Hazardous goods in humanitarian supply chains

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Abstract
Hazardous goods can be either the reason for disasters (e.g. Fukushima) or as relief items part of humanitarian supply chains (e.g. medicines, gases, oils). The publication deals with environmental and health risks which occur from hazardous goods, with the international standard GHS and with possibilities to reduce the identified risks).

Keywords: Hazardous goods, dangerous goods, humanitarian logistics, supply chains

Introduction
When thinking about humanitarian aid and humanitarian supply chains the topic "hazardous goods" isn't immediately in mind. What we have in mind is bringing food, non-food-items like tents and tarpaulins for camps, medicines and other pharmaceutical products into the affected countries. We also think about the staff of the Non Governmental Organizations (NGOs) and other organizations integrated into the humanitarian aid, which is needed on-site.
But when getting involved into the topic of humanitarian logistics more deeply we can see and understand to what extend hazardous goods matter. Dangerous goods can be one of the reasons for disasters, like in Fukushima, Japan in the year 2011. After an earthquake and tsunami the explosion of atomic power plants have caused radioactive releases and with this a contamination of the area around the plants. The population as well as the staff of aid organizations are affected by the contamination until today and the next years. The Fukushima nuclear disaster that occurred in March 2011 was one of the worst the world has ever seen. "Despite a quick reaction to curtail the spread of radiation and minimize the damage, over 2 years have passed since the accident and radioactive materials are still seeping into the surrounding environment and the Pacific Ocean. In September 2013, estimates put the amount of polluted water dumped into the sea at just over 1,000 tons. It is currently believed that the plume of radioactive cesium-137 released by the disaster could begin flowing into the U.S. coastal waters starting in early 2014" (Blacksmith Institute and Green Cross Switzerland 2013, p. 15). Health risks are described inside the report. Humanitarian logisticians have to deal with logistical processes and supply chains in this special environment. Comparable situations occur after explosions of chemical plants or other production plants with hazardous goods. Humanitarian logisticians also have to deal with dangerous goods after accidents with hazardous goods on rail-roads, streets, and other transport modes. Another kind of disaster where dangerous goods often appear are floods, such as floods after heavy rain or storms in Germany. Whereas water can be cleared out relative fast the contamination e.g.

with oil from destroyed oil-tanks needs much longer to be cleaned up and removed (discussed on the 9th European Congress on Civil Protection 2013).
Furthermore a variety of dangerous goods are part of humanitarian supply chains: Some medicines, gases and oils are just some examples. The processes of delivery and return, their planning and operation need special consideration. Otherwise risks of destroyed environment or health-risks occur. Because of their health and environmental impacts toxins (Blacksmith Institute and Green Cross Switzerland 2013) – and therewith hazardous goods – cause disasters with enormous implications and need special observance in humanitarian supply chains.
With these introducing considerations it is now traceable why this publication centres the topic of hazardous goods. In the following fundamental information will be given, a new international standard for hazardous goods in logistics will be introduced as well as impacts of hazardous goods on humanitarian supply chains. A general overview will be given and is followed by a deeper analysis which focuses on the application of one of the standard models from the private sector. Within the analysis environmental and health risks have to be considered beside the logistic aims costs and service.

Definitions and fundamental information

Humanitarian logistics and supply chains

Humanitarian logistics is defined "as the process of planning, implementing and controlling the efficient, (cost-) effective flow and storage of goods and materials, as well as related information, from the point of origin to the point of consumption for the purpose of alleviating the suffering of vulnerable people. The function encompasses a range of activities, including preparedness, planning, procurement, transport, warehousing, tracking and tracing, and customs clearance" (Thomas and Kopczak 2005, p. 2). In addition the *aims and goals* are part of the definition: "efficient, effective" and "for the purpose of alleviating the suffering of vulnerable people" (e.g. Blecken 2010, pp. 57-61; Bölsche 2013a). When treating with hazardous good environmental aspects considerations about risk reduction have to be taken into account, as well. Publications and initiatives from the *last years* show that humanitarian logistics has been *developed* by several actors from the humanitarian sector, the private sector, researchers and their coordinated initiatives (e.g. publications in Hellingrath 2013). For the development of humanitarian logistics and especially the exchange of information and coordination among the actors in humanitarian supply chains after acute and permanent disasters the *Logistics Cluster of the United Nation* has an important role (www.logcluster.org).
In spite of the progress within the last years several lacks and *weaknesses* still exist in humanitarian logistics, one of them concerns hazardous goods, which are still not in the focus of humanitarian aid organizations and in humanitarian supply chains.
The *significance* of humanitarian logistics becomes obvious when looking into actual *statistics* about disasters and *actual disasters* in 2013. The annual disaster statistical yearbook (Guha-Sapir et.al. 2013) which is published yearly by the Centre for Research on the Epidemiology of Disasters (CRED) summarizes for the year 2012: „ a total of 9,655 people were killed and, 124.5 million people become victims worldwide. Contrary to other indicators, economic damages from natural disasters did show an increase to above average levels, with estimates … US$ 157 billion" (Guha-Sapir et.al. 2013, p. 1).

