IMPACTS OF EMISSIONS ON THE ENVINRONMENT WITHIN FIRES IN BUILDINGS OCCURRENCE IN SLOVAKIA

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The present article deals with a quantitate methodology to determine the impacts of fires which can occur in different types of buildings on the environment developed by project team from University of Zilina in Zilina. The main outcome is stating hazardousness of different kind of buildings for environment in case of fire occurrence and risk matrix which can be used in risk assessment process for impact analysis. There were experts not only from the university environment (project team) involved, but also from practice contributing to the compilation of a structured and systematic approach.

I. 1. PRESENT STATE OF ART

The issues of environmental burdens and impacts of the crisis phenomena on the environment is being paid less attention than to loss of life and financial losses on property [20, 22]. The problem nowadays is CO2 which contributes to global warming and climate changes on earth. However, air is only one part of the environment, and therefore we should not forget others. It is mainly a question of sustainable development, which is associated with this [19, 21].

The issue of the impact of fires in buildings on the environment is not addressed in many sources. Under the project „Scoping study on the impact of fire on the environment and building sustainability" commissioned by Communities and Local Government and carried out by BRE provide clear information to assist Communities and Local Government in developing their priorities for future research on how (or whether) to include environmental protection and sustainability in Approved Document B and how (or whether) to include the impacts of fire in the Communities and Local Government wider sustainability agenda for buildings and construction.

In Slovakia, this issue has not been researched yet. There are few papers/documents describing the problem in theory but to determine the exact impact on the environment, the project team consisting of different researchers in Slovakia has not found many relevant information in the analysis of existing resources.

Given the facts above and on the basis of available information, meetings and consultations with experts, project team has decided to create a new approach to environmental risk assessment, which is listed below and will be part of the model created by the project FIREFF.

I. 2. GOALS AND METHODS OF RESEARCH

Based on an analysis of existing approaches to the assessment of the impacts of fires in buildings on the environment we set the main objective. The main objective was to create an approach for the environmental risk assessment based on the analysis and assessment (quantification) of hazard buildings in terms of impacts of emissions to the environment in the development of fires in Slovakia.

Impacts on the environment are very difficult to determine in some cases, depending on a number of factors and there is a number of variables/data entering the overall assessment process, which it is necessary to consider. In the processing of this procedure, we have used several methods like brainstorming, brainwriting, what-if analysis, CCA analysis, interview, expert review and many other methods. We have combined materials, which we found in the scientific literature and legal standards and regulations with the knowledge we have gained through consultations with experts and team meetings. Relevant references that helped us within methodology creation are presented bellow in each step of this approach.

I. 3. RESULTS OF RESEARCH

On the basis of the analysis of the current state of the art, available domestic and foreign documents, interviews and meetings with experts from the practice were organised and therefore was designed the basic procedure to determine the impact of emissions on the environment when creation and development of fires in the different kind of buildings.

In order to meet the objective defined, we ran an analysis of input materials from a variety of domestic and foreign sources of the issue, and then set the input data necessary for the determination of impacts of emissions and fire-extinguishing substances on the environment in the liquidation of fires in Slovak conditions. The procedure was as follows:

a) Proposal for categorisation of buildings

The categorization of buildings is based on the distribution within the meaning of the standards STN 92 0201 Structural fire protection [4]. This categorisation is based on the type of occupancy of the building or area. The basic prerequisite is that kind of use of the building is one of the primary factors determining the risk of fire hazardousness. Whereas the type of occupancy of the buildings is usually associated with a certain type of fuel – equipment and facilities of the building, it is also possible to establish the basic parameters of the fire in such a way – speed of increase, fire load, the nature of the fuel, etc. The categorisation chosen in such a way retains compatibility with existing standards; in practice, there will not, therefore, be further classification necessary for the purposes of determining the impact of the fire on the environment. Analyses of statistical data of fires provided in Slovakia confirm the appropriateness of categorisation specified. The categorisation of buildings proposed is also a good material used for the purposes of international comparison, which is analysed in more details [6]. The categorisation of buildings proposed is as follows:

