ABSTRACT

Due to the increasing public awareness of the potential risks associated with waste transport, the environmental impact assessment of this activity has become an issue of major importance. This paper presents a project proposal, which can establish a national action plan for waste transport evaluation. Such a programme is sustained by the necessity to obtain an adequate method for the rapid and efficient estimation of individual and social risks due to the transport of hazardous substances in Romania. The main objective is to develop regional strategies for risk assessment in comprising: establishing the areas that must be investigated and their particular characteristics; identifying the transport activities in the areas; determining hazards; establishing the analysis criteria and prioritizing the study areas; evaluating continuous emissions; studying major accidents; studying population health; classifying the risks; establishing regional strategies; implementing political and regulatory measures. The project expectation is to provide a decision tool for risk managers and authorities in order to control or limit transportation and the storage of hazardous substances.

1 INTRODUCTION

In risk assessment the analysis of hazardous material transport and storage is an element often neglected. The potential accidental pollution of the environment is high for hazardous material transport and its analysis is much more difficult than for a fixed plant taking into account the various initiation conditions of an accident and their consequences.

One possibility to minimize the risk in hazardous material transport is to develop a regional strategy for monitoring industrial activities, hazardous materials and their transport routes, and to collect all the necessary data for a complete transport database.

In a national research programme, ICSI Rm. Valcea will initiate a project with the aim of defining a possible strategy to reduce risks in transport and storage of hazardous materials, to establish the most adequate analysis methods and to illustrate the advantages of using Geographic Information System (GIS) in such an analysis.

This paper attempt to highlight a framework for a regional strategy and to explore the benefits of using GIS in risk analysis for hazardous materials transport and storage with regard to the Romanian territory.
2 RISK ANALYSIS AND MANAGEMENT

Any human activities involve risk and risk estimation, assessment and management has become a problem involving a multidisciplinary scientific approach. The goal of risk assessment is a humanitarian one because it is very important to prevent human and economic injuries and damage.

The general steps of risk assessment, highlighted in Figure 1, refer to system/activity definition, hazard identification, quantifying the frequency and consequences of accident sequences, risk analysis, estimation of risk levels and improvement proposals (process improvement, intervention after accidents, etc.). [1,2]

![Figure 1: General steps in risk analysis](image)

Risk management represents a way in which the evaluation results are used to control the risk, to identify the places where the safety of the activity was satisfactory or not, and to elaborate solutions for risk reduction. The risk management approach is illustrated in Figure 2.

![Figure 2: General approach in risk management](image)
3 METHODOLOGICAL FRAMEWORK

This paper has the aim of presenting a general method and its associated procedures to choose the priorities in the frame of different risk sources for hazardous materials transport and storage to facilitate a detailed risk assessment on a priority basis. This will represent assessment of major accident risks caused by transportation of hazardous substances by road, railway and pipelines.

The risks considered are those for public health due to explosions, fires and emissions of dangerous substances under established parameters.

The transport risk assessment method includes the main tasks necessary to classify the risks and to achieve a graduated priorities scheme as follows: a list of hazardous substances, a classification of transport and storage activities, a selection of activities that must be studied, establishing the effects category, estimating consequences to the population and the frequency of accidents, estimating the social risk, risk hierarchisation depending on priorities.

4 PROCEDURAL STEPS FOR RISK ASSESSMENT

For a complete identification of the characteristics of transport and storage activities over the whole of a given territory the study must be performed in separate zones of approximately 100 km², with important industrial activity and a substantial number of people.

The main steps of the regional risk assessment process in a integrated manner are highlighted in Figure 3 and Figure 4, representing a possible strategy for hazardous materials transport and regional storage risk assessment. [3]

For a better understanding, a short presentation of the procedural steps for hazardous materials transport and storage are illustrated:

P.1. Establishing the boundary and the main characteristics of the studied area
   P.1.1. Boundary area definition
   P.1.2. Area description
   P.1.3. The area map

P.2. Defining and centralizing the transport and storage of hazardous materials in the area

Once the studied area and its main characteristics are established a database regarding hazardous materials transport activities must be made. It is important to collect information regarding names, localization, type, production, storage and/or transport conditions, physical characteristics and quantity of substances and an activities criteria selection depending on the distance to populated areas, traffic density, etc.

Those activities that do not represent a direct danger for the population, because of distance or low transport rate, were excluded from the hazardous substance classification scheme. The studied areas (roads, railways, and pipes) were divided into 1 km parcels. Those portions that don’t match with the distance criteria face on populated area are ignored.

The nearest places to populated area were selected for every parcel and for rail transport special attention was paid to marshalling yards.

P.2.1. Classification of activities by type;
   P.2.2. Data collection regarding hazardous activities in the area (place, environmental impact, etc.);
   P.2.3. Exclusion of those activities with low impact;
   P.2.4. Hazardous substances inventory compilation and activities enumeration; estimation of the maximum quantity of hazardous substances released in an accident.
P.3. Estimation of accident frequency
The frequency estimation for different accident events can be made using:
- statistical data for hazardous substances storage and transport;
- expert experience;
- failure modes and effects analysis method;
- failure tree method; others.

