



# **LIFE 'HAWAMAN' PROJECT**

## **LIFE06 TCY/TR/000292**

### **Improvement of Industrial Hazardous Waste Management in Turkey**

## **Estimation of industrial hazardous waste quantities in Turkey**

Author: Wilfried DENZ - **gtz**

T.C. Çevre ve Orman Bakanlığı  
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# **1 INTRODUCTION**

## **1.1 General information**

Subject to the project description, the Twinning project "TR03/EN/IB-01 Waste" activities on hazardous waste regarded the lack of reliable data as one obstacle to base any kind of concept on. Due to this the estimation of quantities and types of waste for certain industrial activities was a basic task of the HAWAMAN-Project to base the hazardous waste management concept on.

The realistic estimation of kind, amount and geographic origin of the currently produced hazardous waste is the most important basis for the introduction of a waste management system that includes the implementation of waste transportation, interim storage and treatment facilities and the optimal organisation of waste transportation – where appropriate via interim storage facilities - to treatment facilities.

A too imprecise evaluation of the amount of waste could either lead to expensive bad investments in oversized waste treatment plants or to insufficient capacities for a proper and environmental sound waste treatment.

## **1.2 Project Description Task A3: estimation of quantities and types of waste**

With regard to the project description the following work steps for the estimation of quantities and types of waste were planned:

- Definition of industry sectors generating hazardous waste
- Compilation of basic data for estimation of hazardous waste amounts, e.g.
  - Population per province
  - GNP per province
  - Industry structure with list of enterprises with employees, sector and province
  - Number of motor vehicles
- Estimation of amount of hazardous industrial waste for selected industry sectors based on international experiences and the above mentioned basic data from Turkey
- Report on the methodology, used experiences/data, results and compilation/development of maps

The estimation is using a heuristic method based on long year international experiences.

The estimation does not include any prognosis for future hazardous waste quantities and qualities which will change due e.g.:

- Economic development
- Structural changes in industry

It does not cover all waste streams.

The report with its data amount per type of waste per province gives the basis for the following project tasks on waste logistics and waste management treatment concept.

## **2 METHODOLOGY**

### **2.1 Possible methodologies and discussion**

There are several methods in order to estimate the types, amounts and regional distribution of the hazardous waste in a country in which exists no working hazardous waste management system so far.

#### **2.1.1 Data from waste generators**

a) Asking waste generators:

This will lead to no reliable data with very high aberration from real situation, because waste types and waste amounts often are unknown, esp. in countries with no hazardous waste management system; participation  $\ll$  100 %; this method is labour and time intensive. Even in countries with long-time existing hazardous waste management system the data given by the companies are not very reliable; they just can give a qualitative, but not quantitative statement, if the waste amounts will in- or decrease.

b) Material balances from companies:

Input/output balances from companies or processes are not existing normally, this method is not practicable and very labour and time intensive.

c) Internal Notification / waste declaration forms:

Because waste types and waste amounts often are unknown in the companies at present, the waste types and amounts given in the Internal Notification often are wrong resp. consciously bigger or smaller than in reality. Even with a long-time existing hazardous waste management system Internal Notification will not give reliable data.

#### **2.1.2 Data from waste transportation**

Because a hazardous waste management system is not covering the hole country resp. not existing now, only partial data about waste transportation are existing. An extrapolation of this data is not possible, because only a part of the waste types are transported to treatment facilities, for the other part e.g. no treatment facilities are existing.

But even with a long time existing hazardous waste management system the Waste Transportation Forms will not give 100% reliable data: There is a gap between the Waste Transportation Forms amounts

- from waste generators to waste transportation service and
- from waste transportation service to waste facilities,

e.g. because of m<sup>3</sup> to ton conversion, partly filled transportation units and evaporation of water.

#### **2.1.3 Data based on material and product amounts**

Material input and product output data and the associated waste ratios are not available for all industrial sectors, so only part of the waste amounts can be estimated.

Even if these data are known:

- the material efficiency = waste ratios can differ by magnitudes
- statistical problems can falsify the data:
  - a. production of product in one or more companies (see figure)?
  - b. waste per produced item, e.g. vehicle: truck or compact car?
  - c. complete production at facility or import of parts?

