
Total	38	100.00

Table 2. *Distribution by age group of the investigated subjects*

Age (years)	Frequency	Percent %
20-40	17	44.74
40-60	14	36.84
Over 60	7	18.42
Total	38	100.00

Among the 38 subjects that filled in the questionnaire, 4 subjects stated they have chronic bronchitis and all of them were smokers (**Table 4**). One subject (nonsmoker) stated to be suffering of bronchial asthma (**Tabel 3**). As regards the respiratory symptoms and signs, 5 subjects (4 of them, smokers) stated they had

cough more than 3 months a year, and 2 subjects (both of them smokers) stated they had cough for more than 2 years; expectoration was also mentioned by 10 subjects (5 of them smokers), 3 subjects (2 of them, smokers) have mentioned the sensation of suffocation, while 6 subjects (3 of them, smokers) have mentioned dyspnoea. 5 subjects (3 of them, smokers) stated they had wheezing, while a subject, nonsmoker, have mentioned wheezing as a symptom in a respiratory infection.

As regards the pulmonary function test results, 31 out of 38 performed tests had final interpretable results and in the case of 74.2% of the investigated subjects, the results were within the normal range. 4 subjects out of 38 (12.9%) had an obstructive respiratory disfunction, 2 subjects out of 38 (6.45%) had a restrictive respiratory disfunction and other 2 subjects out of 38 (6.45%) had a mixed respiratory disfunction.

Table 3. *Frequency of the bronchial asthma among the investigated subjects by distance from the plant*

Distance from the plant (m)	No. of persons with bronchial asthma (questionnaire)	Smoking (yes /no)	Result of the spirometry
712	1	no	Mixed respiratory disfunction
1057	0	-	-
(1403-1679)	0	-	-
1072	0	-	-
1950	0	-	-
(2825-2835)	0	-	-
(2944-3025)	0	-	-

Table 4 *Frequency of the chronic bronchitis among the investigated subjects by distance from the plant*

Distance from the plant (m)	No. of persons with chronic bronchitis (questionnaire)	Smoking (yes /no)	Result of the spirometry
712	2	yes (30/day, 40 years)	obstructive respiratory disfunction
970			

		yes (20/day, 28 years)	obstructive respiratory disfunction
1057	0	-	-
1403	1	yes (20/day, 30 years)	obstructive respiratory disfunction
1072	0	-	-
1950	0	-	-
(2825-2835)	0	-	-
3025	1	yes (10/day, 10 years)	normal

Formaldehyde measurement results
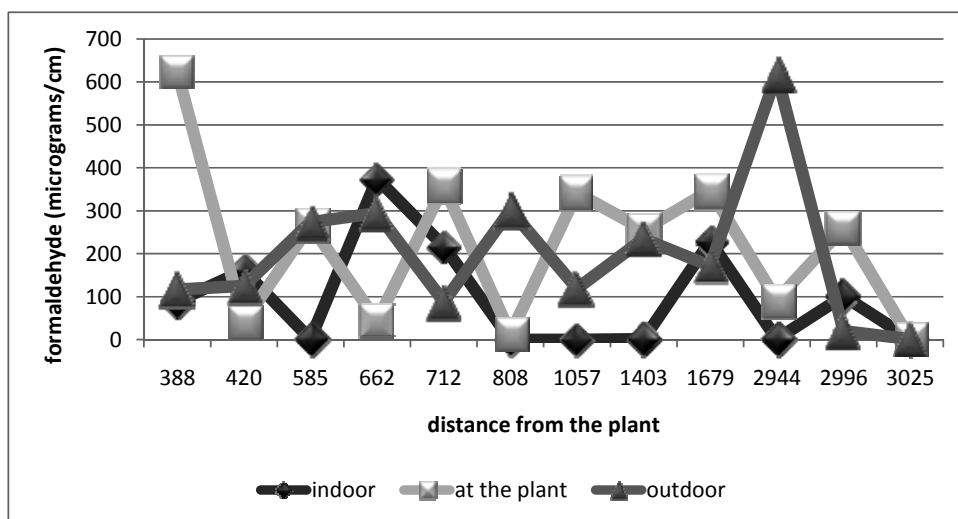
Fig. 1. *Concentrations of formaldehyde at the plant, inside and outside the houses by the distance from the plant*

The formaldehyde concentration measured inside the houses in the area of influence of of a factory producing pressed wood products were higher than those measured outside the houses.

The chart (Figure 1), shows that the formaldehyde concentration inside and outside the houses in the area of influence of a factory producing pressed wood products do not compose a specific pattern by the distance to the plant, as we

don't constantly find only low concentrations of formaldehyde far away from the plant and only high concentrations closer to the plant. Also, there is no obvious overlapping of the lines representing the formaldehyde concentration at the plant and those representing the formaldehyde concentrations inside and outside the houses near the plant, considering the fact that the measurements were performed simultaneously at the plant, inside and outside the houses.

The formaldehyde concentrations measured at the plant ranged between 1.3 and 624 $\mu g/m^3$, the concentrations measured outside the houses in the study area were within 1.3-618.7 $\mu g/m^3$ range and those measured inside the houses in the study area, ranged between 1.3 and 375.1 $\mu g/m^3$ (Table 5).

Table 5. *Mean value, standard deviation, minimum and maximun values of formaldehyde concentrations simultaneously measured indoor, outdoor and at the plant*

Formaldehyde ($\mu g/m^3$)	Mean	Standard deviation	Minimum	Maximum
indoor	117.9	127.3	1.3	375.1
outdoor	197.1	166.6	1.3	618.7
plant	220.4	187.7	1.3	624

The statsitical analysis using liniar regresion models, didn't show a statistically significant correlation between the formaldehyde concentrations simultaneously measured outside the houses in the area of influence of the plant and at the plant, on one hand, and on the other hand, between the formaldehyde concentrations simultaneously measured inside the houses in the area of influence of the plant and at the plant. Also, there was no significant correlation betwen the formaldehyde concentrations measured inside and outside the houses in the area of influence of the plant, suggesting that more probably there are other sources of formaldehyde inside the houses (e.g. furniture etc), acting independently of those from outside. (Tables 6-8).

Table 6. *Liniar regression model testing the correlation between the formaldehyde concentrations measured outdoor and the formaldehyde concentrations measured at the plant*

Formaldehyde outdoor	Coefficient	Standard Error	t	p>|t|	95% Confidence Interval
Formaldehyde at the plant	-0.2561111	0.268696	-0.953	0.363	-0.8548031 0.3425809

Table 7. *Liniar regression model testing the correlation between the formaldehyde concentrations measured indoor and the formaldehyde concentrations measured at the plant*

Formaldehyde indoor	Coefficient	Standard Error	t	p>|t|	95% Confidence Interval
Formaldehyde at the plant	0.0091043	0.2087129	0.044	0.966	-0.455937 0.4741455

Table 8. *Liniar regression model testing the correlation between the formaldehyde concentrations measured indoor and the formaldehyde concentrations measured at the plant*

Formaldehyde indoor	Coefficient	Standard Error	t	p>|t|	95% Confidence Interval
Formaldehyde outdoor	-0.0949597	0.2332801	-0.407	0.693	-0.6147402 0.4248209

Exposure dose and cancer risks using standard input parameters and individual input parameters for calculations

The calculations included in the Tables 9-11 estimate a theoretical excess cancer risk expressed as the proportion of a population that may be affected by a carcinogen (as formaldehyde) during a lifetime of exposure (but the excess cancer risk can be calculated on a specified period of exposure - e.g. 15 or 35 years, by including in risk calculation, the period of exposure). For example, an estimated cancer risk of 1×10^{-6} predicts the probability of one additional case of cancer over background in a population group of 1 million.

The scenario on which the risk to develop a cancer as a result of the exposure to formaldehyde was theoretically estimated by mathematical models, the only available quantitative method to be used in the risk analysis, is the worst case scenario (the probability for this scenario to validate is very low). It has to be mentioned that the cancer risk calculation is based on estimations and the true risk remains unknown and cannot be calculated as there was no information collected on many factors such as genetic, methabolic factors with interindividual variability and also there was no information collected on the contribution of other sources of formaldehyde to which the subjects may be exposed. In the condition of the worst case scenario, the theoretically estimated additional risk cancer in the investigated population group from the area of influence of the plant, were within the range 10^{-6} - 10^{-3}, as orders of magnitude (Table 11).

The Tables 9-10 contain the additional cancer risks calculated for adults, age 19-65, using standard intake rate and the standard body weight of 70 kg, considering the distance to the plant. The calculations showed a higher theoretical risk for those living closer to the plant (388 m) as compared with those living further from the plant (3025 m).

Distance from the plant – 3025 m

Table 9. *Scenario for exposure dose calculation in case of an adult, age 19-65, with standard intake rate and a standard body weight of 70 kg*

Environ metal media	Substance	CASN	Route of exposure	Exposure dose (mg/kg/day)	Cancer Risk (15 years)	Cancer Risk (35 years)
Outdoor air	formaldehyde	000050-00-0	Respiratory	2.82E-04	3.62E-06	8.45E-06
Indoor air	formaldehyde	000050-00-0	Respiratory	2.82E-04	3.62E-06	8.45E-06

Distance from the plant – 388 m

Table 10. *Scenario for exposure dose calculation in case of an adult, age 19-65, with standard intake rate and a standard body weight of 70 kg*

Environ metal media	Substance	CASN	Route of exposure	Exposure dose (mg/kg/day)	Cancer Risk (15 years)	Cancer Risk (35 years)
Outdoor air	formaldehyde	000050-00-0	Respiratory	2.54E-02	3.26E-04	7.61E-04
Indoor air	formaldehyde	000050-00-0	Respiratory	1.94E-02	2.49E-04	5.82E-04

Table 11. *Exposure dose and cancer risks in the worst case scenario using individual input parameters for calculations*

Distance (m)	Subjects description	Exposure dose	Cancer risk (15 years)	Cancer risk (35 years)
388	7 – adult, male, 50 years	2.90E-02	3.26E-04	7.61E-04
	1 – adult, male, 34 years	2.70E-02		
420	8 – adult, male, 62 years	1.33E-02	3.49E-04	8.14E-04
568	18 – adult, male, 24 years	4.88E-02	5.93E-04	1.38E-03
585	15 – adult, male, 20 years	1.01E-01	7.62E-04	1.78E-03
	16 – adult, female, 49 years	6.86E-02		
	17 – adult, male, 53 years	5.59E-02		
662	9 – adult, male, 38 years	6.11E-02	8.22E-04	1.92E-03
712	10 – adult, female, 51 years	5.98E-03	2.45E-04	5.72E-04
	11 – adult, male, 55 years	9.72E-03		
	12 – adult, female, 28 years	2.72E-02		
	13 – adult, male, 29 years	1.86E-02		
713	14 – adult, female, 31 years	1.88E-02	2.51E-04	5.85E-04
	26 – adult, female, 72 years	1.14E-02		
755	25 – adult, female, 54 years	2.77E-02	3.26E-04	7.61E-04
808	20 – adult, female, 38 years	6.47E-02	8.39E-04	1.96E-03
889	27 – adult, female, 33 years	2.76E-02	2.40E-04	5.59E-04
940	21 – adult, female, 50 years	6.04E-02	8.38E-04	1.96E-03
970	38 – adult, female, 55 years	5.19E-02	8.22E-04	1.92E-03
974	22 – adult, male, 65 years	1.05E-01	8.30E-04	1.94E-03
976	19 – adult, female, 55 years	4.78E-02	8.33E-04	1.94E-03
1057	28 – adult, female, 29 years	3.67E-02	3.31E-04	7.72E-04
1072	23 – adult, female, 36 years	3.04E-02	3.31E-04	7.73E-04
1403	32 – adult, male, 56 years	5.90E-02	6.54E-04	1.53E-03
	33 – adult, female, 55 years	3.51E-02		
	34 – adult, female, 76 years	4.07E-02		
1677	30 – adult, female, 61 years	1.63E-02	4.76E-04	1.11E-03
1679	29 – adult, female, 49 years	3.55E-02	4.79E-04	1.12E-03

1950	31 – adult, female, 32 years	7.23E-02	6.55E-04	1.53E-03
2825	3 – adult, male, 41 years	2.87E-02	4.79E-04	1.12E-03
	4 – adult, female, 36 years	5.58E-02		
2835	24 – adult, male, 24 years	3.15E-03	3.06E-05	7.15E-05
2944	35 – adult, female, 34 years	1.95E-01	1.72E-03	4.02E-03
	36 – adult, male, 40 years	1.22E-01		
2982	37 – adult, female, 69 years	8.07E-03	3.26E-04	7.61E-04
2996	5 – adult, male, 66 years	3.17E-03	5.57E-05	1.30E-04
	6 – adult, female, 60 years	3.16E-03		
3025	2 – adult, female, 38 years	3.42E-04	3.62E-06	8.45E-06

DISCUSSIONS

The issue of formaldehyde exposure is long-standing and has been studied over time. Awareness about the health risks of formaldehyde is increasing, and exposure exists for all types of housing across world.

A study conducted in Sweden investigated exposure to formaldehyde in the general population with personal and stationary measurements and simultaneous measurements of individual indoor and outdoor concentrations. Median personal exposure to formaldehyde ranged between 22-23 $\mu g/m^3$, concentrations that are within the guideline value range of 12-60 $\mu g/m^3$ proposed in Sweden. Indoor concentrations were generally slightly higher than personal exposure, while outdoor concentrations were low (Gustafson et al., 2005).

The long-term effects of formaldehyde exposure have been evaluated over time in epidemiologic studies.

The International Agency for Research on Cancer (IARC) has classified formaldehyde as a human carcinogen (IARC, 2006).
Formaldehyde undergoes rapid chemical changes immediately after absorbtion, therefore, some scientists consider that is unlikely for formaldehyde to have effects at other sites than the upper respiratory tract. However, some laboratory studies suggest that formaldehyde may affect the lymphatic and hematopoietic systems (Hauptmann et al., 2003).

Since the 1980s, the National Cancer Institute (NCI) in USA, conducted studies to determine if there is an association between exposure to formaldehyde and an increase in the risk of cancer, most of the studies being conducted in the occupational environment, among professionals who were potentially exposed to formaldehyde in their work (anatomists and embalmers, funeral industry workers). An NCI case-control study among funeral industry workers exposed to formaldehyde found an association between increasing formaldehyde exposure and mortality from myeloid leukemia (Hauptmann et al., 2009).

The results of a cohort study, conducted by NCI, looking at workers in industries with the potential for formaldehyde exposure (Hauptmann et al., 2003) showed an increased risk of death due to leukemia, particularly myeloid leukemia,

among workers exposed to formaldehyde. The risk was associated with increasing peak and average levels of exposure, with the duration of exposure, but there was no association with cumulative exposure. The analysis of the data from an additional 10 years follow up of the same workers (Beane et al., 2009) continued to show a possible link between formaldehyde exposure and cancers of the hematopoietic and lymphatic systems, particularly myeloid leukemia. The risk was highest earlier in the follow-up period and declined steadily over time, so that the cumulative excess risk of myeloid leukemia was no longer statistically significant at the end of the follow-up period. The researchers mentioned similar patterns of risks over time for other hazardous substances known to cause leukemia.

A cohort study of textile workers performed by the National Institute for Occupational Safety and Health (NIOSH) also found an association between the duration of exposure to formaldehyde and leukemia deaths (Pinkerton et al., 2004) while a cohort study of British industry workers found no association between formaldehyde exposure and leukemia deaths (Coggon et al., 2003).