Beyond natural disasters the database of the CRED also registers and measures *technological disasters*. Some examples are shipwrecks, rail- and road-accidents and explosions of plants. Technological disasters do not always but often occur in attendance with hazardous goods. In 2013 one example is a chemical leak from a factory in Shanghai, China (www.emdat.be, disaster number 2013-0313). Summing up for 2012 the amount of technological disasters was 188. In all 6,050 died, 10,090 became injured and 13,504 were affected by another kind. The total damage is registered with US$ 31 million. Such detailed information can be created within the emergency database by individual search, filters and aggregations (www.emdat.be, database, advanced search). But what is not available is a filter for harzardous or dangerous goods. Technological disasters are reported all in all and not separated in sub-categories. Some disasters can be identified as disasters with hazardous goods, such as the above mentioned chemical leak from a factory in Shanghai. But an accident on road, railway or water is typically not registered with special notes on dangerous goods and if so the chemical agent isn't declared. A development of the emergency database could be a declaration and classification of different sub-categories of technological disasters, such as sub-categories for disasters with hazardous goods. Within this chapter two *weaknesses* with a special view on *hazardous goods* have been identified: One concerns the consideration of hazardous goods in humanitarian logistics and the other concerns the statistical database.
These weaknesses and the huge consequences of dangerous goods on health and environment as they are documented in the Environmental Toxin Report (Blacksmith Institute and Green Cross Switzerland 2013) this publication focuses on hazardous goods in humanitarian supply chains.

Hazardous goods and their relevance in humanitarian supply chains
"A good is considered as *dangerous* when it may present a danger on population, environment or on infrastructure according to its physiochemical properties or because of the reactions it can imply." (Gaci et.at 2012, p. 186). The characteristic of *hazardous* goods is that these goods have a chemical composition (Pan American Health Organization and World Health Organization 2001 pp. 38-39), e.g. toxins, oxidisers, irritants, radioactivity, sensitizing agents, carcinogens, corrosives, or highly reactive substances in the chemicals or mixtures.
The *Environmental Toxin Report* 2012 documents the health impacts of toxic pollutants and their sources. It identifies the ten most important sources of environmental toxins and quantifies the global scale of health damage due to toxic substances (Blacksmith Institute and Green Cross Switzerland 2013). A recent study of more than 3,000 toxic sites shows that as many as 200 million people globally are affected by toxic chemicals (www.blacksmithinstitute.org). Some of the world's *ten most polluted places* of the 2012th report are given below (Blacksmith Institute and Green Cross Switzerland 2013, more details like description, impacts and volumes are given in the report):

- Matanza-Riachuelo, Argentina → volatile organic compounds, especially toluene
- Hazaribagh, Bangladesh → chrome
- Agbogbloshie Dumpsite, Ghana → lead, cadmium, mercury
- Citarum River, Indonesia → lead, cadmium, chrome, pesticides, other chemicals
- …
- Chernobyl, Ukraine → radionuclides

The report documents the huge consequences of hazardous goods on the environment. *Humanitarian logistics* is one central activity after disasters and in consequence after disasters with hazardous goods, like in Chernobyl (mentioned in the box above). And dangerous goods such as medical products, fluids and others are part of other humanitarian supply chains. To avoid or reduce environmental pollution and toxication logisticians and supply chain managers have to care for hazardous goods within the whole chain. Otherwise the humanitarian logistics goal "alleviating the suffering of vulnerable people" is not fulfilled. Hazardous goods generate vulnerable states and long-term suffering for the affected people.