## Production in 1 facility      Production in 3 facilities

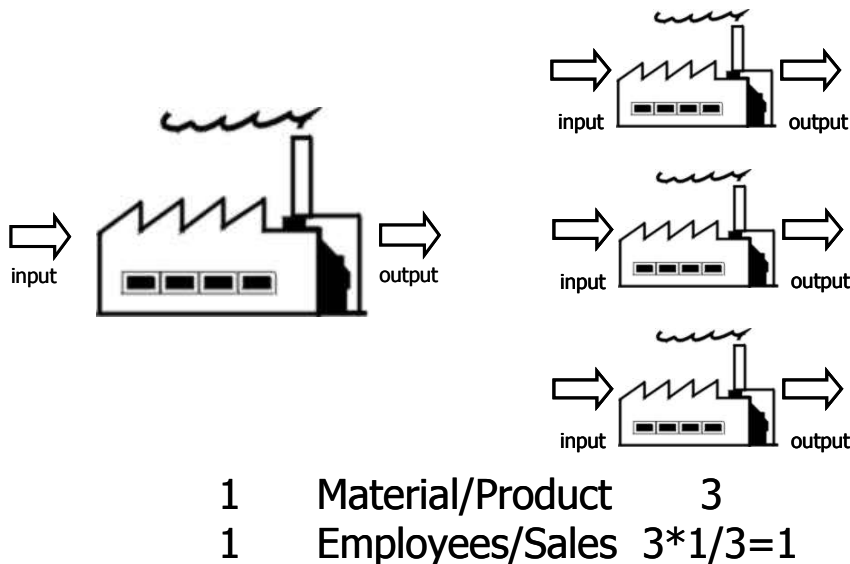


Fig.: Production in 1 or 3 facilities: material balance differs by factor three

### 2.1.4 Data based on inhabitants/employees and GNP/sales per region

This method gives a rough estimation about waste situation (per region). A lot of data are available from countries with long-time existing hazardous waste management systems. It is a very cheap and simple method.

Problem: some of the industrial sectors are waste intensive, others not. Without considering the employees per sector, the aberration from the real data may be high. E.g. the main industry in Turkey are the textile and food industry (with only small amounts of hazardous waste) plus metal industry; in Germany are the metal and chemical sector, which are very waste relevant, are the two main industrial sectors.

### 2.1.5 Data based on inhabitants/employees per sector and region

Data based on employees/sales per industrial sector and per region gives a good estimation about waste situation per region, not very labour and time intensive, but the waste ratios are not available in studies/literature up to now and have to be developed with experience from a lot of waste management projects in a lot of countries knowing the situation in the waste generating industries (see Chapter 2.2).

### **2.1.6 Waste quantities data - Discussion**

The development of waste amounts in regions without a long time existing hazardous waste management system depends on:

- the presence of waste facilities
- the possibility of waste recycling
- the costs for waste treatment (disposal and recycling)
- the authorities (surveillance, penalties)
- the laws and regulations, judgement
- the limits for gas emissions (filter dust and sludges from flue gas cleaning) and sewage (waste water sludges) and their implementation
- achievements in waste minimisation / material efficiency
- development of industry, but:
- mind the „Delinking“ between GNP/employees and waste amounts: a higher production will not lead to similar higher waste amounts

So every hazardous waste management system has to be built up in a manner, that it can react flexible on changes in waste types and amounts.

Comparing waste factors from other countries mind:

- big waste ratios are mainly caused by mineral wastes (e.g. Luxemburg > 50% contaminated soils!)
- hazardous waste, which is recycled, sometimes is included and sometimes excluded
- sometimes hazardous waste, which is treated by the waste generator, is in/excluded
- some regional waste balances are worked out by consultants, who are interested in big waste amounts, so there is more work for planning more and bigger treatment facilities
- waste factors for countries with no (long time) existing hazardous waste management system are often copied one by one without being proofed and are based on the method described in chapter 2.1.4.

Conclusion:

Waste balances based on

- regional data (employees/GNP per province) and
- employees or sales per industrial sector

will give as a kind of BATNEC-method the best estimation for a hazardous waste investment planning. It is based on long time and multi-region experience (BATNEC – best available technique not exceeding cost).

## **2.2 Applied heuristic methodology**

For the HAWAMAN-Project a method should be used that gives a waste quantities estimation with low effort that is sufficiently accurate to plan kinds, capacities and locations of waste treatment facilities.

**Our heuristic method is based upon waste ratios per employee and sector.**

For this purpose the industrial sectors were merged to 21 sector groups whose companies have a similar spectrum of waste types. For each of those 21 sector groups a waste sector

sheet was created that contains the typical waste types of this sector group and their waste ratios per employee (see chapter 3.3.1: waste sector sheets).

