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Janne JUURIKAS and Walter LEAL FILHO
TuTech Innovation (Germany)

PROMOTING SUSTAINABLE DEVELOPMENT BY MEANS OF RIVER BASIN MANAGEMENT IN THE BALTIC: THE WATERSKETCH PROJECT

1. Introduction – General Information about the River Elbe

The River Elbe is the third largest river in Central Europe, after the river Danube and the river Rhine in terms of length, as well as catchment area. The area of the drainage basin of the River Elbe comprises 148,268 km^2 [IKSE, 1995, 2000] and is shared by Germany, the Czech Republic, Austria and Poland. However, Austria and Poland account for less than 1% of the catchment area while 2/3 are located in Germany and 1/3 in the Czech Republic. The River Elbe rises in the Krkonoše mountains (Riesengebirge), part of the Sudeten range, flows through the Czech Republic, central and northern parts of Germany and discharges into the North Sea near Cuxhaven. The length of the River Elbe is 1091 km (727 km in Germany, 364 km in Czech Republic) [IKSE, 2000] and along its route, the catchment area drains some of the major cities in the area, such as Prague, Dresden, Berlin and Hamburg (Fig. 1).

The catchment area covers three main natural regions – the mountainous section, the loess region and the Pleistocene lowland. The hydrogeology of the catchment area changes from bedrock aquifers in the mountains in the south-west to porous sediment aquifers in the lowland region. The lower part of the river Elbe is characterised by its estuary and the coastal landscape mainly dominated by the Hanseatic City of Hamburg, especially by its harbour. Tidal fluctuations, which lead to very special forms of wetland habitats and biodiversity, also influence

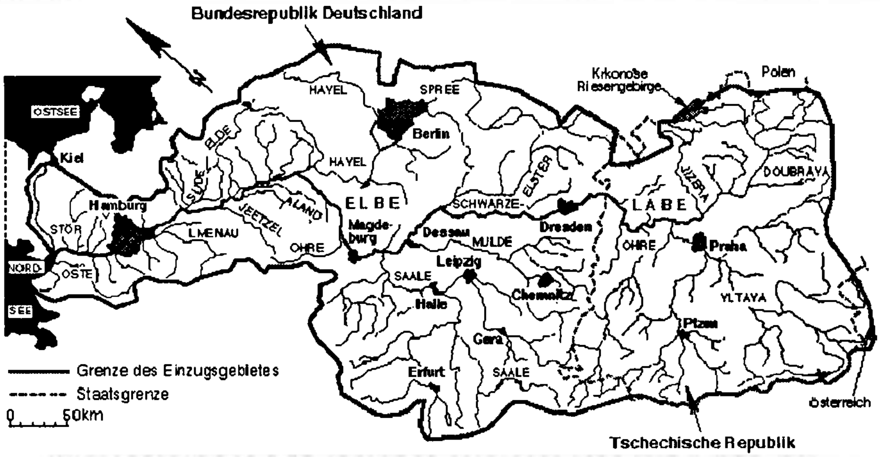

Fig. 1. Drainage area of the River Elbe [AGRE ELBE, 2001]

the population and industry located in this region by frequent storms blown in from the sea.

The average discharge into the North Sea is about 877 m³/s [IWAC, 2001]. The major tributaries are the Moldau/Vltava, Havel and Saale, each comprising a catchment area of roughly 25 000 km². The total population living in the drainage basin is around 25 million, 18 million in Germany (31% of the total population) and 7 million in the Czech Republic (58% of the total population) [IKSE, 2000].

The catchment area of the Elbe River consists of forested land (29%), urban areas (7%), agricultural areas (61%) and surface water (1.5%) [Behrendt and Hofmann, 2002; Leal Filho, 2004]. The water of the River Elbe is used for several purposes: to a certain extent, it is used to produce drinking water via bank filtration, which makes comprehensive treatment necessary [BALTICOM, 2000]. More than half of the land in the basin is used for agricultural purposes. The major industries include the chemical and pharmaceutical industry, paper and pulp industry, metal industry, mining, glass and ceramics and the leather and textile industries. A large portion of the Elbe river basin, around 86% in the German part and 22% of the Czech part, are classified as protected areas/nature reserves [IWAC, 2001].