It can be assumed that the humanitarian logistics goal "costs" and with this the efficiency is also influenced enormously by hazardous goods, especially in the long run: "Emergency response is extremely costly. It is estimated that *every day dollar spent on prevention today saves four dollars in emergency response tomorrow*. There is no economic sense in spending money on emergency response alone. Years of investment can disappear in minutes if risk reduction and prevention are ignored" (Larson 2011, p. 15). This quotation has a high significance for humanitarian logistics and with a special view on hazardous goods it can be assumed that investments in prevention can exceed the amount of later savings mentioned within the citation. An estimation of consequential costs after pollution and toxication is nearly impossible. Statistical databases, fundamentals for resilient calculations are missing and the question how influences on health an environment could be measured isn't answered in an adequate way.

Just few *publications* exist with a special view on *hazardous goods in humanitarian supply chains*. Some publications from neighboring fields can be transferred (e.g. Pan American Health Organization and World Health Organization 2001, pp. 38-41; Gaci 2012 pp. 188-201; Mc Guire 2011, pp. 133, 937, 957, 977).

With view to the international standardization of hazardous goods developments from the last years can be stated. Several years ago global logistics and supply of hazardous goods was hindered by multiple national standards for the classification of hazardous goods and the regulation within logistical processes like transport, storage and handling. With rising internationalization the missing standard caused problems within international chains. With the "Globally Harmonized System of Classification and Labeling of Chemicals – GHS" a new standard has been created for global (humanitarian) logistics and supply chains (Bölsche 2013b). The next chapter goes more in detail concerning this standard.

International regulation, classification and standardization

Globally Harmonized System of Classification and Labeling of Chemicals (GHS)

The work about the elaboration of the *Globally Harmonized System of Classification and Labeling of Chemicals (GHS)* began with the premise that existing systems should be harmonized in order to develop a single, globally harmonized system to address classification of chemicals, labels, and safety data sheets. It replaces the various classification and labeling standards by using consistent criteria for classification and labeling on a global level. Chapter 19 of Agenda 21, adopted in 1992 at the United Nations Conference on Environment and Development, provided the international mandate to complete this task. The GHS addresses classification of chemicals by types of hazard and proposes harmonized hazard communication elements, including labels and safety data sheets. It aims at ensuring that information on physical hazards and toxicity

from chemicals are available in order to enhance the protection of human health and the environment during the handling, transport and use of these chemicals at national, regional and worldwide level. The first edition of the GHS was adopted in December 2002. Since then, the GHS has been updated every two years. The 5th revised edition of the GHS was published in 2013 (UN 2013, www.unece.org/trans/danger/danger.html). The GHS is not able to avoid negative consequences of hazardous goods in supply chains but the risks on health and environment can be reduced within a harmonized system.
The *European Union* (EU) has implemented the United Nations' GHS into EU law as the *CLP Regulation* (Classification, Labeling, Packaging). This regulation entered into force in January 2009 and will be totally applied in 2015 (Gaci 2012, p. 187; www.ocha.eu). Important elements of the international GHS- and the European CLP-Standard are as well the classification of hazards as a harmonized communication by using labels and safety data sheets. Some basics will be described in the following passages.

Classification, labeling and safety data sheets
A *hazard class* defines the nature of a hazard and the effects of the substances on health and environment (UN 2013, pp. 43-248; Gaci 2012, p. 187-188):

- Physical hazards: 16 categories, e.g. explosives, flammable gases, solids, aerosols.
- Health hazards: 10 categories, e.g. acute toxicity; skin corrosion, irritation.
- Environmental hazards: 2 categories, namely acute and chronic aquatic toxicity.
- Classification of mixtures.

The United Nations document describes each hazard class in detail on over 200 pages within the main document and over that in several annexes. In this publication the author references to the UN GHS description and doesn't go more in detail (UN 2013). Each hazardous good contained in packaging should be *labeled* according to the GHS rules (or CLP rules inside the European Union) as shown below (UN 2013, pp. 23-34):

