Summary:

With the Disposal and Recovery Atlas NRW published in December 2001, North Rhine-Westphalia is – for the very first time – presenting its entire highly developed and largely differentiated waste treatment infrastructure. In addition and for the first time as well, the study paved the way for the establishment of a complete waste disposal and recovery balance in North Rhine-Westphalia as an important source of information, as - due to legal restrictions and imperfections - no other source of information is available in order to close the gap between the legally prescribed annual reports - a gap, which refers to two thirds of the total of waste. The waste balance exclusively results from the data base central register ENADA of waste disposal and recovery plants managed by the State Environmental Office. The database records all 3000 waste facilities in North Rhine Westphalia. The waste balance gives an idea of the economic importance of waste industries in NRW.

The results of these investigations are available on the homepages of the State Ministry of the Environment (www.munlv.nrw.de) and of the State Environmental Office of NRW (www.lua.nrw.de).

1. Introduction

With the publication of the Waste Disposal and Recovery Atlas in December 2001, the State Environmental Office succeeded in representing the entire disposal infrastructure of this highly industrialized and densely populated European region in a detailed way and for the very first time. To a large extent, North Rhine-Westphalia's recycling industry is privately organized. It ensures an environmentally safe disposal of waste and significantly contributes to the closed substance cycles for commercial and industrial waste, postulated by the German Waste Act.

The study paved the way for a complete waste disposal balance in North Rhine-Westphalia, which is an important contribution of public administration to this privately managed commercial and industrial waste management sector.

The report is supposed to show as well that such a presentation requires carefully developed and harmonized legal instruments and an administration infrastructure for data collection as well as good data based records and a staff sufficiently skilled to interpret them.

2. Amount of waste generated and disposed of in North Rhine-Westphalia (NRW)

Since the revision of the Federal Environmental Statistics Law in the year of 1996, the total amount of waste generated in Germany is no longer deducible. This can only still be done in the field of hazardous waste and domestic waste - as far as these data are available. From this, a wide gap in knowledge appears in the field of non-hazardous commercial and industrial waste as far as privately disposed of. Since 1996, this gap widened continuously according to the extent to which the private disposal of industrial and commercial waste increased - supported by the arrangements of the Federal Waste Law.
Currently, a clear representation of waste generation in Germany can only be established by means of a complete description of the waste disposal and recovery plus import/export balance. In order to avoid double counting, however, the balance will have to take into account that waste passes through sequences of waste disposal and treatment plants before being recovered or eliminated.

A complete register of waste disposal and recovery plants and the willingness of the operators to contribute to this register are essential pre-conditions for such a disposal and recovery balance. Operators know that they will profit by this cooperation, as these data will contribute to nationwide waste management statistics which they will, in turn, require for investment and planning purposes.

For the first time since the Federal Environmental Statistics Law was modified in 1993, it was possible to establish a complete waste balance within the framework of the publication of the disposal and recovery atlas NRW in 2001. Owing to a wider reference range, it resulted in significantly higher waste quantities compared with previous approaches, as e.g. the above mentioned statistics according to the Federal Environmental Statistics Law.

The complete balance consists of contributions of various annual disposal and recovery reports which were legally prescribed: reports pertaining to hazardous waste disposal (European Directive), reports on the so-called „mass waste“ (according to NRW State Law), reports on sewage sludge, and finally the domestic and municipal waste balance according to the European Directive and Federal Law (Appendix 1, upper part). These reports provide overlapping and sometimes even contradictory figures which were harmonized within the framework of the disposal and recovery atlas project.

Additionally, data were collected from operators for the remaining, mostly industrial and commercial waste disposal and were, for the first time, published in connection with the atlas. Finally and for the first time as well, results of State investigations on material or on the energetic reuse of waste in specific industrial processes (cement kilns, electric power stations) without previous reprocessing (so-called „direct reuse“) were included in this balance as well.

These data were combined in order to obtain a complete balance of disposal and recovery in North Rhine-Westphalia:

In 1998, **73.58 mn** tons of waste were disposed of in North Rhine-Westphalia. Almost two thirds - in total **47.14 mn** tons - were recovered and merely **26.44 mn** tons (36 %) were eliminated. For further details, please refer to chapter 5.

Analyzing the results by means of the information source, it can be concluded that **52%** of the waste quantities disposed of or recovered in North Rhine-Westphalia were **not** taken from the above mentioned annual, legally prescribed reports: About **36%** were taken from direct information provided by waste facility operators - information related to the waste disposal and recovery register operated by the State Environmental Office. In addition, the **material and energetic direct reuse in industrial processes** – a single investigation initiated by the State Ministry of the Environment and elaborated by experts for the period of 1998/1999 - constitute another **16 %** of the total balance.