P.4. Estimation of consequences
The estimation of consequences for every selected activity is performed after a sufficient set of data has been gathered for the hazardous activities in the area. The consequences of an accident means the number of fatalities at population level who live and work in the neighbourhood of a storage plant or near a road, railway or pipeline for hazardous substances transport.
P.4.1. Activity selection
P.4.2. Separate analysis of substances
A group of substances that act together are considered as one substance. If an inflammable substance is also toxic, both effects are considered.
P.4.3. Activity classification
Using the activity classification tables the negative activity type will be established, as well as the physical and chemical characteristics of the substances (boiling point, molecular weight, heat of evaporation, liquid density, compressibility coefficient, dynamic viscosity, heat of combustion, upper and lower explosion limits, MAC value, probit coefficients). The effects categories take into account the maximum effect distance and affected perimeter.
P.4.4. Determining the maximum effect distance and the affected area
P.4.5. Estimating the population distribution in the affected area
P.4.6. Establishing the meteorological conditions (wind direction, wind speed class, atmospheric stability class)
P.4.7. Establishing a dispersion model
P.4.8. Evaluating the consequences

![Diagram of risk assessment process]

**Figure 4:** Possible strategy for regional risk assessment

P.5. Estimation of social risk
For every analyzed activity (storage plant or part of a road, railway or pipeline) one or more estimates of the fatality number and the frequency of major accidents will be achieved.
The risk for the population can be estimated using these values, representing the measure of activity’ frequency and negative consequences.

P.5.1. Establishing the risk estimation mode: qualitative/quantitative

P.5.2. Establishing the risk level for every activity using a scale of consequence classes and one of the probability classes

P.5.3. If an activity represents an increased risk for the population due to utilization of many different hazardous substances that can cause accidents independently one another, the risk will be the amount of risk value determined by substances from the same consequence class.

P.5.4. Representation of the results of activity classification depending on risk in a graphical mode

P.6. Risk hierarchisation depending on priorities

P.6.1. A criteria for social risk acceptance is defined:

The acceptability criteria can be established by many methods:
- establishing a threshold only for the probability;
- establishing a threshold only for the consequences;
- taking into account both the probability and consequences.

An event with lower frequency and greatest consequences is more important for study than one with a lower frequency and lower consequences.

P.6.2. Identifying the activities having an unacceptable risk level.

5 USING GIS IN RISK ANALYSIS FOR HAZARDOUS MATERIALS TRANSPORT

The necessity for GIS in analysis of hazardous materials transport is sustained by the rapid and efficient individual and social risk achievement. One important role of GIS is the ability to bring together data from a variety of sources, for example, health, socioeconomic data and environmental data, within a common framework. Once a map has been created in the GIS it can be integrated with other information, such as census data. The programme could provide a preliminary hazards evaluation allowing the decision factors to assess where the transport activity is acceptable or not, or a detailed analysis is required. Providing alternative solutions such as changing the transport routes or modes and identifying the least dangerous one is also permitted.

The main ideas to be developed in this programme are:
- data collection reduction and the activity organization by using average values for some parameters;
- separate estimation of consequences for every accident states depending on meteorological conditions and their introduction in a database;
- comparing the estimated individual and group risks with a standard one, established at national or international level, to a rapidly information achieving regarding the risk level.

The hardest task in the program’s development is data collection that for every route must contain information regarding vehicle types, transported substances, emission scenarios, meteorological conditions, accident rates and population density.

To define the accident scenarios an emissions classification can be drawn up depending on the released quantity of substance: without emission, low emission (<10 L), medium emission (10-200 L) and major emission (>200 L). Taking into account that in most cases a low emission (such as a substance released by a small leak) leads to a negligible hazard which can be treated as a no emission case. In the other cases we can presume that once the accident occurs the product is released by a circular break on the bottom of a tank.
The meteorological data are provided for a 10 year period, by month, and include average values for minimum and maximum temperatures, humidity, wind direction and the persistence of certain wind speed classes.

**Figure 5:** Data distribution in a geographical information system

The accident rate used in hazardous substances transport risk analysis must be expressed as accidents per kilometer and per vehicle (generally, the existing data are expressed as number of accidents per kilometer and per year).

**Figure 6:** South-East Romania population density
The data regarding the population density are to obtained from census data. In principle, every county must be divided in two zones: one that includes the towns with an intensely populated area and the other outside the towns with lowest population density. An example of population density classes is presented in Table 1. Figure 6 illustrates the population density in South-East Romania.

<table>
<thead>
<tr>
<th>The population density class</th>
<th>The population density (/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolated area</td>
<td>0 – 49</td>
</tr>
<tr>
<td>Rural area</td>
<td>50 – 149</td>
</tr>
<tr>
<td>Suburban area</td>
<td>150 – 499</td>
</tr>
<tr>
<td>Urban area</td>
<td>500 - 3000</td>
</tr>
</tbody>
</table>

The greatest attention must be paid to the selection of substances included in the database. All results regarding the individual and social risks should be compared with standards. Unfortunately Romania doesn’t have its own set of limit values used to define risk acceptability.

6 CONCLUSIONS

From the perspective of Romanian sustainable development there exists an increased interest regarding the impact of human activities on the environment taking into account that any human action or activity represents a degree of risk and risk assessment and management is a multidisciplinary problem. The application at national level of such a programme can lead to increased awareness, risk reduction of hazardous substance storage and transport, and improve the legal framework. Such an analysis provides many advantages. The route identification for hazardous substance transport is just one of them. Developing the accident scenarios, collecting data and analyzing them permits us to explore at maximum potential a geographical information system to assess the risk for transport. The GIS benefits are better and easier work for the analyst, permitting rapid route modifications and evaluation of an accident’s possible impacts. If the geographical information systems would be applied in Romania on a large scale by staff in management, a better control of transport activity could be provided, in order to minimize risks.

REFERENCES