2. The Free and Hanseatic City of Hamburg

The Free and Hanseatic City of Hamburg is the second largest city in Germany with 1.7 million inhabitants. Like Bremen and Berlin it is a city-state. Hamburg is the cultural and commercial centre of Northern Germany, and its metropolitan region consists of approximately 3 million people. The municipal area is 755.3 km^2, whereas the metropolitan region covers a total surface area of ca. 19 000 km^2 and embraces 14 districts around the City of Hamburg.

With 30 m^2 of living space per person, Hamburg enjoys the largest average personal living space of all the big cities in the world. In fact, 12% of the city is made up of green and recreational areas, whereas ca. 36% of the land is occupied by buildings or open space, 27% by arable land, 12% by roads and 8% by water [Statistisches Amt..., 2004]. Some facts and figures are listed in Table 1.

The geographic and geologic conditions of Hamburg are closely related to housing development, population growth and the economic structure in the City. Hamburg is thus not only "the city built on water" – as it is called, due to the multiplicity of small rivers and canals apart from the Elbe and Lake Alster – but it also "lives from the water" [Umzetzung..., 2005a]. Due to access to the North and Baltic Seas (via the Kiel Canal) and the efficient land and water connections with the hinterland, Hamburg Port plays an important role making Hamburg the most important international trade and logistics centre in Germany and a hub for the whole Baltic Sea Region and Central Europe. The international trade volumes account for approximately one third of European exports. The port and shipping sectors employ around 75,000 people in Hamburg. More than 145,000 jobs in a vast range of industrial and service sectors are indirectly dependent on the port. Besides the level of regional employment, the seaport activities of Hamburg also play a significant role in regional economic growth. In fact, the proportion of GDP generated from seaport related activities is higher than the proportion of GDP related to other economic sectors in the Hamburg city-region [IKSE, 1995, 2000; Statistisches Amt..., 2004; Umsetzung..., 2005a].

Due to its location, Hamburg is also very attractive to industries and businesses. It is the third biggest industrial area in Germany, after the Ruhr area and Berlin. 70% of all industry related businesses in Hamburg are concentrated in one of the following six branches: Aircraft-, ship- building and the automotive industry; electro technology, high-tech mechanics and the optic industry; mechanical engineering; chemistry; mineral oil processing; and metal production. The importance of Hamburg can also be seen from the fact that not only big industries have their headquarters here, but there are also more than 80,000 medium-sized businesses present [IWAC, 2001; Leal Filho, 2004; Umsetzung..., 2005a, 2005b].

Table 1. Some facts and figures about Hamburg

	Hamburg	Unit	Germany	Unit	As a percentage of the German total
Inhabitants	1,729,000		82,537,000		2.1
Total Area	75,532	ha	35,703,099	ha	0.2
Built-up Area and Open Space	26,878	ha	2,308,079	ha	1.2
Recreational Area	5,702	ha	265,853	ha	2.1
Road Area	8,860	ha	1,711,764	ha	0.5
Arable Land	21,000	ha	19,102,791	ha	0.1
Forested Area	3,432	ha	10,531,415	ha	0.0
Surface Area of Water	6,115	ha	808,462	ha	0.8
Share of Gross Domestic Product	77,080	M. Euro	2,129,200	M. Euro	3.6
Gross Value Added of which:	70,020	M. Euro	1,963,580	M. Euro	3.6
Agriculture, Forestry, Fishing	120	M. Euro	21,950	M. Euro	0.5
Manufacturing industry	13,200	M. Euro	475,300	M. Euro	2.8
Trade, Transport	18,310	M. Euro	365,000	M. Euro	5.0
Financial, renting and business service activities	25,670	M. Euro	589,970	M. Euro	4.4
Construction	1,840	M. Euro	87,210	M. Euro	2.1
Other service activities	13,110	M. Euro	424,150	M. Euro	3.1
Unemployment Rate in % (yearly average 2004)	11.0		12.5		
Gross Earnings per captia/Year	29,319	Euro			

Source: Statistisches Amt..., 2004.