In addition, several case-control studies, as well as analysis of a large NCI industrial cohort (Beane et al. 2009; Hauptmann et al., 2004), have found an association between formaldehyde exposure and nasopharyngeal cancer, while this association has not been found in some other studies.

Based on the epidemiologic data from cohort and case-control studies on one hand and the experimental data from laboratory research, on the other hand, NCI investigators have concluded that exposure to formaldehyde may cause leukemia, particularly myeloid leukemia and nasopharyngeal cancer, in humans.
Other studies investigating the risk associated with formaldehyde exposure were conducted in Canada where formaldehyde has been assessed as a Priority Substance under the Canadian Environmental Protection Act.

Based on the data derived from laboratory studies, exposure by inhalation to formaldehyde under conditions that induce cytotoxicity and regenerative proliferation within the respiratory tract is considered to be a carcinogenic hazard to humans. At airborne levels for which the prevalence of sensory irritation is minimal (i.e., 0.1 mg/m^3), estimated risks of respiratory-tract cancers for the general population are low (Liptelo and Meek, 2003).

Concern has arisen in recent years about formaldehyde exposure as a risk factor for asthma. Formaldehyde exposure was investigated in relation to asthma among young children in a population-based case-control study conducted in Australia. The study found seasonal differences in formaldehyde levels indoors with significantly higher exposure during the summer for cases and controls. The results suggest that domestic exposure to formaldehyde may increase the risk of childhood asthma (Rumchev et al., 2002).

In our study, because of conservative models used to derive IURs, this approach provides a theoretical estimate of risk; the true or actual risk is unknown and could be as low as zero (EPA, 2003). When considering numerical risk estimates, the IURs are generated using mathematical models applied to epidemiologic or experimental data for carcinogenic effects. The mathematical models extrapolate from higher experimental doses to lower environmental doses. Often, the experimental data represent exposures to hazardous substances at concentrations orders of

magnitude higher than concentrations found in the environment. In addition, these models often assume that there are no thresholds for carcinogenic effects - a single molecule of a carcinogen is assumed to be able to cause cancer (ATSDR, 2005).

The estimated values of the additional cancer risks in our study were within the range of values for such risks estimated by the EPA (with the range maximum value of 10^{-3}, as order of magnitude) in the conditions of exposure to the formaldehyde concentrations measured in the air, in the study area.

CONCLUSIONS

1. Formaldehyde concentrations measured inside and outside the houses within the study area, do not define a specific pattern considering the distance to the plant, as we don't find constantly, only low concentrations at larger distances from the plant and only high concentrations at shorter distances from the plant and also, the variation of the formaldehyde concentrations measured inside and outside the houses does not overlap on the variation of the fomaldehyde concentrations measured at the plant, as the measurements were performed simultaneously.
2. The statistical analysis that used the liniar regression model did not show a significant statistical correlation between the formaldehyde concentrations simultaneously measured outside the houses and at the plant and also, there was no correlation between the formaldehyde concentrations simultaneously measured inside the houses and at the plant. There was no correlation between the formaldehyde concentrations simultaneously measured outside and inside the houses, sugesting the presence of other sources of formaldehyde inside the houses.
3. Among the 38 subjects participating in the study, 4 stated in the questionnaire they have chronic bronchitis and all of them were somkers. One subject out of 38, nonsmoker, stated she has bronchial asthma.
4. The pulmonary function tests showed that for 74% of the investigated subjects, the results were within the normal range and in the case of 26% of the subjects, a respiratory disfunction was diagnosed.
5. In the worst case scenario, the additional estimated cancer risk, as a result of formaldehide exposure of the investigated population group in the surroundings of the plant, were between 10^{-6} and 10^{-3} as orders of magnitude.

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THE ENVIRONMENTAL MONITORING IN MINING AREAS BETWEEN DIRECT INVESTIGATIONS AND REMOTE SENSING – THE IMPACTMIN PROJECT

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ABSTRACT. The scientific challenge of the ImpactMin project is to use cutting-edge remote sensing technologies to develop cost-effective, reliable and repeatable approaches for monitoring the impact of mining activities on the environment through time. This monitoring method will be used to identifying, predicting and preventing potentially serious consequences for the natural and human environment. The project will combine the satellite/aerial remote sensing technology with ground investigations. The proposed methods following will be validated on four demonstrative places in Sweden, Bosnia-Herzegovina, Romania and Rusia. The targets of interest on the surface include various organic compounds, large gaseous or aerosol emissions, acid-drainage or heavy-metal carrying sludge, while the water elements include phytoplankton, non-algal particles, hydrocarbon occurrences and chromophoric dissolved organic matter (CDOM) as well bottom substrate type and water depth.

Keywords: *mining areas, environmental monitoring, remote sensing, hyperspectral measurements*

1. INTRODUCTION

Mining is an irreplaceable economic activity that provides raw materials to most of the industries. However, in many cases mining has significant negative impact on the environment. If appropriate measures are not taken, abandoned mining sites are affected by serious environmental problems that may generate negative consequences on the human health.

Some of the negative effects of mining that may occur under such circumstances are the following (Fodor, 2006):

- Contamination of surface and groundwater with heavy metals and toxic chemicals that have been used in the technological processes;
- Pollution of soil, especially with heavy metals, and diminution of its fertility for many years;
- Air pollution during windy periods, related to the mobilization of the fine fraction from waste dumps and tailings deposits;
- Deterioration of the vegetation's health on large areas of land;
- Mass movements and slides on waste dumps, tailings ponds, exposed slopes, that may generate accidents with serious consequences.

Assessing the state of the environment in such areas and quantifying the environmental impact of the ongoing or past mining operations is a very complex task. Over large areas, many monitoring points have to be established and an appropriate sampling and analyzing protocol should be setup. Thus, monitoring the quality of environmental factors by direct measurements with dedicated devices or laboratory analysis of collected samples takes time and involves substantial costs. In addition, health monitoring of vegetation by field observations on large areas around the mining sites is difficult and does not provide complete data.

In this context, the question arises whether a method can be developed by using new remote sensing technologies, in order to obtain cheap, reliable, and reproducible information on the identification, prediction, and prevention of effects on humans and the environment. Remote sensing images can provide information about environmental impact on areas much larger and in a much shorter time than can be done by classical field/lab methods.

Remote sensing applications in geology and mineralogy are multiple. A variety of techniques including both aerial and ground-based (LiDAR) laser scanning data, InSAR, satellite imagery and digital photogrammetry can be used for a range of geological and geomorphological applications including monitoring of temporal change in rock outcrops, spatial modelling, rock mass characterisation and generation of hazard maps. Remote sensing can provide direct (e.g. subsidence, soil movement by SAR) and indirect (e.g. vegetation health) information relevant to mining operations, at a special resolution of 1 to 2 m (Christiansen et al, 2001). The SAR interferometry (InSAR) can provide a geographically comprehensive map of the deformation, with a sampling rate far denser than the most detailed surveys. It is quicker, less labour intensive and hence less expensive compared to the conventional ground-based survey methods (Ng et al, 2008).

A combination of remote sensing and surface measurements has provided useful data and information for important environment externalities such as monitoring pollution incidents and contaminant transport from mining operations (MINEO project), using LANDSAT satellite.

ASTER data has been extensively used for mapping gold and base-metal mineralization through alteration mapping (Moore et al, 2008). Two different methods are used for argillic and silicic alteration mapping: selective principal-component analysis and matched filter processing. Mapping hydrothermal clay-sericite alterations, associated with gold mineralization by processing ASTER imagery data and ETM LANDSAT data has proven to be very efficient (Haroni and Lavafan, 2007).

2. EXPERIMENTAL APPROACH

2.1. General presentation of ImpactMin project

A research project with the title „Impact monitoring of mineral resources exploitation – ImpactMin" is currently running with financial support from the European Commission, under the Seventh Framework Programme (FP7). Eleven institutions from different countries from Eastern and Western Europe are collaborating within the ImpactMin consortium (www.impactmin.eu). The aim of the project is to develop new methods and tools for monitoring the environmental impact generated by the mining operations. This new approach is based on Earth Observations, by using in an innovative manner the satellite remote sensing, aerial lightweight measurements,

and unmanned aerial vehicles. State-of-the-art data processing and analysis techniques will be used with the purpose to properly describe the current situation and to predict the future changes. The new techniques will be validated at four demonstration sites: Kristineberg in Sweden, Mostar in Bosnia & Herzegovina, Rosia Montana in Romania, and Orenburg region in Russia.

Kristineberg (Sweden)

Kristineberg demo-site is located in northern Sweden, about 175 km south-west of Lulea. The mining operations started in 1918 and gradually developed by opening mines in a few points for extracting zinc, copper, and lead. An ore mill was in function until 1991, when tonnage decreased. Currently the ore is transported by trucks to the Boliden concentrator. Five tailings ponds and three open pits are visible in the area (fig. 1).

Fig. 1. *Mining area of Kristineberg, Sweden (GoogleEarth image).*

The remote sensing data in Kristineberg area will be derived from orthophotos and from images taken by the UAVs. The study will assess the ecological resilience in time and space.

Mostar region, Bosnia &Herzegovina

The main objective to be investigated in Mostar region is the former Vihovici coal mine, currently under rehabilitation. The mine was active from 1901 to 1991, and 11 million tons of brown coal were extracted. During the war and even afterwards, the mine was used as a solid waste dump. A combined high-resolution hyperspectral/ gamma-ray survey is scheduled for the area of the abandoned brown-coal mine.

Fig. 2. *Mining area of Mostar, Bosnia-Herzegovina (GoogleEarth image).*

Rosia Montana region, Romania

Rosia Montana region (fig. 3) presents a complex geological-mining-environmental interaction after over two millennia of surface and underground mining and milling operations.

Fig. 3. *Mining area of Roşia Montană, Romania (GoogleEarth image).*

Rosia Montana mining district, located in the Apuseni Mountains in Transylvania, Western Romania hosts a renowned gold and silver deposit, one of the most important in Europe. It belongs to a region known as the Golden

Quadrilateral in the Apuseni Mountains. In the last 2000 years, the ore was traditionally mined underground, in galleries of various shapes and dimensions. The underground operation ceased in 1970, when an open pit mine started to develop in Cetate and Carnic areas. As much of the high grade ore veins were previously exploited by galleries, the remaining material has relatively low contents of gold. Under these circumstances, the mine was largely subsidized by the Romanian State until 2006, when it was closed.

The altitudes in the study area range between 670 m (Abrud River) and more than 1000 m (Carnic hill).

Rosia Montana gold-bearing geological structure is very close to Rosia Poieni, where a porphyry-copper massive ore body occurs. In spite of their proximity, no genetic link was documented between the two structures. Four gold and silver ore bodies were intensively investigated by Rosia Montana Gold Corporation (RMGC) in the last years: Cetate, Carnic, Orlea, Jig. More than 140 km of galleries dating from different ages in the last 2000 years are known (fig. 4).
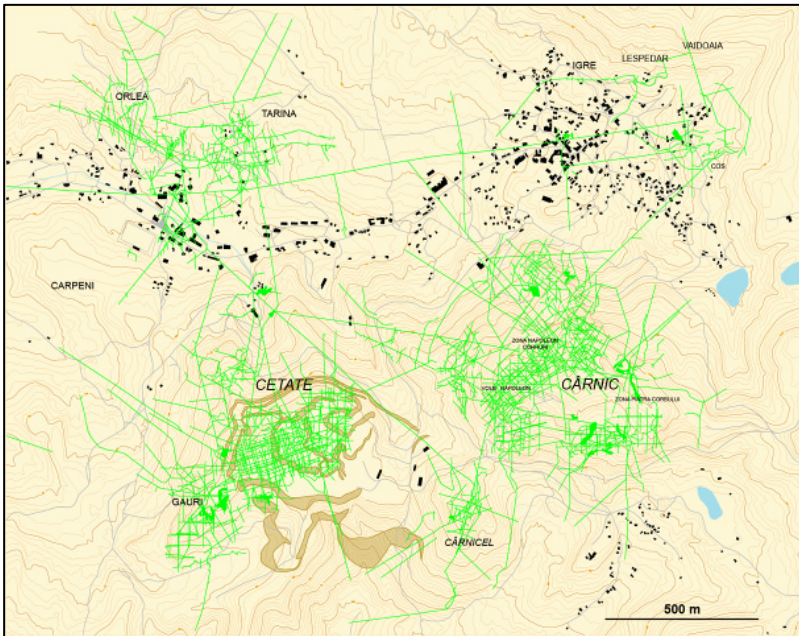
Fig. 4. *Ancient mining galleries in Rosia Montana area (RMGC database).*

The investigation techniques to be used in Rosia Montana are satellite remote sensing combined with ground spectral measurements.

Orenburg region, Russia

In certain areas of Orenburg region (fig. 5), pollution from past and current mining-related activities is known to heavily impact the environment and the human health.

Areas of mining activities in Orenburg region are:

Fig. 5. *Mining area of Orenburg, Russia (GoogleEarth image).*

- Karabash, specific area of taiga vegetation, situated in the district of Chelyabinsk, where they are a copper smelter and several abandoned mines, tailings ponds, waste dumps and stocks of concentrates;
- Uchaly area, forest-steppe border in the Republic of Bashkortostan, where they are both active and abandoned quarries, two open pits with depths of 250-360 m and a dark flooded quarry with a depth of 85 m;
- Sibay, area in the forest-steppe and steppe in the Republic of Bashkortostan, where they are both active and aban-doned mines, waste dumps, ponds, stocks of ores and concentrates;
- Gay, the steppe area of Orenburg district, where there are both active and abandoned mines, waste dumps, tailings ponds, stocks of ore and concentrates;
- Mednogorsk, mountain steppe area, where there is a copper smelter and several abandoned mine workings, waste dumps and stocks of concentrates.