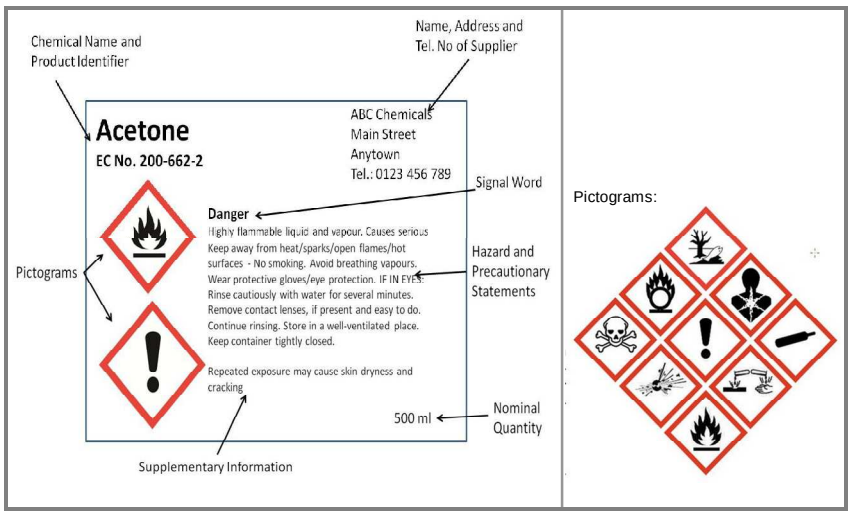

Figure 1: Standards for labeling left-side (e.g. www.labelident.com) and pictograms right-side (www.ocha.eu)

One of the objectives of the work on the GHS has been the development of a harmonized hazard communication system, including labeling and easily understandable symbols,

based on the classification criteria developed for the GHS. Each label contains information about (UN 2013, pp. 23-34; Gaci 2012, p. 188): Supplier of the substance: name, address and telephone number, substance in the packages including quantity, hazard pictograms, signal word, hazard statement, appropriate precautionary statements, and supplemental information. For the *transportation* of hazardous goods special information and in consequence special *pictograms* are needed. The UN Recommendations on the Transport of Dangerous Goods, Model Regulations, encompasses only the most serve hazard categories of the acute toxicity hazard class. It provides label information primarily in a graphic form because of the needs of the target audiences (UN 2013, p 23). Further elements of a standardized and harmonized communication about hazards are *Safety Data Sheets*. They provide a standardized format for comprehensive information (UN 2013, p 25).

Impact of hazardous goods on humanitarian logistics and supply chains

A general overview

Hazardous goods in humanitarian logistics can be both a *reason* for a disaster and as *relief items part* of humanitarian supply chains. In Japan, Fukushima, in the year 2011 for example dangerous goods in the atomic power-plant were one of the reasons for the disaster (comparable to disasters in Bhopal, India in the year 1984 and in Enschede in Holland in the year 2000 and many others).

Furthermore hazardous goods as relief items are part of humanitarian supply chains, e.g. pharmaceutical products, laboratory reagents, fuel gases and oils. The processes with dangerous goods need in both cases special consideration. Otherwise risks like health or environmental risks occur. For example risks occur from pharmaceutical and medical products and medical waste, (xylene or acetone, photographic waste chemicals, refrigerator coolants, heavy metals), such as (Mc Guire 2011)

- health risks: explosion of accidentally incinerated aerosol cans, injury by sharps, accidental distribution of health care goods;
- environmental risks: contamination of water sources, release of toxic pollutants into the air, disruption of sewage treatment plants.

What is needed to handle with, reduce and if possible avoid the mentioned risks are

- *statistical data* about hazardous goods in humanitarian logistics and supply chains, as mentioned in chapter 2,
- *manuals and standardized procedures* for humanitarian logistics and supply chains,
- *training and education* for humanitarian logisticians, and
- *methods* from logistics and supply chain management, especially risk management, process models and performance measurement for deeper analyses, recommendation and implementation into practice.

A deep explanation of all the listed missing aspects would go too far in this publication. So we concentrate in the following on *one possible method* from supply chain management which can be transferred from the private to the *humanitarian sector* (Bölsche 2013a) – and over that to the special topic *hazardous goods* in humanitarian supply chains: The Supply Chain Operations Reference-model (SCOR).

A special view on the Supply Chain Operations Reference-model (SCOR)

The Supply Chain Operations Reference-model (SCOR) has been developed in 1996 by the *Supply Chain Council* (SCC), a global non-profit organization. The SCOR model is a global standard for supply chain management, "a model that provides a unique framework for defining and linking performance metrics, processes, best practices, and people into a unified structure" (www.supply-chain.org). SCOR is composed of three components: Not only process modelling is considered but also performance measurement and best practices (Blecken 2010, p. 106; www.supply-chain.org). Therewith a basis for integrating metrics into the process model is given – which of course has to be adapted to the humanitarian sector with the special focus on hazardous goods. The model is an inter-branch standard process reference-model and offers the integration of organizations from different sectors, such as the industrial sector, and (logistic) service providers. If an involvement of the humanitarian sector and the special consideration of hazardous goods into the SCOR model succeeds than the complete humanitarian supply chain can be considered. The SCOR-model spans over the supply chain from suppliers over the own organization to customers. Within the framework five distinct *management processes* are considered: source, make, deliver, return and plan (Blecken 2010, pp. 105-106; Bölsche 2013a, www.supply-chain.org). Hazardous goods can be integral part in all of these processes.