3. The River Elbe in Hamburg

According to the Water Framework Directive, surface waters are classified according to river basin district. According to such a classification, the sub-river basin of Elbe/Harbour covers a surface area of 156.4 km^2 within the borders of the Free and Hanseatic City of Hamburg incorporating the Southern and Northern arms of the Elbe [Umsetzung, 2005b] and the Port of Hamburg (Figure 2).

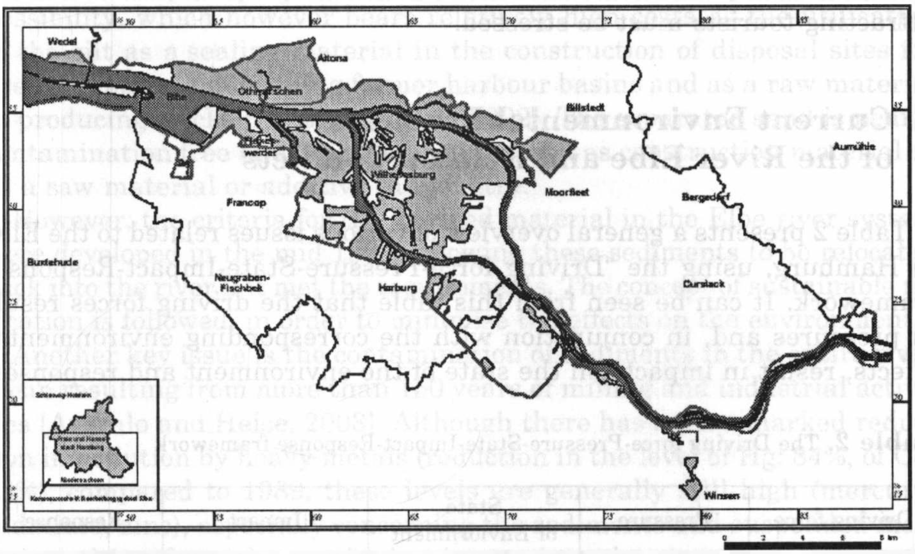

Fig. 2. The river Elbe in Hamburg

Entering Hamburg 620 km from its source, the length of the river Elbe running through the city is approximately 77 km. The landscape of the river basin district can be characterised as a marshy area with sandy soils mixed with gravel and clay. The deeper subsoil of Hamburg consists of layers shifting from clay to sands containing brown coal.

The rate of flow in the Elbe is between 1 and 1.5 m/s (the discharge rate varies from 300 m^3/s to 3000 m^3/s) depending on the tides. The river divides into two branches (*Norderelbe* and *Süderelbe*) close to the City of Hamburg, the latter forming an estuary of width 1.5km downstream of Hamburg and 18 km from Cuxhaven. However, within Hamburg the river has an average width of 200 m and depth of 2 to 5.5 m upstream and 15.30m downstream of *Elbbrücken*. Because of the very gradual gradient and tidal influence, the direction of water drift changes every six hours. For this reason, a given body of water passes the same section several times needing 4 to 70 days (compared to 1 to 2.5 days upstream of Geesthacht) to reach the open waters of the North Sea, resulting in a much greater residence time for polluted water than in the upper reaches of Elbe [Christiansen, 1997].

The water quality, river morphology and other characteristics of the Elbe in Hamburg are mainly influenced by port related and industrial activities, river transport and urbanisation, as well as pressures imposed by activities along the River Elbe upstream of Hamburg. On the other hand, the heavy use of the Elbe for recreational purposes, as well as for attracting tourists must be stressed.