All legally prescribed reports refer to minor portions of the total of waste disposed of and recovered: The **domestic and municipal waste** balance registers approximately **26 %** of the waste disposed of. It is annually prepared and has been published since 1995. The annual report
on hazardous waste and non-hazardous “mass waste” registers 6%, respectively 15% of the amount of waste disposed of in 1998. Finally, the annual sewage sludge reporting made up less than 1 % (dry matter) of the total balance.

For the “mass waste”, 1998 was the last year for reporting, since the corresponding State’s Law was withdrawn from the recording by Court.

Summarizing this, actually two thirds (67%) of all waste generated, disposed of and recovered in North Rhine-Westphalia can not be reported periodically on the basis of prescribed periodical reporting, but only on the basis of voluntary informations from operators.

It is worth to be mentioned here, that the Federal Technical Directive on Waste from Settlements (1992) and the Federal Technical Directive on (hazardous) Waste (1990) identified annual reports as part of the “state of art” in waste facility operation. Till now, this chance for gaining complete informations on waste disposal and recovery has not been used, neighter from legislative, nor from executive power in Germany.

3. ENADA – The data base for waste disposal and recovery plants

The waste balance was exclusively prepared on the basis of ENADA, the data base central register of waste disposal and recovery plants processed by the State Environmental Office. The data base records data of all approx. 3,100 waste disposal and recovery plants in North Rhine-Westphalia, including those industrial facilities reusing such waste material (plastics industry, foundries, cement kilns, etc). The documentation of the present status of the plants (skipped, in operation and planned) gives a clear picture of the development of the waste disposal infrastructure during the last 15 years.

The register answers questions referring to technical aspects as well as to waste flow, i.e.:

- **Who** in NRW is disposing **which volume of which waste type** and **where** is this taking place? – and -
- **How** is **which waste type** disposed of in NRW?

The database ENADA is an ACCESS data base, now in transition to ORACLE; it offers a user-friendly visualization and all usual access tools for evaluation (Figure 1).

The register is based on the data from permissions and other administrative documents relating to waste disposal and recovery facilities and submitted in copy to the LUA, from other data base systems as e.g. the emission control register and - additionally - from our own investigations carried out by means of questionnaires which had to be completed by plant operators. Data base interfaces between relevant data pools as well as ENADA are becoming more and more important as sources of information. All data relevant for waste disposal and recovery plants are collected in the ENADA data base.

**Database contents**

The database contains information on the **operator**, on the **site** and on the **authorities in charge**; it lists main data of **permissions**, for example, authorized waste catalogue and authorized (as well as realized) **capacity of the plant**, it fixes input and output data in full detail as well as all important technical elements including their performance. In the same way as the differentiation of the operator’s services to clients increased, the internal subdivision of the plants into independent subsystems increased as well (Figure 2). These so-called “**process lines**” (independent subsystems for different material streams within an
disposal plant) are particularly important for the correct registration of waste streams in the data base.

Figure 1: Main mask of the waste disposal and recovery facility database ENADA

**ENADA, DATABASE FOR WASTE DISPOSAL FACILITIES**

1. Site, factory (location)
2. Waste disposal plant
3. Operator
4. Input/Output data, Authorized and performed capacity
5. Authorized list of waste types
6. Service module
7. Process line
8. Permit data
9. Technical details/performance of service modules

Figure 2: Structure and contents of ENADA

**Information on operators**

The majority of all disposal and recovery plants in North Rhine-Westphalia (NRW) are privately owned. Numerous small- and medium-sized enterprises (KMU) are engaged in waste disposal and recovery activities: collecting and transporting waste, assorting and
recycling it or even eliminating it in private landfills and incineration plants. At least 2000 out of the total of approx. 2660 disposal plants in NRW registered in ENADA are small- and medium-sized enterprises.

The elimination of "domestic" (household and municipal) waste, formerly carried out by public institutions is now increasingly becoming a task of privately owned plants. Private ownership promises a satisfying investment capacity and sufficient technical and mercantile know-how - required to survive in a competitive recycling market.

In NRW, industrial waste and, in particular, hazardous waste, is traditionally disposed of by private industries - often operated by large-scale industries, as e.g. the chemical or metal industry at the river Rhine and in the industrial Ruhr area or by commercial waste managing companies. Due to this long tradition of private disposal activities in NRW, the largest German waste management enterprises located their headquarters in this state. In order to cope with the increase in cost and to withstand competition, fusion efforts and a concentration of treatment facilities are increased all over Germany and abroad. For 10 years already, electric power companies have discovered the disposal market as a promising object for investment and acquired many of these disposal plants - a fact that once more increased the regional importance of waste management industries in North Rhine-Westphalia.