Some *modifications* are necessary when adapting SCOR to humanitarian supply chains with hazardous goods. As an *example medical products* are chosen below as relief items and dangerous goods. Starting on the first level (Bölsche 2013a and 2013b):

- *Terminologies* should be changed with special focus on the actors in humanitarian aid, e.g. "customer". The organization in the centre could be a Non Governmental Organization (NGO) or several NGOs, the suppliers could be – in dependence from the needed relief items – the pharmaceutical industry, or others suppliers with relevance for humanitarian aid, and the ultimate customers should be dominated as beneficiaries, people in need or affected people.
- Another group of "customers" or stakeholders in humanitarian logistics are *donors*. They influence the budget for humanitarian logistics and in some cases donate items or services for humanitarian aid. In addition, they have special demands on the reporting and accounting system. Donors are not considered in the original SCOR model but have to be considered in an adaption for the humanitarian sector along the whole supply chain.
- In most cases "make" in the sense of "*production*"-processes aren't relevant for NGOs, and they can be disregarded for service providers (NGOs, logistics service providers and others) or they can be regarded as "make to order" processes. But with view to hazardous goods make-processes are relevant because of the production of hazardous goods or with hazardous components. Health risks and environmental risks which occur from the production processes especially in the production of the suppliers (e.g. from pharmaceutical and chemical industry) need to be considered when analyzing medical supply chains.
- The other processes are to a great extent relevant for all actors in humanitarian logistics with hazardous goods in medical or pharmaceutical supply chains: Within the processes *"source"* and *"deliver"* risks from hazardous goods have to be taken into account. The new international standardization GHS needs to be

implemented especially for the delivery of hazardous goods. When sourcing relief items like medicines one performance element for the evaluation of suppliers can be risk attributes for hazardous goods.

- The processes *"return"* are relevant especially in the aftermath of a disaster. Medical waste arises because of unused, expired, damaged, or recalled health care goods and also contaminated medical waste from hospitals has to be considered. Some recommendation for the return processes of medical waste are "no storage in distribution centres" and "safe disposal of toxic compounds and materials". Some healthcare goods require regular or repeated return to suppliers. Over that in the case of closure of operations and health care facilities may require return processes (Mc Guire 2011, pp. 937-978). After accidents with hazardous goods in plants, on roads or other traffic modes return processes are often in the centre of the analysis and logistical processes.
- The individual and aggregated process "*plan*" is needed as well for each organization as for the whole supply chain. Beside other aims and goals such as costs and service goals environmental goals and risk reduction for environment and health risks can be part of the aims and goals. Organizations who are actors in humanitarian supply chains with hazardous goods should build up a consistent system of aims and goals under the special consideration of risks from hazardous goods. Comparable to Carbon Footprints involved organizations with environmental strategies, aims and goals could think about new evaluation models, e.g. "Hazard Footprints", which can be considered in the plan-processes.

The following figure 2 considers the above mentioned requirements concerning the terminologies, integration of donors, and processes. For a better understanding it illustrates a simplified example with a special view to Médecins Sans Frontières (MSF, for more information about MSF see www.msf.org). This approach can be transferred to other humanitarian supply chains, e.g. for UN organizations who are responsible for the distribution of pharmaceutical products in humanitarian supply chains. The special case of hazardous goods and relief items is characterized in figure 2 by GHS pictograms.