5. Current Environmental Problems of the River Elbe and Related Conflicts

Table 2 presents a general overview of various issues related to the Elbe in Hamburg, using the "Driving force-Pressure-State-Impact-Response" framework. It can be seen from this table that the driving forces result in pressures and, in conjunction with the corresponding environmental effects, result in impacts on the state of the environment and responses.

Table 2. The Driving force-Pressure-State-Impact-Response framework

Driving force	Pressure	State of Enviornment	Impact	Response
Port Activities and Navigation	Dredging Utilisation of the port area Shipping accidents	Change of river morphology and ecological condition of the river Pollution (oil, chemicals)	Disappearance of several species of flora and fauna Accumulation of contaminants in sediments and also in fish Treatment and disposal of dredged material made difficult due to the heavy contamination of sediments with heavy metals (especially Cadmium)	National, European and international policies National and international cooperation, agreements and conventions
Flooding	Flood protection	Change of river morphology and ecological condition of the river		
Households and Industries	Point and diffused sources of pollution	Pollution of river water and sediments with nutrients and hazardous substances		

Source: Authors' own elaboration.

A major problem, among the many seen in Hamburg, is the problem of contaminated sediments. In Hamburg dredged sediments must undergo pre-treatment following disposal within the borders of the city, in order to meet the requirements posed by relatively strict environmental laws. Pre-treatment is carried out in the large scale METHA plant with an annual capacity of 1 million m^3 of sediment and consists of separation into sand, silt and smaller amounts of coarse material [Arevalo and Heise, 2003]. Due to the contamination of the silt, it is disposed of in two specially constructed silt mounds ensuring environmental safety. Another feasible possibility, which however bears relatively high costs, is the utilisation of the silt as a sealing material in the construction of disposal sites for dredged material, for lining former harbour basins and as a raw material in producing bricks [Netzband et al., 2002]. The separated sand is nearly contamination free and therefore can be used as construction material or as a raw material or additive in industry.

However, the criteria for the dredged material in the Elbe river system were developed in the mid 1990s allowing these sediments to be relocated back into the river if it met the requirements. The concept of sustainable relocation is followed, in order to minimise the effects on the environment.

Another key issue is the contamination of sediments in the entire river basin resulting from more than 150 years of mining and industrial activities [Arevalo and Heise, 2003]. Although there has been a marked reduction in pollution by heavy metals (reduction in the level of Hg: 84%, of Cd: 22%), compared to 1989, these levels are generally still high (mercury, cadmium, zinc), especially concerning the sediments and suspended matter resulting from the continuing inputs into the river from upstream. There is a high level of copper pollution and the levels of lead, chromium and nickel pollution are critical [Salomons, 2004]. According to the existing LAWA2-Classification, in 1998 suspended sediments were assigned to the class “elevated to high contamination” (Class III–IV) with regard to Hg, Cd and Zn and to “moderate to elevated contamination” (class II–III) with regard to Pb [Arevelo and Heise, 2003].

Among other problematic heavy metals, cadmium is one of several contaminants that have lead to sediment management problems downstream from the sources. This specifically relates to the dredged material from the port of Hamburg, which does not meet the lower Federal German norms for disposal into the North Sea [IKSE, 1995; Gaus mbH, 2004].

One of the principal problem substances in the Elbe today, as well as in the future, is hexachlorobenzene (HCB), due to its high persistency and extensive presence in sediments [Umsetzung..., 2005a]. The reduction in loads is additionally slowed by ongoing inputs from the Czech Republic. Despite a downward trend in pollution loads in the early nineties, DDT and DDD in particular are still found in the Elbe in substantial concentrations, which sometimes reach extreme peak values. The inputs are suspected to come from the River Mulde, as DDT concentrations of up to 2 mg/kg have been measured its sediments [Gaus mbH, 2004].

