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ENVIRONMENTAL PERFORMANCE ASSESSMENT OF MULTIMODAL TRANSPORT SYSTEMS

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Abstract: *The main quest of this comparative study is to gather methodological experience in comparing alternative transport systems in terms of environmental performance. The study has been limited to the operational phase of the transport, both in respect to study the impacts determined by the mobile subsystems to transportation system and further the impacts coming from stationary subsystems to transportation system. This study has been focused on emissions, toxic releases, noise and land use aspects. The research has been limited to the operational stage of the transport means. In this respect, there were not approached those aspects related to the depletion of natural resources, production and scrapping. The methodological demarche has been centered around two different intermodal transport systems.*
Keywords*: environmental performance, multimodal transport*

1. INTRODUCTION

This study is based on the pre-project "*Globe-Influence of geo-climatic changes on global and regional sustainable development in Dobrogea*" within the LCA-methodology has been tested and evaluated for the inland navigation and maritime transport (Globe, 2009). The paper did not identify complete studies that compared the environmental performance of alternative transport chains. The major target of this paperwork is to provide an initial incentive further, to a more comprehensive study, in order to develop some of the conclusions triggered from the above pre project.

2. GOALS AND SCOPE DEFINITION

The main goal of this paper is to compare the environmental performance of alternative transport systems.

Transport chains	Subsystems	Comment
Chain 1 Water Transport	**General cargo vessel**	Vessel operates between A and B
	Harbours	Harbours in A and B (1110 km, 54 h)
	Heavy duty vehicle	Operates between B and customer in C
	Road	Road used by HDV between B and client in C (530 km, 6h)
Chain 2 Road Transport	**Heavy duty vehicle**	Operates between A and D and between E and client in C
	Road	Road used from A to D (596 km, 10 h) and from E to C (993 km, 10 h)
	Loading terminal	Terminal loading general cargo in A
	Car Ferry	The ferry operates between D and E
	Harbours	Harbours for the ferry in D and E (993 km, 10 h)

Tab. 1. Transport chains and their related subsystems

The main transport chains' function is to transport cargo from one place to another, based on different routes and transport means, in different combinations as is has been illustrated within Table no. 1. When comparing transport chains the distance travelled may differ from one alternative to the other causing differences in environmental performance. Therefore, the environmental performance should not be expressed per distance unit (km). The functional unit in this case should be defined as 1 ton general cargo transported from A to C. Transport means is represented by: general cargo vessel **(**M/V Danube II), Heavy Duty Vehicle (Truck with Trailer) and Ferryboat (a ship with 3500 transport units transport capacity). The relationships between system and subsystems are important aspects to be included in the discussion. This study case is illustrating the average technology used today and it covers the operational stage focusing on the environmental burdens listed as: emission in to air (CO_2, NO_X, SO_X, CO, VOC), emission in to water (TBT, Copper oxide) and so on. The alternative transportation systems considered in this research are intermodal, involving both land based and sea based transport. Hence this study will focus on emissions and toxic releases as well as noise and land use (Goedkoop, 1995*).*

3. INVENTORY CALCULATION AND DATA COLLECTION

The amounts of substances that are contributing to the environmental burdens are calculated based on exhaust gas emission (for general cargo vessel, car ferry, HDV), dust or particulars, leakage of eco – toxic substances etc. (Nicolae, 2009a). The calculation of land area use is based on the sum of area required at any time during the transport. The land area required for the transport of cargo has to be allocated to the transport chains according to their use of use of the area, e.g. by time used, number of operations, amount of cargo or economic turnover (Goedkoop, 1995*).*The total area used due within the noise study is expressed as being the area exposed to the noise levels that are exceeding the media of 55 dBA. The movement indicators expressing the transportation vehicles throughout the total area were estimated. A rough simplification when the vessel is stationary at the quay has been applied. Land area usage degree and land area exposure to the noisy factors are related to the functional unit in the same way (Oswald, 2008).

Data for the general cargo vessel and car ferry transport are based on the direct study of corresponsive technical manuals. Data for exhaust gas emission are based on Lloyd`s Register. Leakage from antifouling is a continuous emission. Tribytyltin (TBT) is the most extensively used toxic substance very often used in case of the general cargo vessels. The leaking rate depends on the antifouling type applied and on the operational profile as well. As the ship or antifouling specific leak rates are not available, the IMO assigned limits as 4 micrograms of TBT per cm^2/day is applied. In this paper have been calculated: the general cargo vessel and car ferry fuel consumption and emission related to main engine and two auxiliary engines, general cargo vessel and car ferry area occupation and the noise level (for ships and HDV) (Nicolae, 2009b, IMO 2009).