- administration buildings,
- buildings for learning – buildings for education, science and research,
- recreational buildings – buildings for culture and physical education and historical and religious buildings and objects,
- buildings in the health sector,
- buildings for commerce - building for business and public catering,
- buildings for shared accommodation and recreation,
- buildings for social security,
- industrial buildings – buildings for production, energy and water management buildings,
- buildings for transport – buildings for transport and communications, building for the garage and maintenance of vehicles, garages as part of other buildings, buildings for garage and maintenance of agricultural vehicles,
- buildings for agriculture - buildings for hunting and forestry activity, building for livestock and crop production, objects in the storage of agricultural products, other buildings for the storage of agricultural products,
- buildings for storage - dedicated buildings for storage,
- residential housing stock.

b) The determination of the size of the fires from the perspective of the impact on the environment

There are several possible divisions, which are related to this area and subsequent verbal descriptions. Considering the basic classical division of the size of the fire into 5 categories, on the basis of consultations with the expert group we have excluded the local fire following the consultation (0 – 50 m2) as well as small fire (room of origin 5 – 50 m2), whose impact on the environment in case of emission is negligible. On the basis of this assessment, we determined the size of the fires from the perspective of the impact on the environment as follows:

- Medium-sized fire (1/2 area of the fire zone 50 – 500 m2).
- Big fire (entire fire zone 500 – 1 000 m2).
- Catastrophic fire (extension outside the fire zone above 1 000 m2).

c) The determination of the percentage of the material in the categorisation of buildings specified in Slovak conditions.

On the basis of the proposed categorisation of buildings, it was necessary to assign corresponding types of space according to STN 92 0201 to the individual categories [4]. The material they are composed from, we simply divided into three basic categories:

- cellulose - Q_C,
- plastics – Q_P,
- chemicals – Q_{CH}.

It is necessary to establish proportional representation in each building since this material found in construction significantly affects the increase of fire (so-called the coefficient of increase in fire - slow, medium, fast, ultra fast) [1]. For this reason we have created so-called a table of the percentage of material in the construction. When creating this percentage we were used also expert estimates of practitioners [16]. In practice, there is a significant number of different types of materials in constructions, therefore, we had to do some simplification of this division. As an example we can mention the category 10 (buildings for agriculture), where the percentage of material in the building can fluctuate in plastics and chemicals. It is not possible to determine it exactly because we have had to establish the individual values using the expert estimation and create a representative sample of the material in the various categories of buildings in Table I [2, 3].

Table I Percentage of the material in the categorisation of buildings

	Categorisation of buildings	**Classification according to α-coefficient increase in the fire**	**Type of space**	**Percentage of material in the building**		
				Cellulose - Q_C	**Plastics - Q_P**	**Chemicals - Q_{CH}**
1.	Administrative buildings	Intermediate	offices, record offices, meeting rooms, foyers, corridors	90%	10%	0%
2.	Building for learning	Intermediate	classrooms, lecture rooms, archives, common dressing room	80%	20%	0%
3.	Recreational buildings	Fast	auditorium, cinema, concert hall, exhibitions, museums, churches	60%	40%	0%
4.	Building in the health sector	Intermediate	bed rooms, waiting rooms, pharmacies, massage and rehab. room	50%	50%	0%
5.	Buildings for commerce	Fast	glass, meat, food, toys, textiles, clothing,, drugs, music tools	30%	40%	30%
6.	Building for accommodation and recreation	Intermediate	receptions, halls, corridors, coffee shops, night clubs, cafeterias, bar rooms	40%	55%	5%
7.	Buildings for social security	Fast	homes for retirees	40%	55%	5%
8.	Industry buildings	Intermediate	textiles, clothing,, engineering, chemical, electronics industry	20%	40%	40%
9.	Buildings for transport	Intermediate	waiting rooms, left-luggage office, foyers, corridors, passageways	80%	20%	0%
10.	Buildings for agriculture	Ultra fast	storages, stables, sheds, drying room, manufacturing of compound feeding stuffs	80%	10%	10%
11.	Buildings for storage	Ultra fast	Storehouses	35%	35%	30%
12.	Residential housing	Fast	residential houses, family houses	45%	45%	10%

B. HAZARDOUSNESS OF BUILDINGS ASSESSEMENT

The analysis and evaluation of the impact of emissions on the environment when developing of fires within predefined categorisation of buildings we proceeded as follows:

a) The calculation of the degree of seriousness of the emissions and the occurrence of material from the perspective of the impact on the environment point of view.