Furthermore, oil spills in marine and coastal waters have lead to oil slicks. In 2001 aerial surveillance, which under the Bonn Agreement has to be carried out by the North Sea states as an aid to detecting and combating pollution and to prevent violations of anti-pollution regulations, detected 596 oil slicks in the North Sea. In 2003 the Waterways Police authorities of the German coastal regions inspected a total of 6,036 ships and found deficiencies in 1,533 cases. In cases of minor infringements, they issued cautions to the ships' captains, chief engineers and remaining engineers and imposed fines of up to €35,00 in individual cases. 251 cases were referred to the BSH for further handling. The BSH is the German authority imposing fines for administrative offences that have been committed by shipping in violation of international conventions and national regulations on the protection of the marine environment. Under the German ordinance on violations of the MARPOL regulations, those responsible on board a vessel commit an administrative offence if they maintain the Oil, Cargo, or Garbage Record Book improperly or do not comply with MARPOL discharge regulations. The existence of illegal exhaust pipes from the sludge tank are considered an administrative offence punishable by a fine.

Due to the contamination of Elbe sediments, the Port of Hamburg is still operating a comprehensive system for managing dredged material. In 2002, 2.8 tons (30%) out of the total 9.5 ton load of Cd in the river Elbe was removed in the Schnackeburg region using land disposal. Due to the Elbe flood, the load in 2003 was 60% higher than in previous years [Arevalo and Heise, 2003].

The relocation of dredged material poses a problem related to its capacity and has an impact on the North Sea. Two effects on the coastal ecosystem have to be considered in the process of relocation or withdrawal from the marine system: on the one hand, the withdrawal of slightly contaminated sediments will reduce levels of contaminants (positive); on the other hand, withdrawal of large amounts of sediment will upset the sediment balance in areas of sedimentation (negative) [Christiansen, 1997; Crowder, 1995; Bundesministerium..., 2001]. In a modern impact analysis, both aspects should be placed in the context of questions about sustainable river management and the rising sea level, together with increasing coastal erosion and impacts on mud flats.

As with regard to conflicts, present environmental issues of concern, such as leakage of nutrients, especially nitrates, from agriculture and leakage of harmful substances from mining sites will remain problems in the future. Methods of treating water containing increased concentrations of heavy metals from ore mining, as well as strategies to avoid or to decrease heavy metal concentrations in the Elbe catchment area are under development, but there is still a long way to go. This shows that the present conflict regarding sediment management has no simple solution and will probably remain for the foreseeable future. However, it depends strongly on the ability of different stakeholders to co-operate and to move towards the common goal – of establishing sustainable sediment management for the whole catchment area of the river Elbe, with suitable guidelines and frameworks related to the Water Framework Directive – a subject looked at in depth in the WATERSKETCH project – and therefore also lead to a reduction in costs to both society and the environment.

Future conflicts may arise from several major environmental problems which have to be faced in managing the river Elbe, namely:

– possible degradation of habitats due to the climate change resulting from increasing industrialisation and traffic, further specialisation of agriculture also poses a continuous threat to biodiversity;

– increases in water temperature and pollution resulting from human activities (*e.g.* ballast water) may cause various problems (*e.g.* genetic) to populations and the evolution of new species;

– future water quality problems with new hazardous substances such as endocrine disruptors may arise. PCBs and TBT are such substances, the production and use of which are being (or have already been) strictly limited or even forbidden;

– due to developments in the shipping sector (*e.g.* insufficiently trained crews, sub-standard ships, and inadequate salvage capacity) there is a potential for an increasing number of shipping accidents.

Another future threat is a potentially accelerating rise in sea level, which may, on the one hand, have an impact on the ecosystem and on the other hand pose an increasing burden on coastal protection and the safety of the hinterland.

According to Hamburg´s concept of regional development published in 2000, the goal is to gain a differentiated regional profile by combining science, labour and policies of spatial development in a range of environmental projects. Besides harbour operations and the setting up of highly specialised industries, the Elbe region has been discovered as a landscape of high value for urban planning and the improvement of water quality, since the ecological basis for life and enhancement of the river's recreational appeal have moved into the centre of debate.

