MICA
Minerals Intelligence Capacity Analysis

FACT SHEET

Quantitative Risk Assessment (QRA)

Description of the method of Quantitative Risk Assessment (QRA).

Scope (conceptual model & main characteristics)

Risk Assessment (RA) is a broader method of estimating and managing health risks. The approach calculates the chance of some hazardous event (expressed as probability of death. P_d) and multiplies that with the number of potential casualties if such an event would happen expressed as fraction of death F_d). The result is a theoretical number of casualties per annum, which is then subjected to a comparison with some sort of agreed on acceptable level. RA is relevant for the release of toxic substances into the environment, but is used for incidents rather than prolongued exposure as a result of continuous emissions. It is also used for other disastrous events such as explosions, floods or traffic accidents.

A formal QRA attempts to answer the questions:

1. What can go wrong?
2. How often does it happen?
3. How bad are the consequences?

Based on this information, the decision is made whether the risk is considered acceptable.

Contexts of use, application fields	-> contexts (e.g., environmental, economic, social assessment) -> which types of stakeholder questions are concerned?

A Quantitative Risk Assessment (QRA) is a valuable tool for determining the risk of the use, handling, transport and storage of dangerous substances. QRAs are used to demonstrate the risk caused by the activity and to provide the competent authorities with relevant information to enable decisions on the acceptabilityof risk related to developments on site, or around the establishment or transport route (RIVM, 2005).

A Quantitative Risk Assessment (QRA) is a valuable tool for determining the risk of the use, handling, transport and storage of dangerous substances. QRAs are done if dangerous substances are thought to be present at a location (e.g. industrial sites and transportation routes) in amounts that can endanger the environment. A QRA is used in a Safety Report to demonstrate the risk caused by the establishment and to provide the competent authority with relevant information for assessing incremental risk and for enabling decisions on the acceptability of risk related to developments on site of or around the establishment. A Safety Report should be made if the amount of dangerous substances that can be present in an establishment exceeds a threshold value. The procedure to determine whether a Safety Report has to be made is given in the 'Seveso-III directive', the Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC (EC, 2016; EC, 2012). The procedure is outlined in for example the Dutch Reference Manual Bevi Risk Assessments (RIVM, 2015; RIVM, 2009; RIVM, 2005) and the ARAMIS, developed in an European project, a risk assessment methodology for industries in the framework of the SEVESO II directive (Salvi & Debray, 2014).

The Minerva portal of the Major Accident Hazards Bureau at the European Commission's Joint Research Centre provides a collection of technical information and tools supporting the Industrial Accident policy. (JRC, 2016)

Type(s) of data or knowledge needed and their possible source(s)	-> which types of data are needed to run the method, from which sources could they come… -> could be qualitative data or quantitative data, and also tacit knowledge, hybrid, etc.

Risk assessment are performed for the use, handling, transport and storage of dangerous substances. QRA's are performed for installations or transport routes for these two different applications slightly different models and procedures are used (RIVM, 2015; RIVM, 2009; RIVM, 2005)

Roughly the following information is needed to perform a quantified risk assessment for a static installation:

- Selection of installation to estimate loss of containment events:
  Type and location of installations
- Dispersion of the substance:
  Physical and chemical properties of the substance, meteorological data
- Exposure and damage:
  Toxicological data of the substance
- Individual risk and societal risk assessment:
  information of the people density and distribution at the location

The basic data needed in conducting a QRA for a specific transport route include the:

- Description of the transport route (location, type of route, obstacles present)
- Description of the transport streams (annual number of transport units per substance or category, during daytime and night-time)
- Description of the number of accidents and traffic intensities in order to determine accident frequencies
- Description of the transport units (type of unit, characteristic inventory)
- Description of the ignition sources
- Physical, chemical and toxicological properties of transported (representative) substances
- Terrain classification of the surroundings of the transportation route
- Meteorological data
- Population present in the surroundings of the transportation route

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Model used (if any, geological mathematical, heuristic…)	-> e.g., geological model for mapping -> e.g., mathematical model such as mass balancing, matrix inversion, can be stepwise such as agent -based models, dynamic including time or quasidynamic specifying time series… -> can also be a scenario

In general three steps in the procedure of risk assessment can be distinguished all making use of dedicated models

- the methods for determining and processing probabilities, is to be used to derive scenarios leading to a loss of containment event

- the models to determine the outflow and dispersion of dangerous substances in the environment
- models to describe the impact on humans of exposure to toxic substances , heat radiation and overpressure (RIVM, 2015; RIVM, 2009; RIVM, 2005)

System and/or parameters considered	-> **the system can be described by its boundaries**. These can refer to a geographic location, like a country, or a city, the time period involved, products, materials, processes etc. involved, like flows and stocks of copper, or the cradle-to-grave chain of a cell phone, or the car fleet, or the construction sector, or the whole economy… -> **parameters** could possibly refer to geographic co-ordinates, scale, commodities considered, genesis of ore deposits and others…

Quantitative risk assessment calculates the probability and consequences of an incident either for a static installation or a mobile transport vessel along a transport route. The calculated risks are substance specific, installation specific and site specific.

Time / Space / Resolution /Accuracy / Plausibility…	-> to which spatio-temporal domain it applies, with which resolution and/or accuracy (e.g., near future, EU 28, 1 year, country/regional/local level…) -> for foresight methods can also be plausibility, legitimacy and credibility…

The consequences and probability of the risks are calculated for the present situation. The probability of the incident is mostly based on a year. The risk assessments are made case by case for detailed specified installations and transport routes.