**Technical data**

The information concerning technical details on disposal and recovery facilities was extracted from permits, operator’s flow sheets and our questionnaires. From the beginning, these technical data have been one of the essential aspects of the waste disposal register. The intense study of the technical description was necessary for the correct definition and grouping as well as for a reasonable subdivision of the facilities in the database. This resulted in practical definitions and classification criteria for different kinds of treatment plants (for example a distinction between screening and mechanical reprocessing plants or between mechanical reprocessing and chemical-physical treatment plants.

The technical questionnaires we had prepared were suitable for all types of treatment plants and the evaluation of the data provided by the operators increased our knowledge on the state of the art in waste disposal technology to a large extent. Contrary to the frequently more general description of waste treatment techniques available from scientific documentation, systematic evaluations of all types of treatment techniques implemented in NRW can now be extracted from this data base. The register permits an assessment of all necessary details on waste disposal and recovery plants and on the performance of the environmentally relevant plant units. It paves the way for an interpretation of waste facilities on the basis of their contribution to a closed commercial and industrial substance waste management.

**Material flow data**

In all questionnaires and investigations, the second essential aspect considered always was the amount of waste treated (input and output data). With a comparison of capacity and input data, important information can be deduced for planning purposes and rentability reflections. The more waste treatment is effected by privately owned companies, the more figures with regional relevance are expected to be provided by public institutions for further private activities and investment!

After recording these input and output data in the disposal register, it became necessary to compare these results to other potentially contradictory data referring to the same matter, but originating from other sources. Therefore, a new data base directly related to the facility register was created, the so-called waste amount database AMEDA (ACCESS). In this
data base all data dealing with waste quantities in disposal and recovery facilities are collected and sorted according to the data source, year, waste facility (and sub-unit), and waste type (EWC-Code), see appendix 3. This main data pool primarily aimed at making all facility-related input and output data available for comparative evaluations. Problems above all resulted from different definitions of what a plant actually is and what is the correct process line related to a certain waste stream.

Up to now, approx. 255,000 data sets have been recorded for the period from 1989 to 2001. These data sets originated from 12 different data sources. These sources (import/export control, hazardous waste control, sewage sludge report, domestic waste balance, Dual Refuse System Report, emission control register, landfill control system etc.) are closely related to different legal backgrounds and their well adjusted data collection instruments. None is complete, several are overlapping; always with the risk of gaps and contradictions. AMEDA for the first time permits an analysis of these figures which resulted in the first complete balance of waste disposal activities in NRW, published in the waste disposal and recovery atlas (see chapter 4).

Future efforts will have to concentrate on the operators’ reporting duties on waste input and output data of disposal facilities. As a consequence, the multitude of the operators’ reporting duties referring to various sectors will have to be substituted by a single and universal annual waste stream balance centrally registered in the State Environmental Office, assessed and made accessible to all private and public authorities and covering all legal necessities concerned. This is, what German Directives aimed for when asking for “state of art” reporting and documentation from operators.

Starting from these complete and correct quantitative data, investigations (and regulations) of pollutant loads may follow in a next step, necessary for evaluating disposal and recovery techniques with regard to their environmental effectiveness. In the so-called North Rhine-Westphalian “Eco-Rucksack” project we are combining the facility-related information on waste chemistry (concentration values) from our waste analysis database ABANDA (ACCESS) with the mass flow data of AMEDA. Systematic investigations on the environmental impact of waste treatment activities are currently started in North Rhine-Westphalia.

Data base development

Actually, the distribution of the waste disposal and recovery register ENADA via the Intranet (internal authority communications network) is realised in order to make the register available to other waste authorities and in order to enhance a more effective communication with them. Therefore, the ACCESS-based application recently has been transformed into a browser-capable version (ORACLE / php / JAVA-script). A less comprehensive Internet version soon will be made available as well.

This Internet presentation of waste facilities was prepared by means of the publication of the Waste Disposal and Recovery Atlas with its data sheet listing 860 waste facilities on CD-ROM. This CD-ROM provides triple access to the individual data sheet, reflecting the disposal and recovery infrastructure of North Rhine-Westphalia:

- Based on a Geographical Information System, with a selection of a regional or local frame within NRW, in several zooming stages for the identification of a plant of interest,
- Based on listings, with a choice of a thematic sorting criterion (ID-number, zip code number, type of plant or capacity of the plant) and identification of a plant of interest from the shortlist, and
- Based on the type of waste or EWC-Code with selection of an authorized EWC-Code or waste type, listing of the corresponding plants, licensed for this waste and identification of a plant of interest from the shortlist.
Results of the inventory

In total 3090 relevant facilities are in operation in North Rhine Westfalia. More details on the waste treatment infrastructure are available from a separate publication (MORSTADT; STRIEGEL, SARDINIA 2003)

4. Waste disposal and recovery balance North Rhine-Westphalia

The total balance reveals the following actual waste disposal and recovery practice in North Rhine-Westphalia (Appendix 1, lower part):

Throughout the year 1998, **73.58 mn tons** of waste were treated and landfilled, corresponding to approx. **4 tons** per inhabitant and year. Almost two thirds, (**47.14 mn tons**) were recycled and one third only (**26.44 mn tons**) were eliminated in landfills and incinerators. In a simplified approach and neglecting some secondary residues from treatment plants, all waste for chemical-physical treatment (of hazardous liquid waste and sludge), waste for incineration and waste for landfilling was considered as "eliminated" waste; all waste for mechanical reprocessing, biological treatment and direct reuse was taken as "recycled" waste.