2.2. Calibration and validation

The images obtained will be expressed by means of spectral values (digital numbers), integer values ranging from 0 (black) to 255 (white), which are different from one spectral band to another (Clark et al, 2002; Richards and Jia, 2006; Mihai, 2009). Each spectral class is formed by a group of color pixels that have the same spectral band. The purpose of classification of digital images, in other words sizing method, is to assign to each pixel of the image (Fig. 6A) a significance in the database, resulting in an image as a mosaic of pixels (Fig. 6B), each belonging to a particular indicator (e.g. hematite).
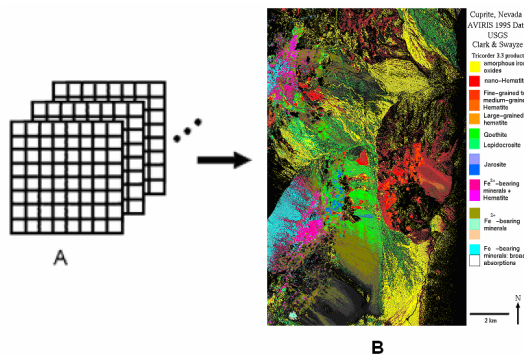
Fig. 6. *Pixel classification using samples (after USGS).*

Samples of surface, subsurface and stream sediments will be collected at all demo-sites for spectral analysis with dedicated devices needed for the calibration of the Remote Sensing data and for systematic mineralogical characterization of the surface materials. Figure 7 presents an example of the spectral signatures of various minerals from soil (Clark et al, 1993).
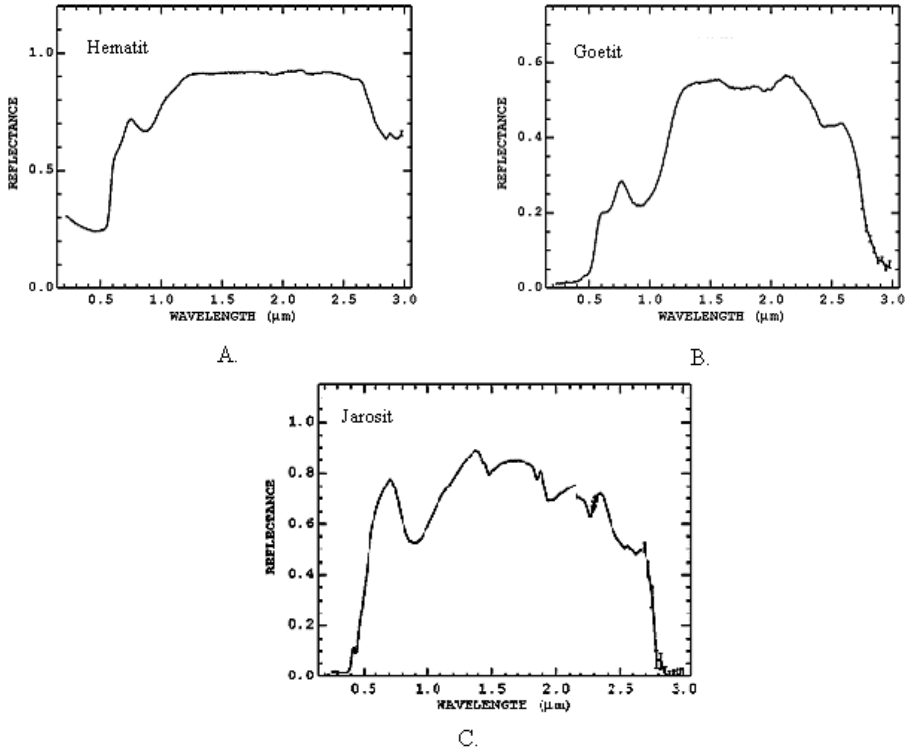
Fig. 7. Spectral signatures: hematite (A), goethite (B) and jarosite (C) (Clark, 1993).

The next step is the comparison between the results of spectral measurements carried out on the ground and those of satellite/air measurement. If there are differences, additional corrections are necessary, based on a multiplier for each spectral band separately. After applying the correction, the spectra should be similar (Clark, 2002).

3. CONCLUSIONS

Monitoring the quality of environmental factors by direct measurements with dedicated devices or laboratory analysis of collected samples takes time and involves high costs too. In addition, health monitoring of vegetation by field observations is difficult and does not provide complete data. Using a combination of satellite remote sensing, aerial lightweight measurements and Unmanned Aerial Vehicles (UAVs) can be developed a new method for monitoring the impact of mining activities on the environment through time to predict and prevent potentially serious consequences for the natural and human environment.

The developed method will be sufficiently flexible to operate under different circumstances at acceptable cost and will monitor relatively small changes through time.

The ImpactMin project will develop further operational training course, will provide a practical education on the use of remote sensing of impact assessment in mining areas and information in application development projects and initiatives for professionals and mining sectors using Earth Observations.

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THE DYNAMIC MOVEMENT OF THE POPULATION OF PHYLLAPHIS FAGI IN THE FORESTS OF BEECH FROM THE UPPER BASIN OF THE DOAMNEI RIVER

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ABSTRACT. *Phyllaphis fagi* is an aphid, frequently encountered in the beech forests in our country. During a whole year it presents a succession of asexual and sexual generations. The attack is strong in spring when on the back of the beech leaves whitish colonies are formed. The collecting of the field data allowed the determination of the type of distribution, the determination through calculation of the number of the testing units, the density, the numerical evolution of the population in the tested surfaces, the coefficient of multiplication, the frequency of the attacked leaves compared to the number of individuals on each leaf, the accomplishment of a correlation between the climatic factors and the dynamic movement of the population.

Key words: *The Doamnei River, pest insects, beech, Phyllaphis fagi.*

INTRODUCTION

The research of the pest insects in the beech forests was done in the hilly area of the village of Pietosani (in the Arges district) in the period 2008-2009. In the hilly area of the village of Pietosani there are different types of forests: beech groves, locust trees, spruce groves (Fig. 1). The dominant species is the beech; the oak, the locust trees, the spruce form either insular clusters of different sizes or transversal strips along the hill within the beech groves. This kind of settlement is due to some reafforestation that took place 57 years ago. Within the studied area, together with *Phyllaphis fagi* other species like *Mikiola fagi* and *Orchestes fagi* have been identified and these plus other biotic and abiotic factors contributed to the drying of the beech (Chira, 2003). *Phyllaphis fagi* is a species which during a whole year alternates asexual and sexual generations. Within the asexual generations we identify: the fundatrix represented by the wingless females having a dimension of 2-3 mm and a light green or light yellow colour and also some darkspots on the back. Their body is covered with white waxy filaments which are secreted by their own body. These parthenogenetical give birth to some wingless females called fundatrigenes. These fundatrigenes are alike the fundatrix but have a smaller dimension. The same, these parthenogenetical form wingless and winged females which migrate and generate new attacks. In autumn a sexual even generation appears, also parthenogenetical and it lays big eggs from which wingless females and winged males emerge (Fig. 2). After the mating, the females lay 10-15 resistance eggs (for winter) and the cycle

starts again (Marcu, 1995). The attack is strong in spring when on the back of the beech leaves whitish colonies are formed (Fig. 3). Having a buccal cavity adapted to stinging and sucking they feed on leaves sap. During the strong attacks the leaves become black due to some mould which lead to the decrease of the productivity (Thomas, 2000). During the summer attacks the leave appears perforated which has as a result the reducing of the foliated surface and from here that of the photosynthesis (Fig. 4).

Fig. *1.* *Image taken from a satellite of the researched area.S1, S2, S3-points of taking datas along the way. M=spruce groves; ST=oak forest; SL=locust trees.*

Fig. *2.* *Winged male.*

Fig. 3. *Colony of Phyllaphy fagi*

Fig. 4. *The drying of beech leaves*

METHODS AND STUDYING TECHNIQUES

The research of the insect has been done in a beech forest along an area that surrounded the skirt of the Stufoasa forest (in the village of Retevoiesti, Arges) and also the trees in the massif. Along this research surface three stations of taking tests have been established. Each testing surface was limited to 100 m^2. The tested surface is exposed south and it is occupied by a young beech grove. The tested surface limited in the middle of the way has a south exposure and it is occupied by beech trees having a medium dimension compared to those at the skirt of the forest and those in the massif. The tested surface in the massif has a west exposure and

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it is occupied by a mature and vigorous beech grove. The gathering of tests has been weekly done starting with the 15th of May till the 17th of September. From the limited surfaces branches of leaves (5) picked randomly were taken from the inferior third. On each branch the insects were counted on the first 20 leaves and from the obtained data the following were determined: the type of distribution, the determination through calculation of the number of tested units, the density, the numerical evolution of the population in the three tested surfaces, the coefficient of multiplication, the frequency of the attacked leaves reported to the number of individuals on a leaf.

RESULTS AND DISCUSSIONS

The drawing of the data from the working field was weekly accomplished in the three points of the area. In the three tested points which are different from the point of view of the age of the trees and the kind of exposure different numerical values of the population of Phyllaphy fagi were registered. In the calculation of the statistic data, the results obtained on the 15th of June 2008 in the middle of the area were used.

Starting from these data we determined the average of individuals on a leaf, the deviation of the average, the variation, the standard deviation, the number of the tested units, the type of distribution (Table 2). Taking a leaf as tested surface the density in the three points was monthly determined in 2008 and 2009 (Table 3).

Table 1. *Numerical data*

X	0	1	2	3	4	5	6	7	9	11	12	14	16	18	20	30	40	42	58
f	27	30	8	3	5	5	5	2	4	3	3	1	1	3	2	1	1	1	1

X=the number of individuals/ tested unit (a leaf); f=the number of units that had 0,1,2,3,…individuals.

Table 2. *Statistic data obtained for Phyllaphis fagi*

The average of individuals per leaf	Standard error of the average mean	Variance	Standard deviation	Determination of number of sample units	Distribution type
5.24	0.53	29	5.38	26	Grouped

Table 3. *The density of the population*

Months	Densitatea					
	Skirt		Middle of transect		Massive	
	2008	2009	2008	2009	2008	2009
May	3.6	3.78	5	0.35	2.29	0.04
June	5.49	2.71	5.09	0.87	2.1	0.09
July	4.02	2.58	3.39	0.89	0.74	0.11
August	2.32	1.6	0.5	0.34	0	0.02

From the analysis of the table we notice that the maximum density was accomplished in June at the skirt of the forest. Starting with the month of June the population registers a numerical decrease in all the points of the way. The least densities were realized in the massif. These differences are due to the different exposure of the trees but also to the different ages of the trees in the three tested points. The numerical evolution of *Phyllaphis fagi* during the year 2008 was weekly followed on the three tested surfaces starting with the month of May. By analysing the chart (Fig. 5) we notice that in the months of June and July, in the skirt and in the middle sudden increase and decrease of the number of population took place. The maximum number of individuals was registered in the skirt of the forest on the 15th of June. After the 20th of July a sudden numerical decrease is noticed in all the three points.
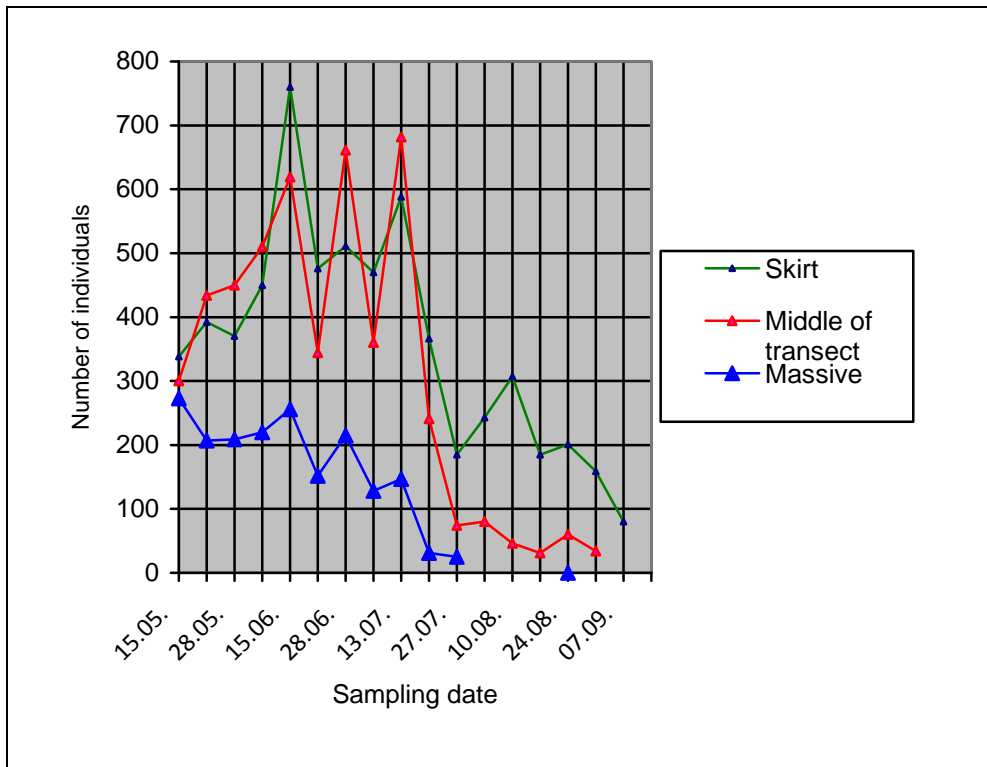
Fig. 5. *Numerical evolution of Phyllaphis fagi population during 2008*

The numerical evolution of the population of attacked during the year 2009 was weekly followed in the three tested points of the area starting with the 15th of May. Comparing the results with those from the year 2008 in 2009 there weren't noticed any sudden increase or decrease of the population (Fig. 6). The maximum number of individuals was also noticed at the skirt of the forest on the 30th of May. The effective of the population registered less values than the year before.
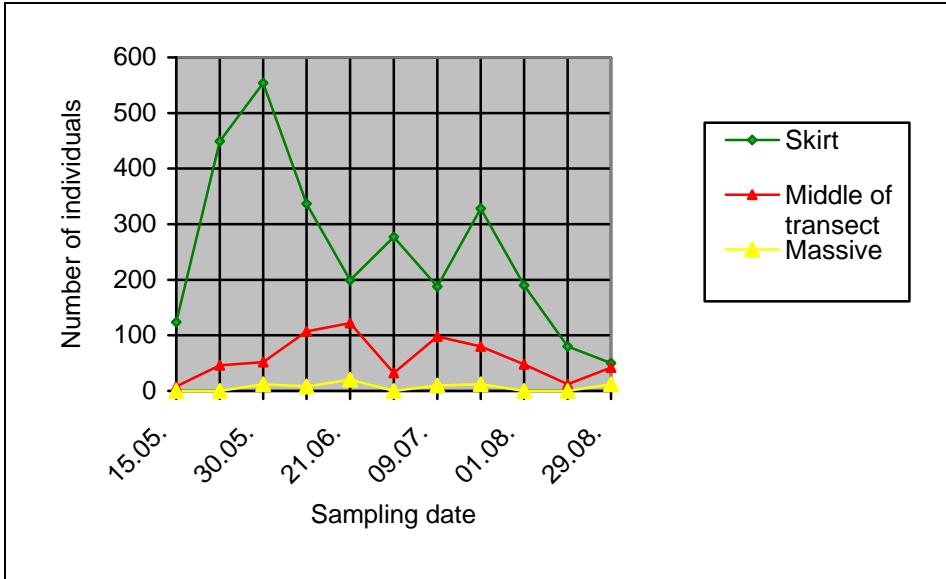
Fig. 6. *Numerical evolution of Phyllaphis fagi population during 2009*

Fig. 7. *Population progress curves in 2008 and 2009*

Adding the number of individuals registered at a certain point in time in all the three tested locations, we realized the population evolution curve for the years 2008 and 2009. From the analysis of this figure (Fig. 7) which contains the number of individuals during each decade of the months May, June, July, August we notice that the population present two peaks along a year. The first numerical increase of the population takes place at the end of May and the beginning of June and the second one at the end of July and the be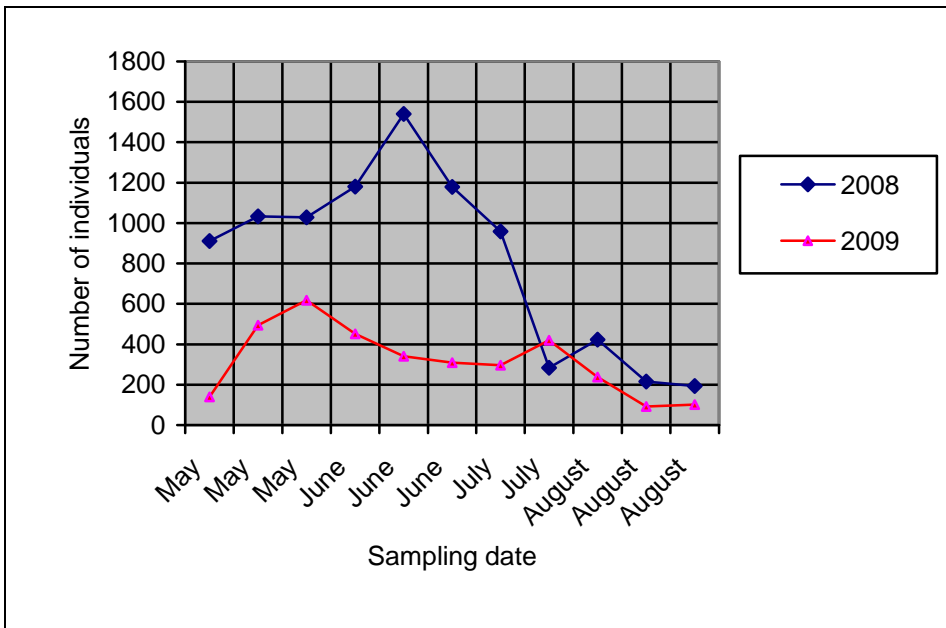ginning of August. The second increase coincides with the appearance of the sexual generation which lays resistance eggs. The dynamic movement of the population of *Phyllaphis fagi* was also followed under the influence of the climatic factors: temperature and rains. In order to describe the climatic conditions in the researched area we accomplished a climatic diagram of Walter and Lieth type which shows the very humid periods, the humid periods, the dryness periods and those of drought. Unlike the original type of climatic diagam which is realized starting with the monthly average temperatures and the monthly sum of rains, the actual climatic diagram has as a basis the average temperatures and the sum of rains for each decade of May, June, July and August. By correlating the population evolution curve with the climatic factors we notice that the peaks of the increase of the populatin coincides with the wet periods and the numerical decrease with the periods of dryness and drought (Fig. 8). The thermic optimus for the development of the asexual generation is between 16.4-18.4 centigrades and for the sexual generation between 21.4-21.6 centigrades.