To assess the risk of buildings in terms of emissions to the environment impact, we first define the main criteria:

The degree (extent) of seriousness of the material that has the greatest negative impacts in the emissions leaked when burning fires on the environment in different buildings – Zi.

Percentage (occurrence) of the material within the prescribed categorisation of buildings in the Slovak Republic – Qi.

According to expert estimates of the project team, experts from practice and technical-scientific analysis of domestic and foreign literature, we can assume that the greatest danger, in terms of emission and their subsequent impacts on the environment, is represented by these materials with a specified coefficient (Z):

- Plastics – coefficient Zp – 0.45,
- Chemicals – coefficient Zch – 0.35,
- Cellulose – coefficient Zc – 0.2.

We decided to set in order plastic, cellulose and chemical material as the most frequent materials used in buildings sculptures. We consider cellulose less dangerous for environment in case of fire occurrence because there are less dangerous exhausts. According to comparison of chemical and plastic coefficient it depends on nature of hazardous substance (more dangerous or less dangerous), that is why we placed on first place plastic because it is always dangerous for the environment when building fire occurrence. Then we split number 1 into relative pieces and allocated each to certain material according to stated order.

Table II shows the results of calculating seriousness of emission and presence of materials in terms of the impacts on environment at the specified categorisation of buildings in Slovakia using MS Excel.

Table II calculation of the degree of seriousness of the emissions and the occurrence of material from the perspective of the impact on the environment point of view

No.	Categorisation of buildings	Type of space	Percentage of material in the building - Q			Impact of emissions on the environment				
			Cellulose - Q_c	Plastic - Q_p	Chemicals - Q_{ch}	Cellulose severity - Z_c	Plastic severity - Z_p	Chemical severity – Z_{ch}	Final index - I_E	Rank
1.	Administrative buildings	offices, record offices, meeting rooms, foyers, corridors	0.90	0.10	0.00	0.20	0.45	0.35	0.23	12
2.	Buildings for education	classrooms, lecture rooms, archives, common dressing room	0.80	0.20	0.00	0.20	0.45	0.35	0.25	10.11
3.	Recreational buildings	auditorium, cinema, concert hall, exhibitions,	0.60	0.40	0.00	0.20	0.45	0.35	0.30	8

		museums, churches								
4.	Buildings in the health sector	bed rooms, waiting rooms, pharmacies, massage and rehab. Room	0.50	0.50	0.00	0.20	0.45	0.35	0.33	5,6,7
5.	Buildings for commerce	glass, meat, food, toys, textiles, clothing,, drugs, music tools	0.30	0.40	0.30	0.20	0.45	0.35	0.35	2,34
6.	Buildings for shared accommodation and recreation	receptions, halls, corridors, coffee shops, night clubs, cafeterias, bar rooms	0.40	0.55	0.05	0.20	0.45	0.35	0.35	2,34
7.	Buildings for social security	homes for retirees	0.40	0.55	0.05	0.20	0.45	0.35	0.35	2,34
8.	Industrial buildings	textiles, clothing,, engineering, chemical, electronics industry	0.20	0.40	0.40	0.20	0.45	0.35	0.36	1
9.	Buildings for transport	waiting rooms, left-luggage office, foyers, corridors, passageways	0.80	0.20	0.00	0.20	0.45	0.35	0.25	10,11
10.	Buildings for agriculture	storages, stables, sheds, drying room, manufacturing of compound feeding stuffs	0.90	0.10	0.10	0.20	0.45	0.35	0.26	9
11.	Buildings for storage	storehouses	0.35	0.35	0.30	0.20	0.45	0.35	0.33	5,6,7
12.	Residential housing stock	residential houses, family houses	0.45	0.45	0.10	0.20	0.45	0.35	0.33	5,6,7

b) The hazard categorisation of buildings from the viewpoint of the emission of fires on the environment