Out of all disposal and recycling options, **mechanical reprocessing** in the meantime comes up to 46 % and **landfilling** to 26 % only; within a couple of years, the mechanical reprocessing became more and more important and will certainly continue to grow. The direct material reuse in industrial processes (15 %) and the incineration (approx. 8 %) are constituting important disposal options as well. Biological and mechanical/biological processing, chemical-physical treatment plants and waste-to-energy plants are representing the remaining portion of approx. 5 % only.

Meanwhile, many other waste types are discovered for mechanical reprocessing prior to subsequent material or energetic recycling.

5. Perspectives

From 2002 onwards, the European Guideline for Integrated Environmental Control (IVU-directive) demands from all member states to provide reports on the emission of pollutant substances in order to submit them to the European Commission for publication. Operators of regionally important landfills and waste treatment plants are obliged to deliver this information as well. This European Pollutants Emission Register (EPER) is, however, valid for airborne and waterborne pollutants only. For the completion of the "emission register" and for the preparation of input/output balances, North Rhine-Westphalia intends to register pollution from waste streams as well. Starting point of this project are the waste treatment plants.

Only the completion of the EPER-reports and the systematic collection of waste stream and pollutant flow data by treatment plants will provide an integral view of the material flow through treatment and disposal facilities. With these new data, the transfer of pollutants into products as well as into the environment will become more evident. Additionally, these data can help to measure the efficiency of reprocessing and recycling in terms of canalizing pollutants to safe confinement or destruction and to keep secondary raw material free from pollutant substances. This attempt is confirmed by the draft of the UN convention of Aarhus to PRTR (pollutant and transfer register).
Regarding this development, the future role of the data base of waste disposal and recovery plants (ENADA) becomes clearer: in addition to the data sets already collected, plant-specific environmental indicators like transfer coefficients will have to be determined, collected and evaluated in order to measure the ecological relevance of disposal options and to promote the further development of waste treatment techniques. These additional plant-specific data must, for example, permit

- a comparison of the realized treatment techniques with the requirements of an optimized closed commercial and industrial substance waste management,
- a determination of the degree of the pollutant expulsion from material recycling processes
- a preparation of energy balances of waste processing plants and
- access to information on the degree of the achieved raw material substitution.

In a first project of the State Environmental Office of North Rhine-Westphalia called “Ecological rucksack (backpack) of disposal measures” (in short: "eco-rucksack", Figure 4) the plant-specific information on waste input and output (available in the data base of the waste disposal plants, ENADA) is combined with the plant-specific findings on waste chemistry (stored in the waste analysis data base, ABANDA). Waste quantities (tons/a) and concentration data mg/kg) are connected for calculating pollutant transfer passing the facility in terms of pollutant load (kg/a). These data serve to determine the distribution (transfer =) of pollutants onto the different environmental media (waste water, air, waste and recycling products). This approach is now tested in some chemical-physical treatment plants.

ENADA, the data base of the waste disposal plants, can store the plant-specific transfer factors and correlate these findings with material and treatment conditions. Regarding the fact that there are approximately 1500 regionally significant waste treatment plants, it becomes clear that this research is limited to important treatment techniques and conflict fields (for example incinerators / cement kilns or compost/biogas plants).

--- Material and Energy

![Material and Energy Diagram](image)

**Figure 4: Comparison of the ecological “rucksack” of different waste treatment options**
Bibliography:

Becker, C. Striegel, K.-H. ABANDA und ENADA, die abfallwirtschaftlichen Datenbanken zu Stoffen und Anlagen im Verbund, - Beitrag zum Tagungsband der BEW Fortbildungsveranstaltung „Stoffflussanalyse“ am 7.5.2001 in Duisburg (Description of two data bases on waste analysis and waste treatment facilities used for integrated waste stream analysis in North Rhine-Westphalia)


LUA NRW = Landesumweltamt Nordrhein-Westfalen (State Environmental Office), MUNLV NRW = Umweltministerium Nordrhein Westfalen (State Ministry of the Environment).
Appendix 1: Waste disposal and recovery balance of North Rhine Westfalia State/Germany