Fig. 8. *Climatediagram of Walter and Lieth type for Retevoieşti in 2008*

These data confirm the experienced results obtained by Iversen and Harding (2007) who studied the development of the species at different temperatures in laboratory conditions. At the level of the skirt of the forest, the frequency of the leaves attacked by *Phyllaphis fagi*, considering the number of individuals per a leaf, shows that 26% of the leaves have zero individuals and the rest have a number between 1 and 45 individuals (Fig. 9). A high percent of leaves have between 1 and 8 individuals. Once we advance to the massif the percent of leaves with zero individuals increases (41%). During the period of the research there were identified leaves containing over one hundred individuals.
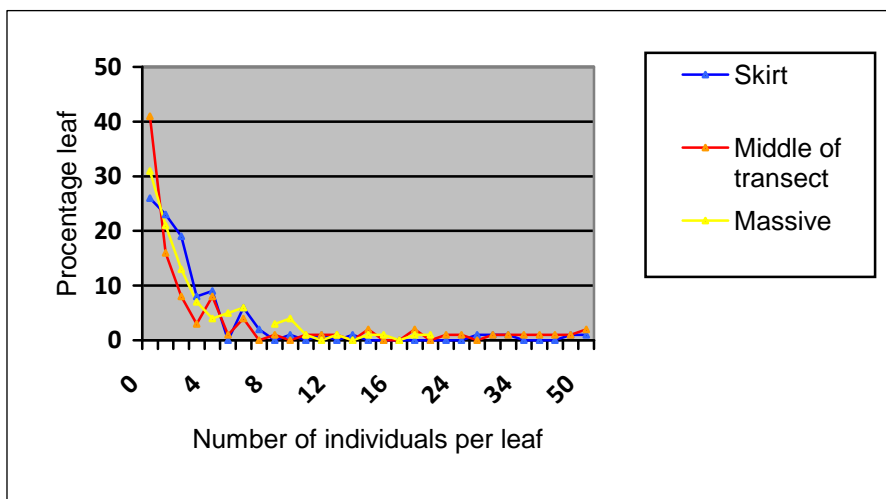
Fig. 9. *The frequency of the leaves attacked by Phyllaphis fagi, after the number of individuals per leaf, on the 15th of May, in all the three points of the research*

CONCLUSIONS

The research of the insect called Phyllaphy fagi was accomplished in a beech forest in a region with three tested zones, in the period 2008-2009.the species has been identified in all the three points in all the researched trees, but the intensity of the attack proved to be different. At the skirt of the forest, whish has a south exposure and where the trees are young the attack is strong. Here the maximum number of individuals was registered. The intensity of the attack decreases as we go to the massif where the trees are mature. The curves of the evolution of the population show the presence of two high peaks: one at the end of May and the beginning of June and the other at the end of July and the beginning of August. The diagram of Walter and Lieth type realized for the decades of May, June, July and August show the existence of a correlation between the climatic factors and the evolution of the population. The numerical increase of the population coincides or is preceded by the humid periods and the numerical decrease is associated with the periods of dryness

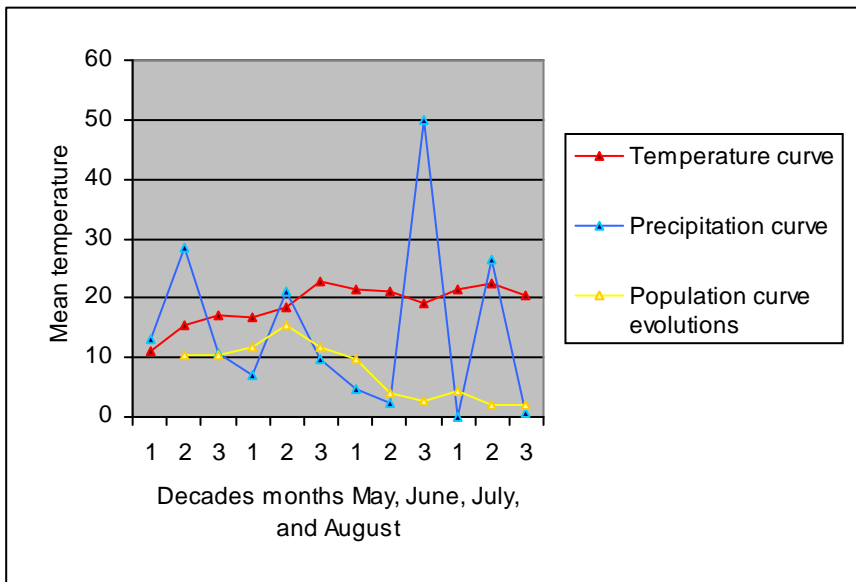and drought. The thermic optimus for the development of the asexual generation is between 16.4-18.4 centigrades and for the sexual generation between 21.4-21.6 centigrades. At the level of the skirt of the forest, the frequency of the leaves attacked by Phyllaphy fagi, considering the number of individuals per a leaf, shows that 26% of the leaves have zero individuals and the rest have a number between 1 and 45 individuals. A high percent of leaves have between 1 and 8 individuals. Once we advance to the massif the percent of leaves with zero individuals increases. In 2009 the intensity of the attack was weaker than in 2008 although the climatic conditions were almost the same. This difference is explained by the low temperatures in the last decade of the month of April when negative temperatures were registered. The coefficient of the increase of the population was of 0.74. Phyllaphy fagi regisres in good climatic conditions significant numerical explosions which altogether with other biotic factors contributes to the drying of the beech.

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SIGNIFICANCE OF EFFECTIVE EARLY WARNING SYSTEMS FOR COMMUNITY AND ENVIRONMENTAL SAFETY

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ABSTRACT. Natural and technological hazards are responsible for significant material damage and have caused the loss of many human lives along the time. Effective emergency response can avoid the escalation of an event into a disaster. Disaster impacts may include loss of life, injury, disease and other negative effects on human physical, mental and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation.

The term ''early warning'' occurred during the cold war to describe a military strategy which prevents the potential threat from ballistic intercontinental missiles. These early warning systems (still operational) were designed to alert target areas as soon as a missile was detected by a radar setup or a launch discovered by a satellite system. Nowadays, early warning systems are designed for epidemiological, economical, social, and for all the types of natural and environmental risks.

Early warning system is a set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities, and organizations threatened by a hazard to prepare and to act appropriately and in due time to reduce the possibility of harm or loss. The objective of early warning is to enable individuals and communities threatened by natural or similar hazards to act in due time and in an appropriate manner so as to reduce the possibility of personal injury, loss of life and damage to property or fragile environments.

Key words: *early warning systems, emergency response, risk assessment.*

INTRODUCTION

Along the time, natural and technological hazards have been responsible for great material damage and have caused the loss of many human lives. Also, they sometimes caused highly brutal and destructive disorders in certain systems which had a huge negative impact upon the economic and social development of local communities.

The human society and the environment are often exposed to extremely dangerous phenomena which might have different origins, be they natural or anthropic.

These events (powerful earthquakes, volcanic eruptions, landslides, violent storms, floods, droughts, fires, technological accidents, conflict situations, etc.) regularly occur without warning. They destroy numerous villages, devastate the land used in agriculture, damage the infrastructure and can cause many casualties in the ranks of the affected communities. Other common results of such phenomena are large material losses, ecological unbalances and severe effects on the local population.

The magnitude and frequency of hazards are continually following an ascending trend, directly correlated with the expansion of populated areas, especially within the hazard's area of influence.

One only has to look back a couple of years to find a large diversity of destructive events such as: major earthquakes in the USA, Japan, Armenia, Iran, Egypt, Turkey, Salvador and India; tropical cyclones in the Caribbean region and violent storms on the European Atlantic coastline; vast floods in Bangladesh, Pakistan and the Mississippi region in the USA, volcanic activity in the Pacific perimeter and the Mediterranean Sea (Sicily); technological disasters like the explosion of the sewage system of Guadalajara (Mexico) and public and social disputes in Kuwait, Kurdistan, Somalia, Mozambique etc.

HISTORY OF NATURAL AND TECHNOLOGICAL ACCIDENTS

At global level, during the last 35 years, the number of catastrophes has constantly increased, recording faster pace at the end of the 80's, with the recurrence of extreme events, both natural and technological.

Over the last 3 decades statistics have shown that, at planetary level, various disasters have accounted for the loss of 8 million people and have also caused disease and suffering for 1 billion people as well as great material loss, worth hundreds of billions of dollars. Each year, an average number of 25,000 deaths are caused by disasters and about 3 billion dollars of material losses are attributed to them.

Statistics also reveal that each year, about 180 catastrophes occur, excluding the accidents related to transport issues, while this number was as low as 100 in the early 70's.

Considering the distribution of catastrophes over the last 35 years it is clearly visible that the largest percentage is that of natural catastrophes (66%) and the rest (34%) is of anthropic origins. When referring to the number of casualties, the most life threatening are earthquakes (~41% of the total number of victims), followed by floods (30%), cyclones and tropical storms (14%), volcanic activity (2%) and the remaining 13% are due to anthropic events.

According to the Disaster Epidemiology Research Center (DERC), 326 natural disasters and 259 technological catastrophes have been reported globally in 2008, with these being the smallest numbers of the current decade. However, the number of deaths was 235,736, topped only by the number of fatalities from 2004 which was 241,635 (the main cause being the Indian Ocean Tsunami).

In 2008, Nargis Cyclone left 138,366 people dead or missing in Myanmar and the earthquake of Sichuan killed 87,476 people in China. These two disasters accounted for 93% of all casualties. The number of people deceased in technological catastrophes is the smallest of this decade (6,926) with over 76% of fatalities being

attributed to transport accidents. The total number of people affected by natural disasters remained the same as in the previous year (213 million) and below the 10 year average of 270 million. The extreme winter conditions in China affected 77 million people, which add up to about one third of the total number of people affected by natural disasters. The earthquake of Sichuan affected 46 million people, major floods in the USA impacted 11 million people, while the drought in Thailand about 10 million people. Another 19 major natural disasters affected between 1 and 8 million people each, with eleven of these having occurred in Asia, 5 in Africa and 3 in the Americas.

By comparison one can see that technological disasters were responsible for the smallest number of affected people (about 39,000), this being the smallest number of the decade. Over 50% of these were attributed to diverse accidents. The cost of destructions in the USA topped at about 181 billion US dollars.

In 2009, 335 natural disasters were reported globally. These were responsible for the death of 10,655 persons and have taken their toll on more than 119 million, while also provoking over 41.3 billion dollars worth of damage. The lack of natural catastrophes with a huge impact on humans in this year, the so called "mega catastrophes", was reflected in the decrease in the number of fatalities and material loss as compared to the 2000 – 2008 period (Figure 1).
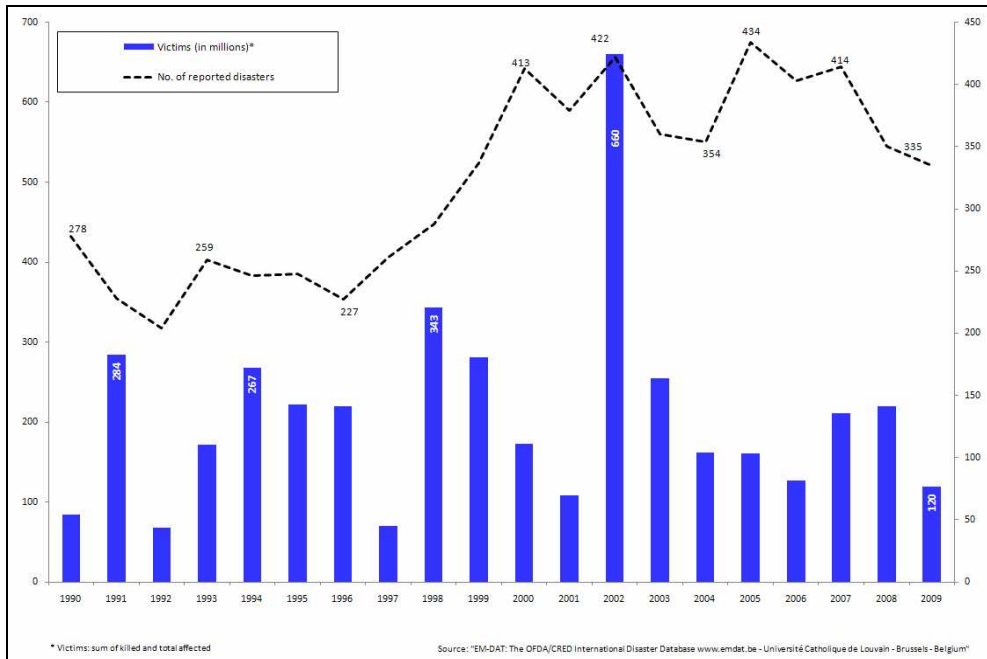

Fig. 1. *Number of fatalities per disaster (Source: OFDA/CRED, 2005)*

Recent world events have increased public awareness regarding the need to prepare for catastrophic events. However, it is important to recognize that disasters caused by periodic natural phenomena and human activity, occur each year, affecting large portions of the world's population.

Every year, disasters affect tens of millions of people, cause economic losses of tens of billions of dollars, and kill tens of thousands of people. Disaster response requires planning and preparation to ensure adequate policies, a viable plan of action, sufficient emergency supplies, and appropriately skilled personnel.

HAZARDS, VULNERABILITY, DISASTERS AND RISK REDUCTION

A crisis or emergency is a threatening condition that requires urgent action. Effective emergency action can avoid the escalation of an event into a disaster. Emergency management involves plans and institutional arrangements to engage and guide the efforts of government, non-government, voluntary and private agencies in comprehensive and coordinated ways to respond to the entire spectrum of emergency needs (UNISDR, 2009).

Disaster is a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources. Disasters are a result of the combination of: the exposure to a hazard; the conditions of vulnerability that are present; and insufficient capacity or measures to reduce or cope with the potential negative consequences. Disaster impacts may include loss of life, injury, disease and other negative effects on human physical, mental and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation.

Vulnerability is determined by characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. There are many aspects of vulnerability, arising from various physical, social, economic, and environmental factors. Examples may include poor design and construction of buildings, inadequate protection of assets, lack of public information and awareness, limited official recognition of risks and preparedness measures, and disregard for wise environmental management, varies significantly within a community and over time.