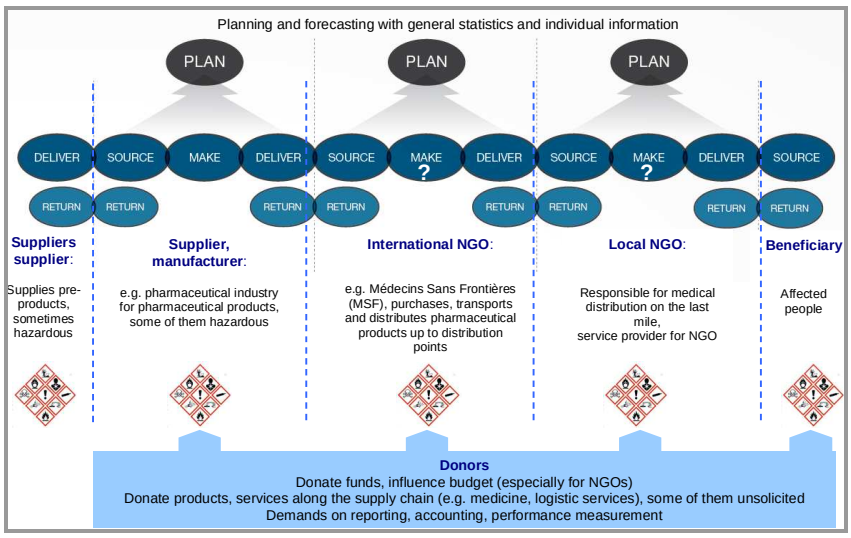

Figure 2: SCOR, First level, Example medical supply chain

With a special view on performance measurement in humanitarian logistics, SCOR Level 1 metrics are strategic, high-level measures that cross multiple SCOR processes (www.supply-chain.org). They can be adjusted to the organizations in the humanitarian supply chain and special measures for risks from hazardous goods can be complemented. The newest version SCOR 11.0, published in the end of the year 2012, is extended by a new "*enable*" process which focuses on the management of relationships, performance and information of a supply chain (see figure 3). Considerations about risk management, compliance and business rules as well as the needed data and information are part of the core process enable (www.supply-chain.org). These elements of SCOR 11.0 include important considerations relevant for humanitarian supply chains with hazardous goods and the management of risks within the supply chain.

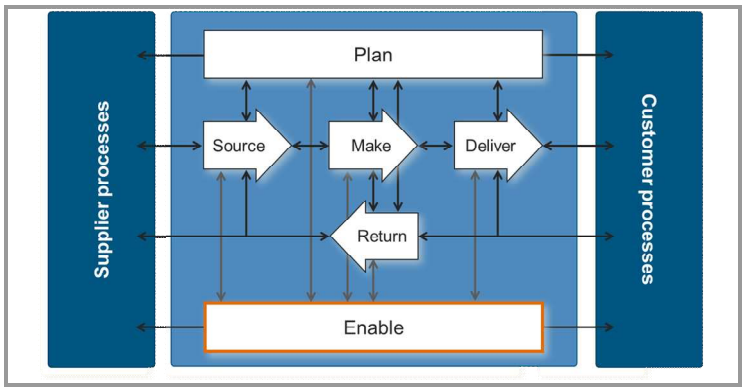

Figure 3: The process "enable" in SCOR 11.0 (www.supply-chain.org)

This publication gives a first impression about the SCOR-model and its application for hazardous goods in humanitarian supply chains. A more detailed view into the levels is not part of this publication as well as a critical analysis of the SCOR model and a discussion about quantitative performance indicators. Therewith ideas for future research and developments are given with these concluding remarks.

Application and further developments

It can be summarized that hazardous goods do matter in humanitarian supply chains. The need for action has been shown within this publication. It can be hold that

- *statistical data* are available about technological disasters (www.em-dat.be) and about the effects of hazardous goods on the environment and people (www.greencross.ch),
- *manuals and procedures* have been standardized on an international level by the GHS,
- *training and education* for humanitarian logisticians is in the development, and
- *methods* from logistics and supply chain management can be transferred and adapted from the private to the humanitarian sector with special focus on hazardous goods.

But in the same time it has to be mentioned that further *statistical data* is missing, e.g. about hazardous goods within technological disasters and humanitarian supply chains. Over that the international *standard* GHS hasn't been transferred into practice in all countries yet. Some *training and education* programmes for humanitarian logisticians

have been developed but don't meet all requirements, especially with view to hazardous goods. And finally this publication analyses a first application of *methods and models* (the SCOR-model) on a general level and doesn't go more in detail. Therewith this publication can sensitize for the topic of hazardous goods in humanitarian logistics and give ideas for future research and the application in practice. It doesn't solve the existing problems but it gives impulses for an enhanced consideration of hazardous goods in humanitarian supply chains in the future.

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