4. INVENTORY RESULTS

By using calculus methodology (Nicolae, 2009b) the emissions in the air are calculated for every substance within each its impact category. The calculations are based on fuel consumption for the main machinery systems, auxiliary engines and for HDV. The TBT-leakage is calculated by using a leakage-rate IMO recommended. The results are multiplied by utilized capacity and furthermore divided by real capacity and by special cargo tons transported. Thus will get as result the leakage per special cargo transported. The occupied port area is calculated by using the vessel length, quay width and the time spent in harbor related to loading/unloading 1 ton special cargo (1 SCU). The calculations of area occupation due to trailer traffic is based on vehicle length and width, average speed, time on road, number of vehicles per functional unit. From each sub-system in the transport chain the total amount of each substance are summarized in Table 2.

Impact category	Substance	Transport Chain 1	Transport Chain 2
Climate change	CO_2	84200 g	138000 g
	N_2O	0,246 g	0,714 g
	CH_4	1,52 g	4,40 g
Acidification	SO_2	938 g	867 g
	NO_X	1286 g	1803 g
	NH_3	0,022 g	0,064 g
	TBT	0,096 g	0,041 g
Local air pollution (dust)	Particles	24 g	70 g
Photo oxidant formation	NMVOC	36,6 g	106 g
Noise	Area > 55dBA	6321 m^2h	21110 m^2h
Eutrophication	NH_3	0,022 g	0,064 g
Energy cons.	MJ	930 MJ	1812 MJ
Distance	m^2h	133	299 m^2h
Land use	km	1640 km	2260 km
Exploited c.	%	90 %	86,5/70 %

Tab. 2. Inventory results per ton special cargo [SCU]

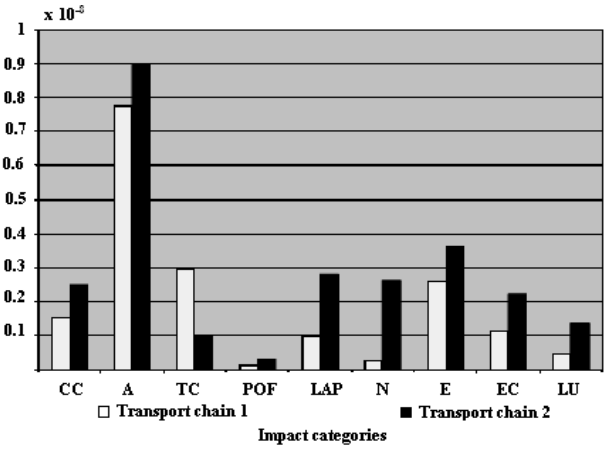

Fig.1. Normalized inventory results; chain 1 is mainly waterborne transport, chain 2 is combination trailer & ferry

In the Figure no. 1 main impact categories are: CC-climate change; A- acidification; TC- toxic contamination; POF- Photo oxidant formation; LAP- Local air pollution (dust); N-Noise; E-Eutrophication; EC- Energy consumption; LU- Land use. The Figure no. 1 indicates that Chain 1 has the best environmental performance within each category except for toxic contamination. In addition to the characterization of different compounds, the environmental impact will be dependent by the emissions place.

5. CONCLUSIONS

In this study case data for two different transport chains have been collected by comparing the environmental performance of transport chains. However, the study does not show how to optimize each chain. This will require more detailed data on machinery systems. Also the maintenance of the transport systems will give minimal contribution. These conclusions depend on the chosen system boundaries. In the main report GLOBE, the importance of the impact categories is discussed. The toxic contamination impact category (TBT, Pb, etc.) is difficult to be evaluated since the local impacts are not included in some of the used appraisal models. The land area usage and the effects of noise were evaluated. As it can be deducted observing the Figure no. 1 the land area usage is contributing in a minimal manner to the total environmental burdens. However, the results show that for Chain 2 the noise should not be neglected as an important impact. The results seem to turn out very similar irrespective of valuation methods used.

The preliminary results are revealing interesting information for further researches, in case of Romanian transportation companies and governmental bodies in their decision making processes. The transport companies will be able to use such information to report the environmental performance of transportation chains in order to plan their logistics operational strategies. For governmental bodies the information can be used for environmental policymaking ("green" taxation and so on). As transportation means will be a part of an entire transport chain it seems reasonable to charge the entire transportation chain and not only a single mean. Databases with environmental performance data for transport chains should be developed. Finally the project results added a great value for further research in order to optimize the economic and environmental performance of transportation chains in idea of eco-efficiency indicators developing for Romanian transportation sector.

6. ACKNOWLEDGMENTS

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