Disaster risk is the potential loss of lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period. This disaster risk definition reflects the concept of disasters as the outcome of continuously present conditions of risk. Disaster risk comprises different types of potential losses which are often difficult to quantify. Nevertheless, with knowledge of the prevailing hazards and the patterns of population and socio-economic development, disaster risks can be assessed and mapped, in broad terms at least.

Natural hazards, such as storms, droughts, volcanic eruptions, or earthquakes, need not spell disaster. A disaster occurs only if a community or population is exposed to the natural hazard and cannot cope with its effects. Heavy rainfalls in the middle of an ocean will not cause a disaster, but the same heavy rainfall on a vulnerable population – say a shanty town on the side of a hillside stripped of trees - may result in landslides and severe life losses. A minor drought may cause a famine if a region's agricultural production is highly stressed by civil war. Vulnerability is the potent additive that mixes with natural hazards to cause disasters.

DISASTER RISK REDUCTION

The concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events. A comprehensive approach to reduce disaster risks is set out in the United Nations-endorsed Hyogo Framework for Action, adopted in 2005, whose expected outcome is "the substantial reduction of disaster losses, in lives and the social, economic and environmental assets of communities and countries".

The increased vulnerability of many communities suggests that local practices and the socio-economic conditions threatened by natural hazards need to be studied so that warnings may contribute to the reduction of risks. While natural disasters affect all countries, they have a disproportionately greater impact on developing countries, including countries with emerging economies, those with economies in transition and those with special circumstances.

Good governance, or the proper management of public affairs, includes the protection of the public from disasters through the implementation of disaster risk reduction policies. Although natural disasters, by definition, cannot be prevented, their human, socio-economic and environmental impacts can and should be minimized through appropriate measures, including early warning and preparedness.

Public authorities can benefit from a better understanding of the importance of early-warnings. The necessity of wise management of the environmental conditions the societies depend on is apparent as early-warning systems take full account of the relationships among natural hazards, social vulnerability and environmental conditions in local communities.

Concept evolution

In 1989, the member states of the United Nations declared the period from 1990 to the year 2000 to be the International Decade for Natural Disaster Reduction (IDNDR). Its objective is to "reduce the loss of life, property damage, and social and economic disruption caused by natural disasters, through concerted international action, especially in developing countries" (IDNDR, 1997).

The fundamental importance of early warning for realizing this objective of disaster reduction was recognized in 1991. The IDNDR's Scientific and Technical Committee declared the subject a program target, by which the success of the Decade would be judged by the year 2000.

The critical nature of early-warning for the protection of vital resources and for addressing national development objectives was highlighted by a technical committee session devoted to the subject at the United Nations' World Conference on Natural Disaster Reduction held in Yokohama, Japan in May 1994. Several of the expert presentations cited the importance of public policy commitment for successful early warning. The primary outcome of the Conference, The Yokohama Strategy for a Safer World: Guidelines for Natural Disaster Prevention, Preparedness and Mitigation further emphasized the importance of applied scientific knowledge and the public awareness of hazard risks as essential components for more effective early warning practices.

The IDNDR Secretariat was requested by the United Nations General Assembly in 1995 to coordinate a review of the existing early warning programs and to suggest means by which global practices could become better coordinated and made more effective. Initial information was conveyed by the Secretary General's Report on Early Warning to the Fiftieth Session of the United Nations General Assembly in October 1995 (UN, 1995).

The three global early warning conferences (1998, 2003 and 2006) catalyzed efforts to examine what was working and what was not working in early warning. The 2005 World Conference on Disaster Reduction in Kobe, Japan followed by the third early warning conference in Bonn, Germany in 2006, led to notable progress in linking early warning to early action and risk reduction.

Timely and effective warnings are THE basis for creating the culture of prevention necessary for a safer world in the twenty-first century.

THE CONCEPT OF "EARLY WARNING"

The term "early warning" was born during the cold war for describing a military strategy to prevent the potential threat from ballistic intercontinental missiles. These early warning systems (still operational) were designed to alert target areas as soon as a missile was detected by a radar setup or a launch discovered by a satellite system. In this context, the term "lead-time" was defined as the time that has elapsed since the detection of the missile and the estimated impact on the target. In the last decades the use of the term "early warning" has broadened to include various types of risks, though with differences in its application. Today early warning systems are designed for epidemiological, economical, social, and for all the types of natural and environmental risks (Satriano et al., 2010).

ISDR defines early warning as "the provision of timely and effective information, through identified institutions, that enables individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response".

Early warning is not only the production of technically accurate warnings but also a system that requires an understanding of risk and a link between producers and consumers of warning information, with the ultimate goal of triggering action to prevent or mitigate a disaster (IFRCRCS, 2009).

Early warning system is a set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss.

Not that the concept of early warning for emergencies is new. It is centuries old. The ancient Chinese used smoke signals from the top of the Great Wall to warn of impending attacks by enemy troops. For hundreds of years, the health sectors in many countries have had warning systems to provide alerts on the outbreak of contagious diseases, and they continue to do so. Modern-day food security practitioners still refer to the sophisticated price monitoring systems established in the Indian Famine Codes in the 1880s, which not only provided early warning but triggered response to potential famines. Contemporary early warning systems emerged in the 1970s and 1980s, as a response to drought-induced famines in the Sahel. Since

droughts, food insecurity and, ultimately, famine evolve very slowly, governments and donors postulated that by tracking certain indicators, such as malnutrition, market prices or rainfall levels, it would be possible to anticipate future food insecurity and intervene before people starved to death. Today, the number of deaths due to drought-induced famine has been reduced dramatically. Early warning systems for food insecurity continue to evolve and improve, although there remains a large gap between warnings and response, especially the capacity and capability to provide longer-term response to address vulnerability and the root causes of risk. Other hazard-specific early warning systems have emerged, especially in developed countries and especially for frequent hazards. Tornado warning systems are well developed in the United States, for example; many countries have established flood early warning systems for major river basins; cyclone warning systems exist and represent excellent examples of international cooperation. Early warning systems for volcanoes exist in most regions or countries where there are active volcanoes. Interestingly, the tsunami early warning system for the Pacific Ocean has been operational for more than 40 years yet such a system was absent in the Indian Ocean in 2004 due to the infrequency of tsunamis in this region.

The fundamental goal of early warning is early and balanced action. Any actions taken before a disaster strikes – whether a few minutes before the event (moving to higher ground during a storm) or a few months beforehand (preparing contingency plans, building stockpiles) or years before (planting trees on hillsides, strengthening building codes) – can help prepare for, mitigate or prevent the hazard from becoming a disaster.

The timely and effective warning of possible disaster is a self-evident objective, universally pursued by Governments and organizations in determining disaster-reduction strategies. It is critical for individuals in local communities organizing practical measures to protect their own lives and property. Advances in science and technology have expanded the possibilities of anticipating the effects of many, but still not all, of the hazards which threaten nearly every country in some way.

As countries incorporate disaster-reduction policies into their national social and economic development plans, establish effective preparedness measures and improve their response capacities, the value of timely and effective warnings in averting losses and protecting resources becomes apparent.

While not all hazards offer the same possibility of prediction or forewarning, national Governments none the less bear the sovereign responsibility to the best of their abilities to protect their citizens from disasters. In this respect, Governments in their policies, and local communities by their actions, display varying degrees of awareness, commitment and ability in adopting successful disaster-reduction strategies.

For all the recent scientific and organizational progress made in the conceptualizing, establishment and operation of early-warning systems, early warning is still inadequate for most of the world's population. The technical ability to foresee and interpret most hazards is no longer as limited as it once was. Modern communications technologies provide more access to information, more quickly. A major challenge remains to ensure that this knowledge can be accessible to, understood by and acted upon by local communities and the people most directly affected by threatened disasters.

Elements of Effective Early Warning Systems

The objective of people-centered early warning systems is to empower individuals and communities threatened by hazards to act in sufficient time and in an appropriate manner so as to reduce the possibility of personal injury, loss of life, damage to property and the environment and loss of livelihoods.
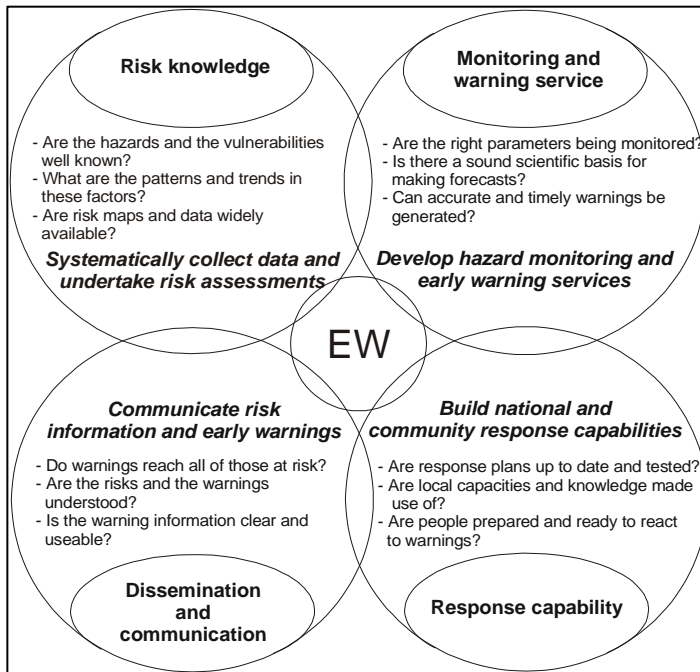

Risk knowledge

- Are the hazards and the vulnerabilities well known?
- What are the patterns and trends in these factors?
- Are risk maps and data widely available?

Systematically collect data and undertake risk assessments

Monitoring and warning service

- Are the right parameters being monitored?
- Is there a sound scientific basis for making forecasts?
- Can accurate and timely warnings be generated?

Develop hazard monitoring and early warning services

EW

Communicate risk information and early warnings

- Do warnings reach all of those at risk?
- Are the risks and the warnings understood?
- Is the warning information clear and useable?

Dissemination and communication

Build national and community response capabilities

- Are response plans up to date and tested?
- Are local capacities and knowledge made use of?
- Are people prepared and ready to react to warnings?

Response capability

Fig. 2. *The four elements of early warning systems (Source: ISDR, 2010)*

A complete and effective early warning system comprises four inter-related elements, spanning knowledge of the risks faced through to preparedness to act on early warning. Failure in any one part can mean failure of the whole system.

The four key elements are: knowledge of the risks; monitoring, analysis and forecasting of the hazards; communication or dissemination of alerts and warnings; and local capabilities to respond to the warnings received. The expression "end-to end warning system" is used to emphasize that warning systems need to span all steps from hazard detection through to community response.

Risk knowledge

Risks arise from the combination of the hazards and the vulnerabilities to hazards that are present. Assessments of risk require systematic collection and analysis of data and should take into account the dynamics and variability of hazards and vulnerabilities that arise from processes such as urbanization, rural land-use

change, environmental degradation and climate change. Risk assessments and risk maps help to motivate people, prioritize early warning system needs and guide preparations for response and disaster prevention activities.

Monitoring and warning service

Warning services lie at the core of the system. They must have a sound scientific basis for predicting and forecasting and must reliably operate twenty-four hours a day. Continuous monitoring of hazard parameters and precursors is necessary to generate accurate warnings in a timely fashion. Warning services for the different hazards should be coordinated where possible to gain the benefit of shared institutional, procedural and communication networks.

Dissemination and communication

Warnings must get to those at risk. For people to understand warnings, they must contain clear, useful information that enables proper responses. Regional, national and community-level communication channels and tools must be pre-identified and one authoritative voice established. The use of multiple communication channels is necessary to ensure everyone is reached and to avoid the failure of any one channel, as well as to reinforce the warning message.

Response capability

Communities must also respect the warning service and know how to react to warnings. This requires systematic education and preparedness programs led by disaster management authorities. It is essential that disaster management plans are in place and are well practiced and tested. The community should be well informed on options for safe behavior and on means to avoid damage and loss of property.

Good early warning systems have strong inter-linkages between the four elements. The major players concerned with the different elements meet regularly to ensure they understand all of the other components and what other parties need from them. Risk scenarios are constructed and reviewed. Specific responsibilities throughout the chain are agreed and implemented. Past events are studied and improvements are made to the early warning system. Manuals and procedures are agreed and published. Communities are consulted and information is disseminated. Operational procedures such as evacuations are practiced and tested.

Behind all of these activities lies a solid base of political support, laws and regulations, institutional responsibility, and trained people. Early warning systems are established and supported as a matter of policy. Preparedness to respond is engrained in society

Effectiveness of early warning

All warning systems, however simple they may be, are based on some idea of how the phenomenon behaves, whether it is a storm or a locust swarm, a landslide or epidemic, a migration of people or the slow destruction of a forest. Scientists call

this idea the "model", and they use the model to say what is likely to happen next. In the simplest cases, the model may amount to no more than common sense – for example the recognition that poor people who have settled in a river valley will lose their dwellings and all their belongings in even a small flood. At the other extreme, models of the physics of the global weather system are immensely complex and require large computers to do all their calculations and produce detailed forecasts for the whole globe. Predictions are never perfect or precise. There is always some uncertainty. A hurricane may change course overnight or weaken; a tsunami may be higher than expected; an earthquake may be likely in a broad region but the location cannot be pinpointed

Many groups are important to disaster early warning systems – public officials, community and business leaders, NGOs, scientists, academics, teachers, the media, community leaders, and of course householders. The best early warning systems find ways to link all these groups and to facilitate their cooperation.

The capacity of a community to respond to a warning can also be constrained by a range of practical as well as conceptual limitations. Adequate human, material and technical resources are needed to establish and operate early-warning systems properly. This raises choices as to whether to apply often scarce resources to meet other competing priorities within a society, or to provide protection for assets over a longer period of time against something which may only occur in the unspecified future, or perhaps not at all.

The functions of early warning are accomplished by various professional or specialized groups in a society. They include the scientific community, government officials, communications authorities, broadcast media, disaster management agencies and often the military. Each of these groups has its own organizational structure and methods of operation. The nature of their regular responsibilities does not necessarily bring them together to address issues of early warnings.

If a narrow approach to warning is taken by an agency or organization, limited to its own area of competence and with less regard to the utilization of its output by others, the reliability and utility of the entire system is diminished. Therefore, each phase of the warning process must be accomplished effectively, accurately and in a timely manner with a full understanding of the relationship to the other parts of the process. A basic indicator of success for early warning is the demonstrated capacity for joint action among the various contributors.

Warning systems are only as good as their weakest link. They can, and frequently do, fail in both developing and developed countries for any of four primary reasons. There can be a failure of forecasting, demonstrated by an inability to understand a hazard or a failure to locate it properly, in time or space. There also may be an ignorance of prevailing conditions of vulnerability determined by physical, social, or economic inadequacies. A third possibility can be a failure to communicate the threat accurately or in sufficient time. Finally, there can be a failure by the recipients of a warning to understand it, to believe it or to take suitable action.

Ultimately, early warning systems succeed or fail depending on community involvement. Too often the populations at risk are not engaged or consulted. Specialist technical services cannot do the job alone. Individual action is not enough. Whether it is for the assessment of the long term risks faced, the preparedness measures to

be taken, the communication and interpretation of warnings, or the commitment to action on warnings, the engagement of communities and their natural leaders is essential, in order to build effective capacity in all links of the early warning chain.