The waste ratios used in the waste sector sheets have not yet been published. They mainly base on data from countries with long-time existing hazardous waste management systems. The result of our calculation gives an estimation of the waste situation in Turkey how it would be if there were already waste surveillance institutions and waste treatment facilities existing for several years.

This result with the distribution of the amounts of the different types of hazardous waste is exactly the result that is required in order to plan kinds, capacities and locations of the needed waste treatment facilities. Our approach covers some of the factors of influence on the waste amounts listed in chapter 2.1.6. It is obvious, that in the years of the launch phase of a hazardous waste management system significant fluctuations and variations from the estimated values will occur.

Our waste ratios were developed based upon our long-year experiences from

- ½ to 3 days on-site-consultancies in 2.900 companies with the aim of hazardous waste minimisation,
- deep knowledge of production processes with their waste produced and waste minimisation possibilities,
- waste treatment centres,
- waste surveillance institutions,
- preparation of regional hazardous waste inventories,
- preparation of hazardous waste management concepts in countries and regions like Botswana, China (Zhejiang), Colombia (Region Bogota), Germany, Morocco, Mexico (Central-Mexico), Taiwan, Turkey (Izmit) and Tunisia,
- planning of waste treatment facilities with knowledge of the waste management system in countries like England, Germany, Hungary, Italy, Qatar and Turkey.

and with consideration of studies and balances like

- numerous waste inventories of EU-countries and regions
- data from world-bank and other institutions
- BREF-documents (Sevilla process)

Due to this information and experience it is possible to create waste sector sheets and to calculate the amount of waste per industrial sector and per province with the waste sector sheets and the basic data (employees per sector and province). By summing these results the waste amounts for Turkey can be calculated.

Our heuristic method has already been utilized successfully in other countries and verified with data from regions with long-time existing hazardous waste management systems. We estimate the accuracy of the final result to plus/minus 25% (see chapter 2.1.6: Discussion). This is sufficiently exact in order to base a hazardous waste management system on.

## **3 WASTE ESTIMATION**

### **3.1 Waste sources and waste types**

According to the assignment only certain sources and types of waste were to be considered at our waste quantity estimation. The focus is on the hazardous waste produced in the industry.

#### **3.1.1 Considered waste producers and waste types**

TOBB-Codes 3000 to 4101:

- Food, beverage and tobacco
- Textile and leather
- Wood products and furniture
- Paper production and paper products
- Printing
- Chemistry, chemical products
- Petrol refineries
- Rubber and plastic products
- Mineral products (e.g. cement, glass)
- Metal production
- Metal working
- Electrical machines and equipment
- Electricity

and in addition:

- Separately collected fractions
- Car repair service
- Agriculture

#### **3.1.2 Disregarded waste producers and waste types**

- Mining
- Logistics/Transportation (but car repair service as a.m.)
- Construction
- Contaminated soils / sites
- Service sector like hotels, commerce and offices (partly included in sep. collected fractions)
- Public services (e.g. sewage sludge or wastes from waste management facilities, but power-plants)
- Health care
- PCBs and PCTs
- Waste electrical and electronic equipment
- End-of-live-vehicles

That means the wastes and waste groups

- EWC 01 Mining
- EWC 17 Construction / Demolition
- EWC 18 Health Care
- EWC 19 Waste + Waste Water Treatment
- EWC 160104 End-of-live-vehicles
- EWC 200123/135 Electr. Equipment

are excluded in our waste quantity estimation.

Mind that in a lot of countries hazardous waste from construction / demolition and waste water / waste treatment account for about half of the hazardous waste quantities.

## **3.2 Basic Data**

### **3.2.1 Needed basic data**

In order to estimate the waste quantities per province on the basis of statistic ratios certain basic data from a as current as possible year are needed:

- For the waste quantity estimation from the considered TOBB industrial sectors the number of employees per industrial sector per province is required as basic data.
- For the waste quantity estimation of the separately collected fractions the capita per province are required as basic data.
- For the waste quantity estimation of the car repair services the quantity of vehicles per province is required as basic data.
- For the waste quantity estimation of the agricultural sector the agricultural employees per province are required as basic data.
- For a comparison with general waste ratios on basis of the GNP information about the GNP of Turkey is required.