On the basis of the calculation of the seriousness of emissions and the occurrence of material in individual buildings, we have asymmetrically divided ranges of individual intervals and assigned different types of buildings to hazard categories in terms of emission impacts of fires on the environment in Slovakia. Most types of buildings were included in the first category of hazard as very dangerous buildings. These results also agree with their subsequent assessment by the team of experts in fire safety area.

Table III Categorisation of buildings based on the hazard in view of the emissions of fires on the environment

Degree	Hazard category of buildings in terms of fire emissions on the environment	Types of buildings (number)	Interval variance
1	very dangerous buildings	8,5,6,7,4,11,12	0.36 - 0.33
2	medium dangerous buildings	3	0.32 - 0.27
3	less dangerous buildings	2,9,1,10	0.26 - 0.23

c) The evaluation of emission impacts of fires on the environment in the buildings specified

Based on the establishment of hazard degree of buildings and the size of fire in the previous step, we may identify the size of the impact of fire on the environment. Individual impacts were divided into three categories and individual degrees are different in colours:

- moderate impacts on the environment,
- medium impacts on the environment,
- catastrophic impacts on the environment.

Following the previous calculations, we determined the risk matrix impacts of emissions of fires on the environment within the categorisation of buildings. The risk matrix, or consequence/impacts and probability matrix is a good graphical tool for risk assessment. The view of the specific risks assumed in the matrix provides a picture of acceptability or non-acceptability of this risk and allows a comparison of individual risks [18, 19]. We have set and assessed the risk matrix as follows:

- Despite the site, moderate impacts needed to be monitored but it is not desirable to take preventive measures.
- Medium impacts require increased attention, especially in identifying the needs of taking / not taking additional measures.
- In the event of catastrophic impacts, it is necessary to take such preventive measures (technical and organisational) to clearly demonstrate reduction in risk to an acceptable level and inform competent officials on residual risk.

Table IV Combination of hazard of buildings and the size of fire in terms of impacts on the environment in buildings specified

Hazard category of buildings in terms of fire emissions on the environment / Size of fire m^2	1 Dangerous buildings	2 Medium dangerous buildings	3 Very dangerous buildings
Medium fire	Moderate impacts on the environment	Moderate impacts on the environment	medium impacts on the environment
Big fire	Moderate impacts on the environment	Medium impacts on the environment	Catastrophic impacts on the environment
Catastrophic	medium impacts on the environment	Catastrophic impacts on the environment	Catastrophic impacts on the environment

II. CONCLUSIONS

Based on the processing analysis we can conclude that among the most dangerous buildings in terms of fire impacts on the environment (emissions and fire-extinguishing substances) include:

- industrial buildings,
- buildings for commerce,
- buildings for storage.

Created risk matrix also can be used when providing impact assessment of emissions when big fires occurs. To be honest it is necessary to say that these impacts are not so significant in comparison to long-term environmental damaging activities, but project team considered this topic as really important within creating of mentioned model.

The next step will be assessing of fire-extinguishing substances which are used within liquidation of fires regarding impacts on environment. This will be done by the same approach starting with assessing of impacts on the environment and creating risk matrix for assessing these risks. Furthermore the project team is developing new formulas which will cover both approaches (emissions impacts, fire-extinguishing impacts) and will be used for identifying final index for each case.

This approach is very specific but the generalization of the results of the project team into MS Excel tables is in accordance with currently established procedure that is used in risk assessing. The categorization of buildings into three groups was necessary to provide for the needs of further use in setting up a tree structure (ETA) for analyzing the impacts of fires on lives, property and the environment in the project. This procedure, however, can also be used separately only for assessing the impacts of fires on the environment not only in Slovakia but also in other countries.

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