In addition, there is always a great deal of uncertainty about the social components of an early warning, and about the specific human impacts that might occur. This can make it difficult for decision makers to act. Decision makers and those at risk must weigh up the chances and consider the implications for their particular situation. Which option to follow – to close down a subway and disrupt a city or let the city keep running and risk chaos? Follow advice to evacuate or stay put and try to protect your home? Plant drought-resistant seed knowing it will not produce as much as the usual seed? Each person or community must make its own judgment as appropriate to their own circumstances. In each case there are costs of acting as well as costs of not acting.

Forecast and warning process

An early warning system is a set of procedures designed to protect human lives and minimize damages to be expected from a disaster which exceeds a certain critical level. It consists of a number of related and connected parts: forecasting, transformation of the forecast into a warning, transmission of the warning to local decision makers, conversion of the warning into remedial action (UN/ISDR, 2004). Each of these components must work efficiently for a successful early warning system. In developing countries such a system is of particular importance for saving human lives.

The first part is making the forecast. It must be application oriented. For the population two objectives are to be met: first objective is to obtain forecasts of event characteristics (specific for different disasters). Second objective for the people of each community is to have a long term forecast.

The second part is to convert forecasts into warnings. Even a warning based on a perfect forecast would be useless if it cannot reach the people for which it is intended. This part therefore includes transmission of the warning to local communities. The transmission stage of the early warning system ends with the warning passed on to the contact person in each community.

The third part of the warning process: the response of people to the warning. The recipient of the warning should be a person who knows how to use the forecast and converts it to a warning seen and accepted at the local level. This person should draw the necessary conclusion for actions that need be taken - such as alerting local police or fire fighters (who in many countries are trained to respond to all natural disasters).

Conversion of forecasts into warnings and transmitting them to the people, as well as local actions are results of a complex administrative process. A typical chain of actions involved in early warning is shown in Figure 3 (Lee and Davis, 1998).
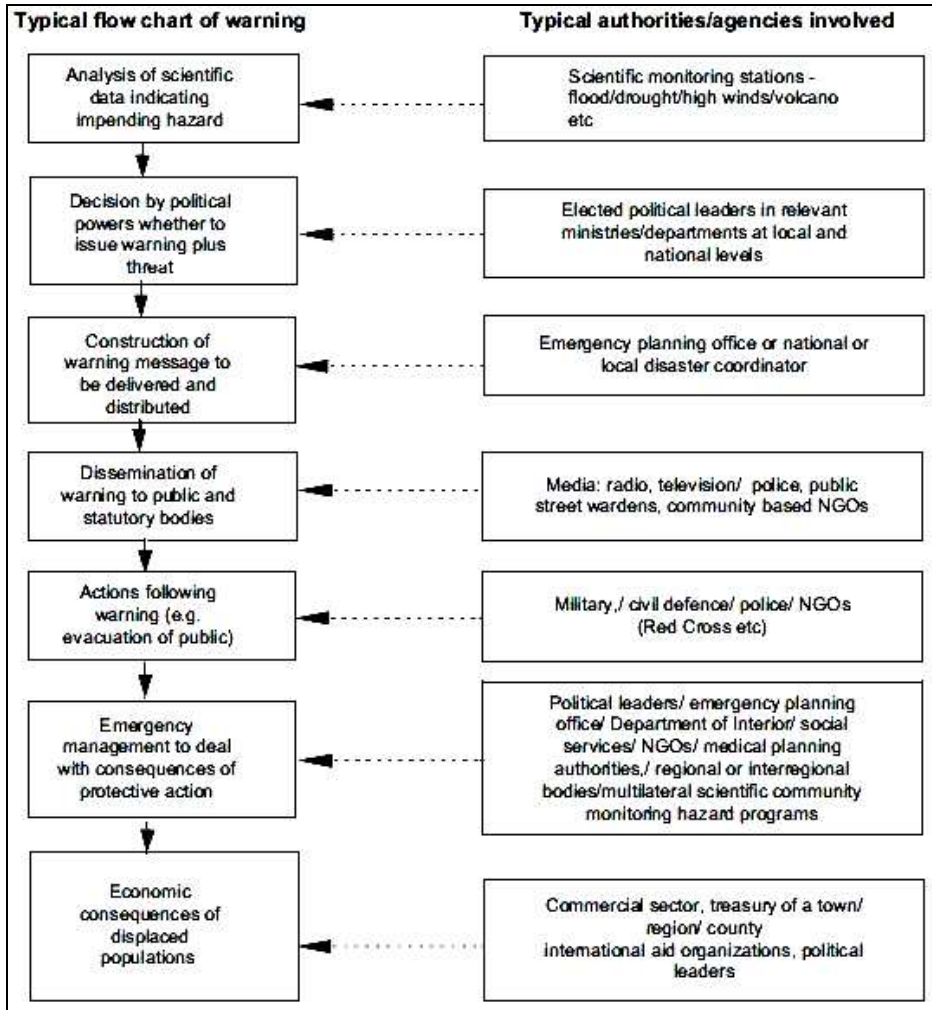
Typical flow chart of warning	Typical authorities/agencies involved
Analysis of scientific data indicating impending hazard	Scientific monitoring stations - flood/drought/high winds/volcano etc
Decision by political powers whether to issue warning plus threat	Elected political leaders in relevant ministries/departments at local and national levels
Construction of warning message to be delivered and distributed	Emergency planning office or national or local disaster coordinator
Dissemination of warning to public and statutory bodies	Media: radio, television/ police, public street wardens, community based NGOs
Actions following warning (e.g. evacuation of public)	Military,/ civil defence/ police/ NGOs (Red Cross etc)
Emergency management to deal with consequences of protective action	Political leaders/ emergency planning office/ Department of Interior/ social services/ NGOs/ medical planning authorities,/ regional or interregional bodies/multilateral scientific community monitoring hazard programs
Economic consequences of displaced populations	Commercial sector, treasury of a town/ region/ county international aid organizations, political leaders

Fig. 3. *A flow chart of warning (Lee and Davis, 1998)*

Just the first line represents the generation of a forecast for any kind of natural extreme event. The other links of the chain indicate the multiplicity of actors involved in the process of early warning, all of whom have to trust the forecast. The importance of a well functioning chain from reliable forecasts to trusted warnings cannot be stressed enough - if the forecast leads to wrong warnings, eventually the interest of local observers will sag and the system will not work (Plate, 2007).

However, even a reliable forecast may not work if people are not prepared to act appropriately. People forget preparedness, in particular in areas where are rare events, so that many years no disasters are forecast. Regular control, and perhaps training, of responsible local persons is an important aspect of maintaining such a

system. In the early warning chain the forecast is the initiator, but no more, of the early warning process. But the major challenge in this chain of actions is the concern of forecasting system development.

Guiding principles for effective early warning

Some principles for the Application of Early Warning at National and Local Levels were elaborated as follows (IDNDR, 1997):

1. Early warning practices need to be a coherent set of linked operational responsibilities established at national and local levels of public administration and authority. To be effective, these early warning *systems* should themselves be components of a broader program of national hazard mitigation and vulnerability reduction.

2. Within each country, the sole responsibility for the issuance of early warnings for natural and similar disasters should rest with an agency, or agencies, designated by the Government.

3. The decision to act upon receipt of warning information is political in character. Authoritative decision-makers should be identified and have locally-recognized political responsibility for their decisions. Normally, action resulting from warnings should be based on previously-established disaster management procedures of organizations at national and local level.

4. In the chain of political responsibility, initial hazard information, is often technically specialized or specific to a single type of hazard authority. To be applied effectively, warnings need to be clearly understood and operationally relevant to local agencies which are more frequently oriented toward non-specific hazard functions.

5. Early warning systems must be based upon risk analysis which includes the assessment of the occurrence of hazards, the nature of their effects and prevailing types of vulnerability, at national and local levels of responsibility. The warning process must lead to demonstrated practices that can communicate warning and advisory information to vulnerable groups of people so that they may take appropriate actions to mitigating loss and damage.

6. Locally predominant hazard types and patterns, including small-scale or localized hydrometeorological hazards related to patterns of human economic or environmental exploitation, must be incorporated if early warning is to be relevant to risk reduction practices.

7. There is a continuing need to monitor and forecast changes in vulnerability patterns, particularly at local levels, such as sudden increases in vulnerability resulting from social developments. These may include conditions of rapid urbanization, abrupt migration, and economic changes, nearby civil conflict or similar elements, which alter the social, economic or environmental conditions of an area.

8. The primary responsibilities must rest at local levels of involvement for producing detailed information on risks, acting on the basis of warnings, communicating warnings to those individuals at risk and, ultimately, for facilitating appropriate community actions to prevent loss and damage. A high resolution of local knowledge and developed experience of local risks, decision-making procedures, definitive authorities concerned means of public communication and established coping strategies are essential for functions to be relevant.

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9. Groups of people that exhibit different types of vulnerability will have different perceptions of risk and various coping strategies. Locally appropriate warning systems will provide a range of communication methods and should provoke multiple strategies for protection and risk reduction.

10. To be sustainable, all aspects of the design and implementation of early warning systems require the substantive involvement of *stakeholders* at the local and national levels. This includes production and verification of information about perceived risks, agreement on the decision-making processes involved, and standard operational protocols. Equally important abilities involve the selection of appropriate communication media and dissemination strategies which can assure an effective level of participation in acting upon receipt of warning information.

Principles for Early Warning Systems at International and Regional Levels

1. In the interest of concerted international efforts to reduce the adverse effects of natural and similar disasters, the technologically advanced countries have an obligation to encourage and support improved early warning practices in developing countries, small island developing states, economies in transition, and other disaster-prone countries with special circumstances.

2. Primarily-affected countries equally have a primary responsibility to conduct a rigorous audit of the effectiveness, or consequential identification of needs, of their early warning capabilities. The conduct of post-mortem assessments of regional and national warning system capabilities is particularly relevant following any disaster event.

3. Specialized regional and global centers involved in the preparation and dissemination of warnings, such as the WMO Regional Specialized Meteorological Centers provide important links to national early warning systems. The application of their technical capabilities and the utility of their products should be carefully integrated with the needs of the countries being served, including any necessary clarification about the warning responsibilities between these centers and national agencies in the same region.

4. In the interest of protecting people from the risk of natural hazards, it is essential that the formulation and presentation of warnings be based on the best available technical and scientific knowledge, and free of political distortion or manipulation.

5. International bodies and regional organizations must work to maintain the vital importance of timely exchange and unrestricted access of observational data and other warning information between countries, particularly when hazardous conditions affect neighboring countries.

6. Timely, accurate, and reliable warnings should be understood in the context of commonly accepted international standards, nomenclature, protocols, and reporting procedures. Established or internationally agreed means of communications should be employed for the international and regional dissemination of any warning information to specific authorities designated in each country.

7. Collaboration and coordination is essential between scientific institutions, early warning agencies, public authorities, the private sector, the media, and local community leaders to ensure that warnings are accurate, timely, and meaningful and can result in appropriate action by an informed population.

CONCLUSIONS

The objective of early warning is to empower individuals and communities, threatened by natural or similar hazards, to act in sufficient time and in an appropriate manner so as to reduce the possibility of personal injury, loss of life and damage to property or fragile environments.

Risk assessment provides the basis for an effective warning system at any level of responsibility. It identifies potential threats from hazards and establishes the degree of local exposure or vulnerability to hazardous conditions. This knowledge is essential for policy decisions which translate warning information into effective preventive action.

Several groups must contribute to this empowerment. Each has a set of essential overlapping functions for which it should be responsible:

- members of vulnerable populations should be aware of the hazards and the related effects to which they are exposed and be able to take specific actions themselves that will minimize their personal threat of loss or damage;

- local communities should have sufficient familiarity with the hazards to which they are exposed and the understanding of advisory information received to be able to act in a manner to advise, instruct or engage the population in a manner that increases their safety or reduces the possible loss of resources on which the community depends;

- national Governments should prepare and issue hazard warnings for their national territory in a timely and effective manner and ensure that warnings and related protective guidance are directed to those populations determined to be most vulnerable to the hazard risk. The provision of support to local communities to utilize information and to develop operational capabilities is an essential function for the translation of early warning knowledge into risk reduction practices;

- regional institutions should provide specialized knowledge, advice or benefit of experience in support of national efforts to develop or to sustain operational capabilities related to hazard risks experienced by countries that share a common geographical environment. Regional organizations are crucial to linking international capabilities to the particular needs of individual countries and in facilitating effective early warning practices among adjacent countries;

- international bodies should provide a means for the shared exchange of data and relevant knowledge as a basis for the efficient transfer of advisory information and the technical, material and organizational support necessary to ensure the development and operational capabilities of national authorities or agencies officially designated as responsible for early warning practice.

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WATER QUALITY IN CLUJ'S PRIVATE DRINKING WATER WELLS

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ABSTRACT. Only 11 % of the population in the rural zone has access to safe drinking water in Romania (2005). Most of human population use wells as the main source of drinking water. The proposed study area of Feleacu is located in the Cluj County, 7.5 km from Cluj-Napoca town. In a review of over 360 tests for 15 private wells done during two years (2007-2008), the most common problems were high levels of iron, nitrate and total dissolved solids (TDS). Wells are generally less than 15 meters deep and they are not properly sealed. Iron concentration ranged from 84 µg/L – 385 µg/L, with 26.66% of samples above the 200 µg/L Romanian drinking water standard. Nitrate concentration ranged from 21 mg/L - 167 mg/L, with 73.33 % above the 50 mg/L Romanian drinking water standard. Groundwater nitrate correlates positively with chloride (R^2=0,991) and sodium (R^2=0,955). That would suggest that the high content of nitrate may result from the septic tank, the cesspool and the animal wastes storage, located next to the well. Total dissolved solids (TDS) vary between 203 mg/L and 1545 mg/L, with 73.33% above the EPA's drinking water standards of 500 mg/L. TDS correlates positively with groundwater chloride (R^2=0,990), nitrate (R^2=0,980), sodium (R^2=0,955) and calcium (R^2=0,765).

Key words: *Well waters, Nitrate in water, Iron in water, Groundwater Quality*

INTRODUCTION

Water is nowadays considered as a precious resource since it is the main source of life. However, it may also be a cause of lots of troubles, which could affect to some extent human health. Therefore, there is an increasing concern on water pollution of both natural and human origin. Water quality assessment is now becoming a necessity. Although the Cluj County is rich in freshwater resources, their quality is not well-known. According to the Romanian National Institute of Statistic (www.insee.ro/cms/files/pdf, 2007) only 11% of the population in the rural zone in Romania has access to safe drinking water. In Feleacu, groundwater is an important water resource. However, groundwater is highly vulnerable to contamination and no comprehensive studies have been completed on groundwater quality in the study zone (Pele, 2001). Wells are generally less than 15 meters deep and they are not properly protected from surfacial pollution. Contaminants occurring in large concentrations are nitrate (NO_3^-) and total iron (Fe^{total}).

REGIONAL, GEOLOGICAL AND HYDRO-GEOLOGICAL SETTING

Feleacu commune, located in the central part of Transylvania, in Cluj County, has a surface area of 61.7 km^2. The geographical coordinates are $46^0 42'40''$ North and $23^0 37'00''$ East. The location lies on the top and the southern slope of Feleac Hill, at the average altitude of 711 m (Fig. 1). According to the last demographic evaluation (1st July 2007) made by Romanian National Institute of Statistic, Feleacu has a population of 3622 people.

The climate in this area is pleasant, temperate-continental type. It is influenced by Apuseni Mountains on autumn and on winter, but also by West Atlantic influences. The summers are warm and the winter are not very cold, in general without blizzard. The annual average temperature of the air is 8.2^0C, and the average of the rain is 663 mm.