### **3.2.2 Sources of basic data**

We received the basic data for the waste quantity estimation of the TOBB industrial sectors from TOBB via the Turkish MoEF. The data have been surveyed in 2007 and thus are very up-to-date. They were edited by Mr Küchen, Argus GmbH Berlin, and analysed by the author of this report.

The database contains information of about approximately 66.000 companies, 38.000 of which have 10 or more employees. **35.800** of those **companies** are among the in chapter 2.1.1 named industrial sectors with altogether **2,17 million employees**.

The other basic data like capita, vehicles, agricultural employees and GNP are taken from current publications of TurkStat [www.turkstat.gov.tr]. They were surveyed in years 2004 and 2005.

### **3.2.3 Preparation of the basic data**

#### **3.2.3.1 Preparation of the TOBB-data**

Step one: Deletion of all data sets with companies that come from other TOBB-sectors than No. 3000-4101.

Step two: Deletion of all data sets with companies with less than 10 employees.

Step three: Approximately 13.000 companies had assignments to more than one TOBB-code. Their employees were prorated on the different sectors.

Step four: Addition of the numbers of employees per province of those TOBB-codes that are assigned to a waste sector sheet (see chapter 3.3.1: waste sector sheets) for every waste sector sheet.

Step five: Creation of Table1 “employees per sector and province”.

### **3.2.3.2 Editing of the other basic data**

The basic data for capita, vehicles, agricultural employees and GNP per province were available at TurkStat in the required form. They were summarised in Table 2 „additional data per province”.

## **3.3 Waste quantities estimation**

### **3.3.1 Waste sector sheets**

We have formed 21 industrial sector groups whose allocated companies each have a similar waste situation and differ relevantly from other groups.

The following 21 waste sector sheets were formed:

Waste sector sheet	TOBB-Codes
Batteries prod.	383902
Cement	3692
Chem. Anorgan.	351112-351131
Chem. Fertilizer	3512
Chem. Organ.	351101-11, 351140-50, 3513
Chem. Other	351155, 3522-3529
Chem. Paint	3521
Electr. Equipment+Machines	383 except 383902
Energy (power plants)	4101
Food-Beverage-Tobacco	31
Leather	322-324
Metal Production (Fe/Steel)	371
Metal Production (NonFe)	372
Metal Working	381, 382, 384,385
Mineral (e.g. cement, glass)	36 except 3692
Paper production and products	341
Petrol refineries	354
Plastics and rubber	355, 356
Printing	342
Textile	321
Wood and furniture	33

The sector 39 “not otherwise specified products” is split to plastics, metal working and wood.

These 21 sector groups were supplemented by the following three non industrial groups:

Agriculture  
 Separately collected fractions  
 Car repair services

For each of these sector groups a list of hazardous waste, that can occur in this sector group, has been created according to EWC. Because it's not always possible to give the waste ratios in every sector for each single waste type, some waste types were partly united to groups with similar waste composition: acids, waste oil, halog. solvents, non-halog. solvents etc.

The waste sector sheets contain from a few to over 30 different waste types and waste type groups depending on the waste situation of this sector group. The waste sector sheets cover 200 hazardous waste types of the EWC. The other missing about 200 hazardous waste types originate from the disregarded sectors like mining, construction / demolition, health care and waste water / waste treatment or are related to waste types that only occur in a few companies or just in small amounts.

For each of these waste types and for each sector group specific waste amounts in tons per 1.000 employees and year are given (see chapter 2.2)

Depending on the stage of development of the industry and the foci within a sector group the ratios of the situation in the country were adjusted specifically. Thereto data for the Turkish economy were considered, for example from the document procedures.pdf on the Life 'HAWAMAN' Project Web Site under Documents part.

Table: Waste sector sheet "MetWork" (excerpt)

<b>Sector:</b>	<b>Shaping and Physical and Mechanical Surface Treatment of Metals</b>	<b>"MetWork"</b>
<b>EWC</b>	<b>Waste type</b>	<b>t per 1.000 empl.</b>
...		
080111and13	waste paint and paint sludges containing organic solvents or other dangerous substances	10
...		
110105to07	pickling acids and basis and other acids	30
110108	phosphatising sludges	10
...		
120107and10	machining oils free of halogens	40
120109	machining emulsions and solutions free of halogens	150
...		
200121	fluorescent tubes and other mercury-containing waste	0,2
...		