Indicators / Outputs / Units	-> this refers to what the method is actually meant for. Units are an important part but that is most of the time not sufficient to express the meaning. For example, **the indicators used in LCA express the cradle-to-grave environmental impacts of a product or service**. This can be expressed in kg CO_2-equivalent. But also in €. Or in millipoints. Or in m^2year land use.

	-> for foresight methods the outputs are products or processes

The results of a QRA are the Individual Risk and the Societal Risk (RIVM, 2015; RIVM, 2009; RIVM, 2005)

- The Individual Risk represents the frequency of an individual dying due to loss of containment events (LOCs). The individual is assumed to be unprotected and to be present during the total exposure time. The Individual Risk is presented as contour lines on a topographic map.
- The Societal Risk represents the frequency of having an accident with N or more people being killed simultaneously. The people involved are assumed to have some means of protection. The Societal Risk is presented as an FN curve, where N is the number of deaths and F the cumulative frequency of accidents with N or more deaths.

Treatment of uncertainty, verification, validation	-> evaluation of the uncertainty related to this method, how it can be calculated/estimated

If the results of a QRA in the decision-making process are to be used, they must be verifiable, reproducible and comparable. These requirements necessitate QRAs made on the basis of similar starting-points, models and basic data. Ideally, differences in QRA results should only arise from differences in process- and site-specific information.

To guarantee such a consistency in starting points and procedure the Dutch Committee for the Prevention of Disasters (CPR) has published a number of documents for attaining comparability in the QRA calculations.

The Committee for the Prevention of Disasters (CPR) has issued three reports describing the methods to be used in a QRA calculation, namely the ‘Red Book’, the ‘Yellow Book’ and the ‘Green Book’. The ‘Red Book’, describing the methods for determining and processing probabilities, is to be used to derive scenarios leading to a loss of containment event [CPR12E]. The ‘Yellow Book’ describes the models to determine the outflow and dispersion of dangerous substances in the environment [CPR14, CPR14E], and finally, the ‘Green Book’ describes the impact on humans of exposure to toxic substances , heat radiation and overpressure [CPR16].

Main publications / references	-> e.g. , ILCD handbook on LCA, standards (e.g. , ISO) -> can include reference to websites/pages

EC, 2016. Industrial accidents. The Seveso Directive - Prevention, preparedness and response http://ec.europa.eu/environment/seveso/

EC, 2102. Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012L0018

JRC, 2016. The Minerva Portal of the Major Accident Hazards Bureau. A Collection of Technical Information and Tools Supporting EU Policy on Control of Major Chemical Hazards. https://minerva.jrc.ec.europa.eu/en/minerva

RIVM, 2015. Handleiding Risicoberekeningen Bevi, Versie 3.3. National Institute of Public Health and the Environment (RIVM), Centre for External Safety, Bilthoven, the Netherlands. http://www.rivm.nl/Documenten_en_publicaties/Professioneel_Praktisch/Richtlijnen/Milieu_Leefomgeving/Handleiding_Risicoberekeningen_Bevi

RIVM, 2009. Reference Manual Bevi Risk Assessments, version 3.2. National Institute of Public Health and the Environment (RIVM), Centre for External Safety, Bilthoven, the Netherlands. http://www.rivm.nl/dsresource?type=pdf&disposition=inline&objectid=rivmp:22450&versionid=&subobjectname=

RIVM, 2005. Guidelines for quantitative risk assessment. 'Purple book', CPR 18E. Publication Series on Dangerous Substances (PGS 3). Sdu Uitgevers, The Hague http://content.publicatiereeksgevaarlijkestoffen.nl/documents/PGS3/PGS3-1999-v0.1-quantitative-risk-assessment.pdf

Salvi, O & B. Debray, 2006. A global view on ARAMIS, a risk assessment methodology for industries in the framework of the SEVESO II directive. Journal of Hazardous Materials. Volume 130, Issue 3, 31 March 2006, Pages 187–199. http://dx.doi.org/10.1016/j.jhazmat.2005.07.034

Related methods	-> List of comparable methods, their particularities… (or a link to one or several other fact sheet(s))

Environmental risk assessment, see factsheet ERA, is part of the broader family of Risk Assessment. ERA is relevant for the release of toxic substances into the environment, but for prolongued exposure as a result of continuous emissions rather than for incidents.

Some examples of operational tools (CAUTION, this list is not exhaustive)	-> e.g., software… Only give a listing and a reference (publication, website/page…) -> **should be provided only if ALL main actors are properly cited**

ADAM (Accident Damage Analysis Module) is a tool developed by MAHB (Major Accident Hazards Bureau from EC-JRC) designed to assess physical effects of an industrial accident in terms of thermal radiation, overpressure or toxic concentration resulting from an unintended release of a dangerous substance. For such a purpose, suitable models have been used and combined, to simulate the possible evolution of each accident: from the time of release to the final damage. This tool is specifically intended to guide the EU competent authorities for assessing the consequences of potential major accidents. https://minerva.jrc.ec.europa.eu/en/ADAM/content

However there are numerous other QRA software tools exist, see for example https://en.wikipedia.org/wiki/Quantitative_risk_assessment_software

Key relevant contacts	-> list of relevant **types** of organisations that could provide further expertise and help with the methods described above.

The Joint Research Centre's Major Accident Hazards Bureau https://minerva.jrc.ec.europa.eu/en/content/minerva/c76dfa82-97a9-435f-8e0e-39a435aeec3a/who_we_are

Glossary of acronyms /abbreviations used	-> Definition