Based on geographical location and geological studies, the subsoil of Feleacu commune can be attached to Sarmatian deposits of the Transylvanian Basin. The Feleac Formation occurs in this area, which is a transgresive heterochrone lithostratigraphic unit (Filipescu, 1996). This formation, mostly detrital, has a siliciclastic character and it consists of the coarse deposits (sands, sandstones, conglomerates) with concretions and rare clay intercalations (Filipescu, 1999). The thickness of these deposits reaches up to tens of meters.

The main petrologic features of the sands form the Feleac Formation have been identified due to the detailed geological investigations (Voiculescu, 1997). These sands are medium to fine-grained, the most frequent values of the grain size ranges from 0.125 mm up to 0.400 mm. Morphological investigations shows the presence of an inhomogeneous or subrounded. Due to the grain size distribution, the Feleacu sands are poorly to moderate sorted. These unconso-lidated rocks can be classified as litho-feldspatic sands, the average component participation being 50% lithic fragments, 20-25% feldspars and 25-30% quartz. The mineral identified are: potasic feldspar, plagioclase fedspar, quartz, hornblende, garnets, magnetite, zircon, staurolite, epidote, actinolite, tourmaline and rutile. The chemical variability of the sands is indicated by the main components content : 74.95-81.91% SiO_2, 6.62-9.44% Al_2O_3 and 1.25-7.18% Fe_2O_3.
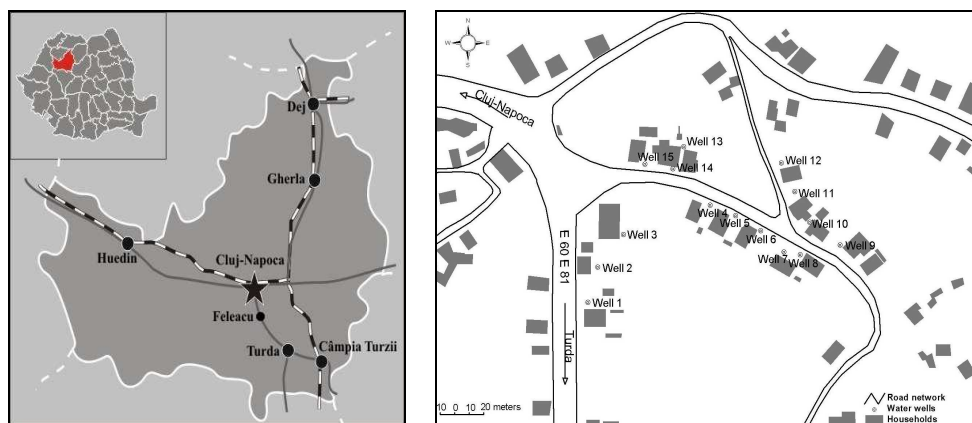
Fig. 1. *Map of Cluj County and the study area* (*Feleacu)*

MATERIAL AND METHODS

The sampling campaign was carried out in the area of Feleacu during two years 2007-2008 (one sample for each well, monthly). There were a total of 360 well water samples collected from 15 private wells. Well owners granting permission for sampling were inter-viewed as to the well depth and age, number of people using the well as a source of drinking water, well driller and distance from well to septic system. Temperature, pH, redox potential (Eh), Electrical Conductivity (EC), Total Dissolved Solids (TDS) and Dissolved Oxygen (DO) were measured in field using portable multi parameter WTW 350 after calibration with standard pH buffers and conductivity standards solutions. For the remaining analysis, samples were collected and passed through a 0.2 µm filter and the other elements in solution were determined in the laboratory: the alkalinity was determined in-situ by acid titration (with 0.1N HCl); UV-1700 Pharma Spec. Shimadzu spectrophotometer was used to determine iron and sulphate using 1,10 phenanthroline and barium reagents. Calcium, sodium, magnesium, chloride and nitrate by photometric RQ flex plus 10 (MERCK). The detection limits for ions were within 0.1 mg/L.

RESULTS AND DISCUSSION

Measured well water temperatures ranged from 9.8 to 17.1 ^{0}C and averaged 12.97 ^{0}C. Measured specific conductivity values varied from 351 to 2683 µS/cm and an average value of 1325 µS/cm. The pH values were in range of 6.8 to 8.4 and averaged 7.56. Sampled water presented an Eh value ranging from + 33 to + 83 mV, indicating oxidizing conditions at the locations. The concentration of DO in well water can significantly affect many geochemical or biological processes such as oxidation or reduction of nutrients. Measured concentrations of DO varied from 1.2 to 2.5 mg/L. The mean concentration value was 2.04 mg/L. The TDS values varied from 203 to 1545 mg/L and averaged 736.33 mg/L.

Well water samples had concentrations of sodium ranging from 18.2 to 145.1 mg/ L with a mean value of 68.2 mg/L. The chloride concentrations varied between 6.5 and 51.1 mg/L with a mean value of 22.2 mg/L. Sampled water contained nitrate in concentrations of 21 to 167 mg/L. The mean value of nitrate level was 72.33 mg/L. Only 4 of 15 water samples analyzed for nitrate contain concentration below the maximum allowed value (50 mg/L) proposed by the Romanian drinking water quality standard (according to Law 458/2002 with subsequent amendments Law 311/2004). The sulphate concentrations varied between 68 and 241 mg/L with a mean value of 152.13 mg/L. Iron contents were between 84 and 385 µg/L with a mean value of 177.73 µg/L. Only 4 of 15 water samples collected had a concentration exceeding 200 µg/L, which is the maximum allowed value given by the Romanian water quality standard. Calcium contents were in concentrations of less than 55 to 184 mg/L, with an average of 131.4 mg/L, and no water sample of 15 presented a concentration value exceeding 200 mg/L (maximum allowed value). The magnesium concentrations varied between 1.4 and 12.1 mg/L and average 4.5 mg/L. Test results are summarized in Table1.

Table 1. *Summary of Feleacu Well water Quality*

Parameter	Low	High	Standard, MCL
Conductivity, µS/cm	351	2683	2500 (EU); 1000 (EPA-USA)
DO, mg/L	1.2	2.5	none Established;
pH	6.8	8.4	6.5 – 8.5 (EU)
Nitrate, mg/L	21	167	50 (EU); 45 (EPA-USA)
Iron, µg/L	84	385	200 (EU); 300 (EPA-USA)
Sulphate, mg/L	68	241	250 (EU) and (EPA-USA)
Chloride, mg/L	6.5	51.1	250 (EU)
Sodium, mg/L	18.2	145.1	200 (EU)
Calcium, mg/L	55	184	200 (EU)
Magnezium, mg/L	1.4	12.1	50 (EU)
TDS, mg/L	203	1545	500 (EPA-USA)

MCL – Maximum contaminant level

Nitrate

The following concentration criteria are used to identify if measured nitrate in well waters could be of anthropogenic origin or not (Strebel, 2008; Kumar, 2007; Croll, 2008):

- Nitrate concentration less than 0.9 mg/L, indicating natural or background level,
- Nitrate concentration between 0.9 mg/L and 13.5 mg/L, representing transitional level,
- Nitrate concentration more than 13.5 mg/L showing an eventual human influence on water quality.

Results show that 100 % of collected samples contained nitrate in concentration higher than 13.5 mg/L. Among them, 73.33 % had nitrate concentration exceeding the maximum allowed value (50 mg/L). Therefore, most of well waters sampled in Cluj County appear to be contaminated by human activities. Figure 2 exhibits that the higher the nitrate content in well water, the greater the chloride and sodium concentration

levels are. However, high level of nitrate with high content of chloride may suspect human and animal waste influence (Cronin, 2007).
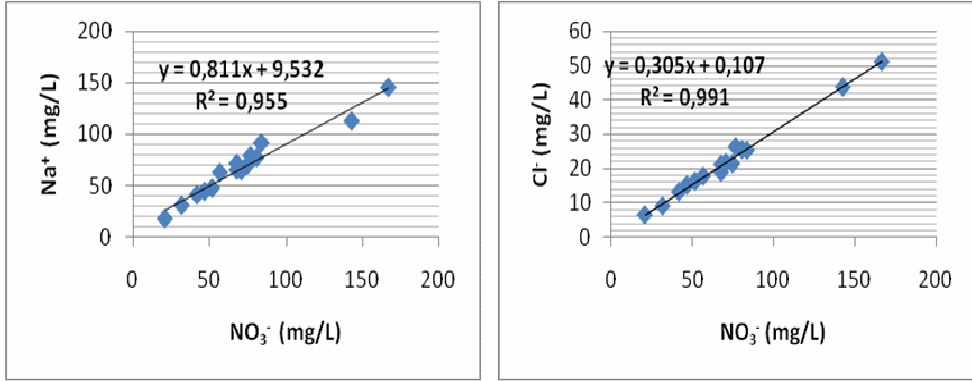

Fig. 2. *Plots of Na^+ and Cl^- versus nitrate in water collected in the study area (Feleacu)*

Total Dissolved Solids (TDS)

More than 26.66 % of the samples collected from wells in Feleacu area contain TDS lower than 500 mg/L. When water mineralization is low with a pH value higher than 6.5 water-rock interaction exert control on the TDS level. However, figure 3 and figure 4 indicating the correlation between TDS and Cl^- (R^2=0.990), NO_3^- (R^2=0,980), Na^+ (R^2=0,955) and Ca^{2+} (R^2=0,765) showed that the more TDS value increases, the more pollution processes influence the TDS level. Indeed, the presence of nitrate at high concentration in well waters seems to correlate with the TDS value.
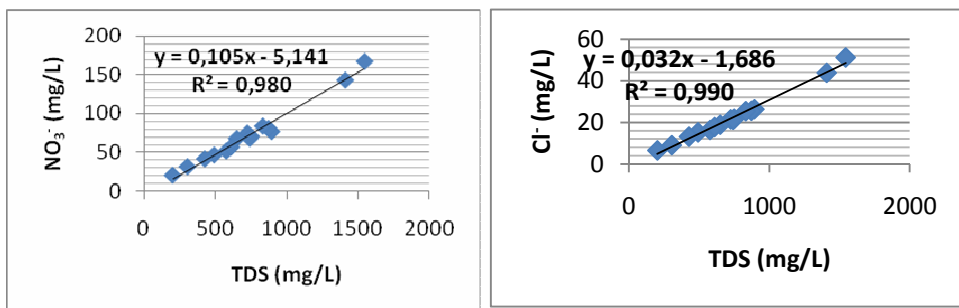

Fig. 3. *Plots of NO_3^- and Cl^- versus TDS for all water collected in the study area (Feleacu)*
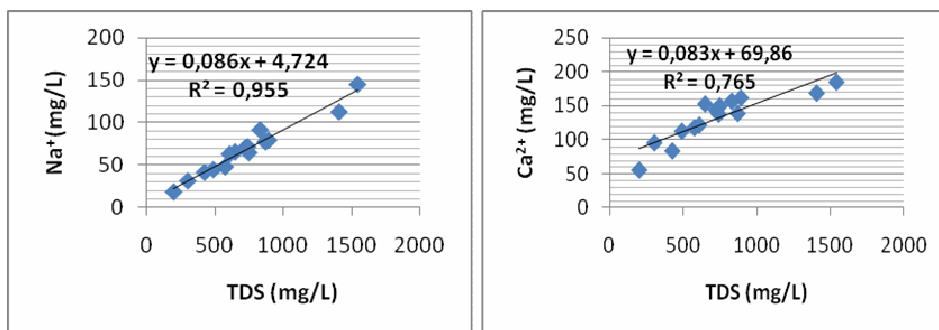
Fig. 4. *Plots of Na$^+$ and Ca^{2+} versus TDS for all water collected in the study area (Feleacu)*

A random distribution of data for the plots of Mg^{2+} and SO$_4^{2-}$ against TDS (figure 5) supports the previous hypothesis.
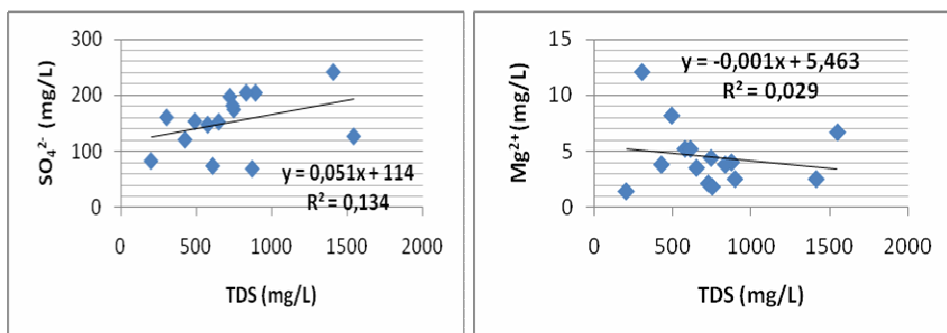

Fig. 5. *Plots of SO$_4^{2-}$ and Mg^{2+} versus TDS for all well water sampled in the study area (Feleacu)*

Iron

More than 73.33 % of water samples were of iron concentrations below 200 µg/L and 20 % of iron levels between 200 µg/L and 300 µg/L. However, at concentration around 200 µg/L in domestic water, iron can produce red, brown or orange colour precipitates (iron bacteria), which may form coatings on the water pipes. 26.66 % of sampled water contained iron at concentration greater than 200 µg/L. At such concentration, Subba Rao (2008) states that iron can strain laundary and cause objectionable tastes in beverages. High concentrations of iron were observed in well water featured by low level of nitrate (Thayalakumaran, 2008).

A random distribution of data for the plots of TDS and NO$_3^-$ against Fe^{total} (figure 6).
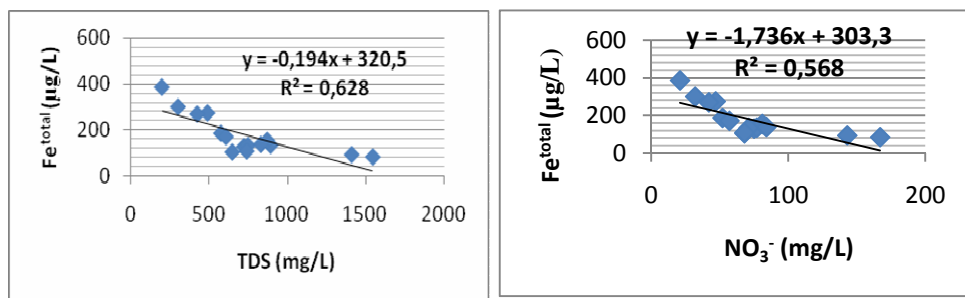
Fig. 6. *Plots of Fe^{total} versus TDS and Fe^{total} versus NO_3^- for all well water sampled in the study area (Feleacu)*

CONCLUSIONS

Groundwater quality was assessed in Feleacu by assessing 15 well water samples. At the scale of this investigation, well waters were contaminated by nitrate in Feleacu. 73.33 % of sampled waters contained nitrate of concentration exceeding 50 mg/L. It went with low content of iron. The pH values ranged from 6.7 to 8.4 and the redox potential indicated oxidizing conditions (+ 33 mV < Eh < + 83 mV). The low dissolved oxygen concentrations (DO < 2 mg/L) and high iron concentrations (> 200 µg/L) found in 26.66 % of the well waters indicate that redox conditions are suitable for nitrate (NO_3^-) attenuation by either denitrification or dissimilatory nitrate reduction to ammonium (NH_4^+). The TDS level varied between 203 mg/L and 1545 mg/L. 73.33 % of the sampled waters were hardly mineralized (TDS > 500 mg/L). The correlations between nitrate concentrations and chloride and sodium concentrations suggested relatively high concentrations of nitrate in well water may be caused by human activities

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TRENDS OF THE GLOBAL SOLAR RADIATION AND PRECIPITATION IN CLUJ-NAPOCA, ROMANIA

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ABSTRACT. The evolution of annual global solar radiation (GSR) and precipitation trends in the Cluj-Napoca area was analyzed for the period 1921 to 2009. In this study, we used data from Cluj-Napoca meteorological station and, also, from other two surrounding stations, Bistriţa and Sibiu. Linear model and significance test method (Student's t-test) were used to find the most appropriate expression of the annual mean GSR and average amount of precipitation interannual evolution. Global solar radiation showed an increasing trend for this period being statistically significant at 0.001 level only at Cluj-Napoca and Bistriţa stations. There is no statistically significant trend in precipitations for this period. According to the linear model, the GSR increased with 8.241 W/m2 at Cluj-Napoca, 9.149 W/m2 at Bistriţa and 2.581 W/m2 at Sibiu, while the amount of precipitations showed increasing trends for Cluj-Napoca (with 55.3 mm) and Bistriţa (with 23.4 mm) and decreasing trend for Sibiu (with 11.1 mm) but these ones not being statistically significant. The significant increasing trend of the global solar radiation is rather the ascensional part of a natural micro-oscillation due to solar variations. The values of Pearson's correlation for Sibiu (r = - 0.33) and Bistriţa station (r = - 0.31) and the 99% probability of making a correct statement for annual (p = 0.01) show that there is a correlation (negative relationship) between annual mean global solar radiation and annual mean precipitations. The value of Pearson's correlation for Cluj-Napoca (r = - 0.15) is not statistically significant.