The solution of future conflicts depends on to what extent the barriers to progress in environmental protection and sustainability are overcome. This is mainly due to the fact that the nature of problems, as well as solutions, is complex and there are international links with different sectors and disciplines. These barriers are exacerbated by shortcomings in institutional structures, non-implementation of commitments already made and a lack of information on and understanding of possible 'win-win' solutions for achieving sustainable outcomes. Ways of protecting natural resources and ecosystems, together with promoting social and territorial unity and innovativeness should be considered when looking for such solutions.

In the future, harbours are not only important logistic centres and interfaces for world trade, but they should be used as crystallization points for new industrial "clusters", minimising harmful impacts by less use of space, reduction of noise and light pollution and better control of emissions and pollutants [Hesse, 2002; Leal Filho and Ubelis, 2004]. Environmental concerns could lead harbours to an increasing market for green shipwrecking, for vessels such as single-hull tankers, old cargo vessels and naval vessels [Umsetzung, 2005b; Arevalo and Heise, 2003; Gaus mbH, 2004]. Some advantages could be provided by recycling expensive raw materials. The EU will issue stringent conditions for ship owners and flags of convenience, which will lead to an increase in the wrecking of older ships.

6. Conclusions

In order to improve the ecological status of the river, integrated sediment management of the Upper Elbe seems to be an essential measure. This is being considered in a case study as part of the Interreg IIIB Project Watersketch [http://www.watersketch.net], which is looking at the issue of sustainable river basin management in the Baltic Sea region.

By means of sediment management, the unnatural withdrawal of dredged material would be reduced and the good condition of the aquatic system of the Upper Elbe would be supported by the relocation of unpolluted dredged material. Selective fixed deposition of dredged material, as a form of hydraulic engineering, could influence sediment transport in a positive way and at the same time the creation of shallow water zones would be enabled.

Contaminated sites in Hamburg, as well as in the whole catchment area, and the historic contamination emitted from approximately 300 old mining sites in the Elbe catchment area are the main sources of diffused pollution causing the contamination of sediment. The extent to which the reduction of dredged material can contribute to achieving a sustainably clean port and environment. A classification system for substances and areas of concern has to be developed, as well as concepts for the handling of historic contaminants. The risk of various sources of contamination should be determined according the prioritisation of a site with respect to social and economical parameters. This leads to a better allocation of resources resulting in the maximum possible reduction in risk and appropriate protection of the socioeconomic value of the river basin.

For the future, the amount of sediments to be dredged could be reduced by means of hydraulic devices like a current deflecting wall. For example, the Koehlfleet Harbour, one of the largest in the Hamburg Harbour complex, has achieved major benefits in reducing the amount of sedimentation by constructing a curved wall at the basin entrance. This structure changes the flow pattern, thus avoiding the trapping effect caused by eddies. Thanks to this construction, the annual sedimentation of approximately 290,000 m^3/yr has been reduced by up to 35% [Christiansen, 1997]. Cost reductions are even greater, because all the sediment in the harbour can be dredged by water injection, which is cheaper [Crowder, 1995]. Such structural measures have proved to be useful in reducing harbour sedimentation. However, the gains may differ on an individual basis. It is expected that an optimized wall will lead to further sediment reduction [Crowder, 1995].

In managing a trans-boundary watercourse, such as the Elbe, the issue of new governments with limited resources inheriting the „legacy of the past" is a serious one, and most likely requires new thinking regarding resource sharing across national and local government borders. Finally, communication between stakeholders and raising public awareness on the issues related to sedimentation are becoming increasingly important, in improving the state of the river. The purpose of coordination between different regulatory bodies and policies requires the inclusion of sediment management in European environmental policy.