Key words: *Global solar radiation; annual mean precipitation; linear trend model; t-test; Pearson's correlation.*

1. INTRODUCTION

Radiative forcing alters heating, and at the Earth's surface this directly affects evaporation as well as sensible heating. Further, increasing temperatures tend to increase evaporation which leads to more precipitation (IPCC, 2007). Globally there has been no statistically significant overall trend in precipitation over the past century, although trends have varied widely by region and over time.

Knowledge of local solar radiation is essential for many applications, including architectural design, solar energy and irrigation systems, crop growth models and evapotranspiration estimates (Almorox and Hontoria, 2004). Unfortunately, solar

radiation measurements are not easily available for many countries as the measurement equipment and techniques involved are expensive. Therefore, it is rather important to elaborate methods to estimate the solar radiation on the basis of meteorological data (Al-Lawati et al., 2003). Over the years, many models have been proposed to predict the amount of global solar radiation using various parameters. The most widely used method is that of Angstrom (Angstrom, 1924), who proposed a linear relationship between the ratio of average daily global radiation to the corresponding value on a completely clear day and the ratio of average daily sunshine duration to the maximum possible sunshine duration. Prescott (Prescott, 1940) put the equation in a more convenient form by replacing the average global radiation on a clear day with the extraterrestrial solar radiation.

2. DATA AND METHODS

The global solar radiation data were calculated from the monthly sunshine hours and were taken from the Monthly Climatic Data for the World (MCDW). Also, monthly precipitation data were taken from MCDW and National Climatic Data Center/Climate Date Online.

The analysis is based on data collected at Cluj-Napoca station (latitude: $46^0 47$'N; longitude: $23^0 34$'E; altitude: 414 m) for a 89-year period. Because using statistical information from only one meteorological station might be considered irrelevant, we added into the analysis other two surroundings stations: Bistrița (latitude: $47^0 09$'N; longitude: $24^0 31$'E; altitude: 367 m) and Sibiu (latitude: $45^0 48$'N; longitude: $24^0 09$'E; altitude: 444 m). The time period is the same (89 years).

For the global solar radiation and precipitation dataset, the annual time series were computed using EViews (3.0) software (statistical software). Linear regressions of each of the time series of these two variables at the used stations over the period 1921-2009 were calculated in order to detect the evolution of solar radiation and precipitation. The *t*-test method (Snedecor and Cochran, 1989) was used to evaluate the significance of solar radiation and precipitation trends. Also, it was used PAST (PAlaeontological STatistics) program to find some correlation between these two variables.

If the global solar radiation (R_s) is not measured with pyranometers, it is usually estimated from sunshine hours and it can be calculated with the Angstrom-Prescott formula (Martinez-Lazono et al., 1984; Gueymard, 1995):

$$R_s = \left(a + b\frac{n}{N} \right) R_a \tag{1}$$

where R_s and R_a are the global solar radiation and extraterrestrial radiation, respectively, on a horizontal surface; n is the actual number of monthly sunshine hours and N is the maximum possible number of monthly sunshine hours; n/N is relative sunshine duration; a gives the fraction of R_a reaching the Earth on cloud-covered days when n = 0, b is the coefficient of regression; ($a + b$) represents the fraction of R_a reaching the Earth on clear-sky days, when n = N.

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Studies on the a and b coefficients of Angstrom's formula have previously been published by Baker & Haines (Baker and Haines,1969) and Panoras & Mavroudis (Panoras and Mavroudis, 1994). Variations in the a and b values are explained as a consequence of local and seasonal changes in the type and thickness of cloud cover, the effects of snow covered surfaces, the concentrations of pollutants and latitude (Linacre, 1992; Boisvert, 1990). Based on measurements made at various locations on the Earth, Allen et al. (Allen et al., 1998) recommended the values of a = 0.25 and b = 0.50 in estimating R_s, when there is available data on sunshine duration and direct measurements on R_s are missing. Therefore, the above a and b values will be used in our study.

The extraterrestrial radiation (R_a) and the monthly maximum possible sunshine duration (N) are given by (Allen et al., 1998):

$$R_a = \frac{24(60)}{\pi} G_{sc}\, d_r \left[\omega_s \sin(\varphi)\sin(\delta) + \cos(\varphi)\cos(\delta)\sin(\omega_s)\right] \tag{2}$$

$$N = (24 \times \omega_s)/\pi \tag{3}$$

where G_{sc} is the solar constant = 0.0820 (MJ m^{-2} min^{-1}), d_r is the inverse relative distance Earth-Sun, ω_s is the sunset hour angle. The hour angle, expressed in radians, is measured at sunset when the sun's center reaches the horizon. φ is the latitude of the site (radians) and δ is the solar declination (radians).

$$d_r = 1 + 0.033 \times \cos(2\pi J /365) \tag{4}$$

$$\delta = 0.409 \times \sin\left[(2\pi J /365) - 1.39\right] \tag{5}$$

where J is the 15th day of each month in the year (for monthly calculations).

$$\omega_s = \arccos\left[-\tan(\varphi)\tan(\delta)\right] \tag{6}$$

3. RESULTS AND DISCUSSION

3.1. Evolution of radiation and temperature trends

The values of the multiannual mean global solar radiation and precipitation at Cluj-Napoca station during the period 1921-2009 (89 years) are 145.562 W/m^2 for GSR and 583.4 mm for precipitation.

The mean annual global solar radiation trend for Cluj-Napoca, plotted as solid line, is presented in Fig. 1a. The analyzed data at Cluj-Napoca show an increased trend (an increasing with 8.241 W/m^2) for mean annual global solar radiation (GSR) during the period 1921-2009 being statistically significant at 0.001 level. This is due to solar variations.

The average amount of precipitation is presented in Fig. 1b. Though, it is shown an increased trend (an increasing with 55.3 mm), this is not statistically significant. This increasing could be due to an oscillation, an expression of the normal variations of the climate.

The mean annual global solar radiation and precipitation at Bistrita and Sibiu staions and their evolution during the period 1921-2009 are presented in Fig. 2a-b. There can be shown two increased trends for annual mean GSR at Bistriţa and Sbiu, an increased trend for precipitations at Bistriţa and a decreased one for Sibiu. However, of these ones only radiation trend for Bistriţa is statistically significant at 0.001 level. The other trends are not relevant.
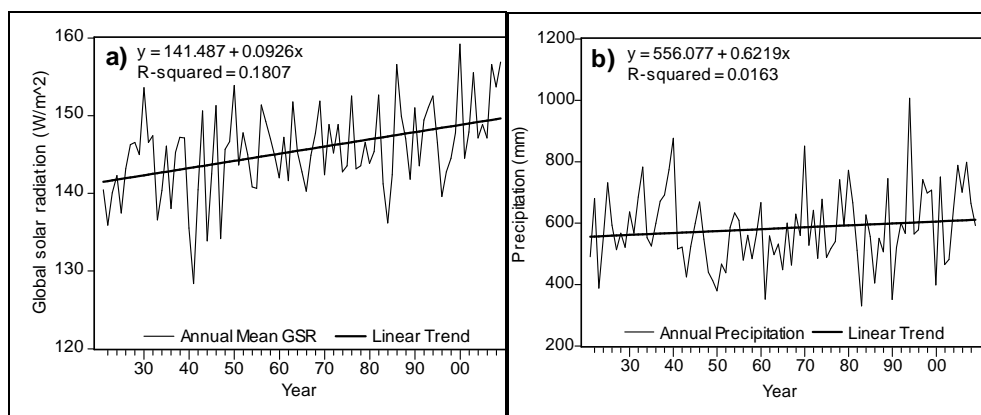

Fig. 1. *Annual global solar radiation (a) and annual precipitation (b) trends at Cluj-Napoca during the period 1921-2009.*

t-Test when applied, indicates that only the annual mean global solar radiation trends for Cluj-Napoca and Bistriţa are statistically significant at 0.001 level (99.9% probability of making a correct statement). The other ones are not relevant.

3.2. Correlation between solar radiation and precipitation

By using the Pearson's r correlation, it has been found a relationship between the solar radiation and precipitation. The scatter plots shown in Fig. 3 depict such a negative relationship which is statistically significant only for Bistriţa and Sibiu stations.

The values of Pearson's correlation are – 0.31 for Bistriţa station and –0.33 for Sibiu station. Such correlations show that there is a negative linear relationship between the solar radiation and precipitation. The 99% (p = 0.01) for annual shows the probability of making a correct statement and demonstrate that these are correlated. The value of Pearson's correlation for Cluj-Napoca (r = - 0.15) is not statistically significant, so it is not relevant for this study.
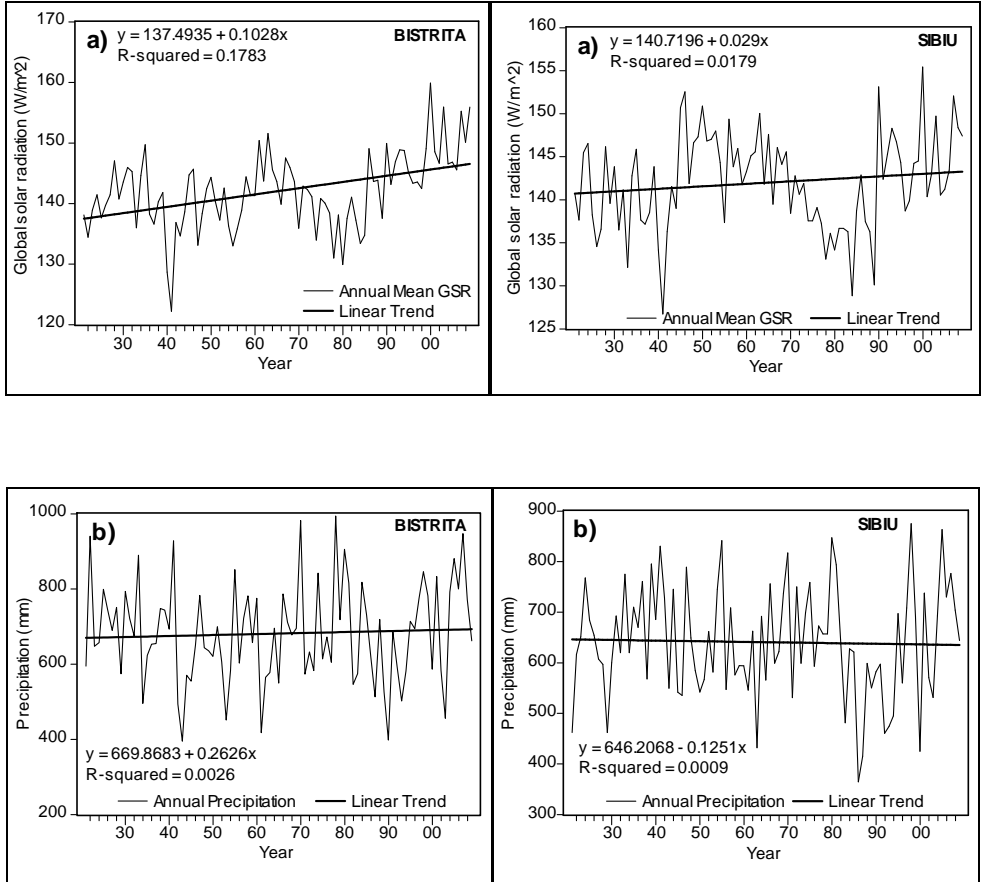
Fig. 2. *Annual global solar radiation (a) and annual precipitation (b) trends at Bistriţa and Sibiu during the period 1921-2009.*
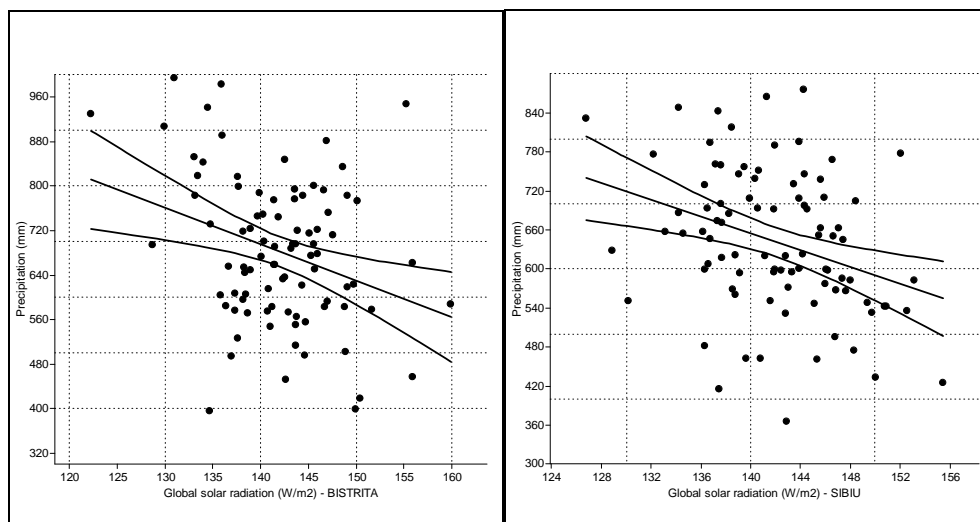
Fig. 3. *Pearson's correlation between global solar radiation and precipitation at Bistriţa and Sibiu with the regression line (the straight line in the middle) and the 95% confidence lines (the curve lines).*

4. CONCLUSIONS

In the Cluj-Napoca area, for the period 1921 to 2009, the global solar radiation (GSR) showed a particular trend being statistically significant at 0.001 level. Also, at Bistriţa meteorological station was shown that the trend was significant at 0.001 level. These significant increasing trends of the annual global solar radiation and the observed fluctuations represent a microcycle, expression of the solar variations.

In the Cluj-Napoca, Bistriţa and Sibiu area, for the period 1921 to 2009, the amount of precipitations showed no particular significant trend.

By using the Pearson's correlation, it was shown that there are negative linear relationships between the global radiation and precipitations.

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