A strategy of the sustainable management of the river Elbe has to consider integration and implementation of sectoral strategies with regard to policies/activities in the coastal zone and hinterland. In other words, it needs an integrated approach [Leal Filho and Ubelis, 2004]. At present, there is often insufficient or a complete lack of cooperation between local, regional, national and EU authorities in the preparation, implementation, enforcement and coordination of rules and regulations, although cooperation between responsible authorities is essential. In order to facilitate sustainable management, the rules and regulations should be harmonised and simplified.

Literature

Arevalo, E., Heise, S., *Sustainable Solutions to the Sediment Management on the River Basin Scale: The Elbe River Case under specific consideration of risk management and communication aspects*, 2nd SedNet-Conference, September 2003.

BALTICOM, *Report on Port Related Processes of Regional Restructuring*, Baltic Transport Communication and Regional Development BALTICOM, June 2000.

Behrendt, H., Hofmann,J., *The Elbe Catchment and Related Coastal Area: German Bight and Wadden Sea. Part A: Catchment Profile.* Berlin: Institute für Gewässerökologie und Binnenfischerei im Forschungsverbund Berlin e.V, May 2002.

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit/ Umweltbundesamt, *Environmental Policy: Water Resources Management in Germany, Part 2: Quality of Inland Surface Waters.* Berlin: Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Umweltbundesamt, 2001.

Christiansen, H., "Erfahrungen mit der Strömungsumlenkwand", *HANSA*, 134(12), Hamburg, 1997.

Crowder, R. A., *Study of the Reduction of Siltation by Means of a Current Deflecting Wall.* Delft: EU-Study LIP II Tidal Flume Measurements, Delft Hydraulics, 1995.

Gaus mbH, *The Wadden Sea: Maritime Safety and Pollution Prevention of Shipping. Analysis of the existing measures and the implementation of agreements regarding maritime safety and prevention of pollution from ships.* Bremen: Gauss mbH, 2004.

Hesse, M., *Logistics Real Estate Markets: indicators of structural change, linking land use and freight transport*, paper for the ERSA 2002-Conference From Industry to advanced Services, Dortmund, Free University of Berlin, Dept. Of Geography, May 2002.

IKSE, *Internationale Kommission zum Schutz der Elbe: Die Elbe und ihr Einzugsgebiet.* Dresden: IKSE, 1995.

IKSE, *Internationale Kommission zum Schutz der Elbe: Die Elbe von 1990 bis 2000 – 10 Jahre erfolgreiche Zusammenarbeit in der IKSE.* Dresden: IKSE, 2000.

IWAC *10 Transboundary Rivers in Europe: Assessment Practices and Environmental Status. International Water Assessment Centre.* Szczecin (http://www.iwac-riza.org), 2001.

Leal Filho, W. (ed), *Ecological Agriculture and Rural Development in CEE Countries.*Dordrecht: Kluwer Academic Publishing, 2004.

Leal Filho, W., Ubelis, A. (eds.), *Integrative Approaches Towards Sustainability in the Baltic Sea Region.* Frankfurt: Peter Lang Scientific Publishers, 2004..

Netzband, A., Reincke, H., Bergemann, M., "The River Elbe – a case study for the ecological and economical chain of sediments", *Journal of Soils & Sediments*, 2(3), pp. 112–116, 2002.

Salomons, W., *European Catchments: Catchment Changes and Their Impact on the Coast.* Amsterdam: Institute for Environmental Studies, Vrije Universiteit, 2004.

Statistisches Amt für Hamburg und Schleswig – Holstein, *Hamburg – ein Stadtporträt in Zahlen.* Statistisches Amt für Hamburg und Schleswig – Holstein, August, 2004.

Umsetzung der EG-Wasserrahmenrichtlinie (WRRL), *Zusammenfassender Bericht über die Hamburger Bearbeitungsgebiete*, 2005a.

Umsetzung der EG-Wasserrahmenrichtlinie (WRRL), Landesinterner Bericht zum Bearbeitungsgebiet Elbe/Hafen Bestandsaufnahme und Erstbewertung (Anhang II/Anhang IV der WRRL), 2005b.