A single waste sector sheet only gives the statistically averaged data for this sector. The waste situation in single companies can differ significantly. Thus a waste sector sheet is not at all suitable to compare the included data with the waste types and amounts of single companies. For example metal working: Some companies galvanise, others don't (no 1101xx-wastes), some lacquer, others don't (no 0801-wastes).

### 3.3.2 Result of waste sector sheets. waste quantities estimation

By entering the number of employees per sector and province into a waste sector sheet you receive the amount of waste that is produced in a sector and a province. By adding all waste sector sheets together you receive the amount of waste in a province, and by adding these values from all provinces together you receive the amount of waste for Turkey. Because some of the 100 wastes and waste groups that are included in the waste sector sheets partly overlap, 28 waste groups were formed for displaying the result.

The result of our waste estimation is:

**in 1.000 tons**

**Total waste amount: 1.350**

Mind that the waste from the disregarded sectors is not included in this and the following numbers.

The 1,35 million tons are divided into these different sector groups:

metal sectors:	548,8 [1.000 tons]
chem. sectors:	396,9
other industrial sectors:	151,3
non industrial groups:	253,4

The wastes from the industrial sectors add up to 1,1 million tons.

For the results in detail see "Tab3 waste amounts per sector and province".

The 1,35 million tons are divided into these different regions:

NUTS1- Region	1.000 t
TR1	314,2
TR2	83,6
TR3	207,2
TR4	303,6
TR5	125,4
TR6	123,0
TR7	54,2
TR8	73,5
TR9	13,9
TRA	6,7
TRB	11,6
TRC	33,5
<b>Total</b>	<b>1.350</b>

For the results in detail refer to "Tab3 waste amounts per sector and province" and "Tab5 amounts per waste and province".

The 1,35 million tons are divided into these different waste groups:

EWC	Waste types	amount in 1.000 t
07xxxx	wastes from organic chem. processes	212,9
12xxxx+13xxxx: oil, non halog.	oil, non halog.	208,3
1002xx-1010xx	wastes from metal production	114,6
06xxxx	wastes from inorganic processes	111,1
190813	sludges containing dangerous substances from other treatment of industrial waste water	99,4
12xxxx+13xxxx: emulsions	oil emulsions and oil/water-separators	80,1
05xxxx	wastes from petroleum refining	65,6
08xxxx	waste paint / ink / sealants	54,7
12xxxx+13xxxx: other wastes containing oil	other wastes containing oil	53,3
150110	packaging containing residues of or contaminated by dangerous substances	48,2
160601+160606+200133	batteries	47,6
11xxxx	wastes from galvanisation	44,8
140603+140605	solvents / solvent sludges, non halog. (without 07)	36,1
150202	absorbents, filter materials, wiping cloths, protective clothing contaminated by dangerous substances	32,9
	Others	140,7
	<b>Total</b>	<b>1.350</b>

For the results in detail with table “Tab5 amounts per waste and province”.

The 1,35 million tons are divided into these different kinds of waste treatment\*:

Direct Landfill	134,0
Solidification for Landfilling	117,2
Phys.-chem. Treatment	445,5
Incineration	315,5
Material Recovery	177,5
Thermal Recovery	160,6
<b>Total</b>	<b>1.350</b>

\*These data are based on the work of Dr. Schultes which may be consulted by the report on Procedures of hazardous waste management in Task C1.

For the results in detail see table “Tab4 waste amounts per treatment and province”.

We have compiled several figures on the regional distribution of the hazardous wastes.

### **3.4 Discussion of the waste quantities estimation**

Mind, that about 20-30 % of the above mentioned input amount of the PCT-facilities has to be – after PCT-treatment as PCT-output - treated thermally, another 20-30 % has to be landfilled and about 50 % is water. And mind, that after solidification for landfill the amount to be landfilled is bigger than the solidificated amount. From the other waste treatment processes also result some hazardous waste (EWC 19).

On analysing and discussing the data it has to be considered that our method is a statistic approach that is only able to achieve realistic results for a great number of companies. The smaller the number of the regarded companies is, the greater the differences from reality can be. This applies for example to the consideration on the level of provinces with few employees or even single or few companies per group.

Even if we tried to achieve results close to reality by our detailed approach, the hazardous waste management system that is based upon our estimation has to be sufficiently flexible in order to cover deviations due to unpredictable developments.

## 4 COMPARISON AND VALIDATION OF OUR RESULTS

### 4.1 Comparison with Germany

Hazardous Waste Situation in Germany 2006

150 Mio. tons of waste, with **18.7 Mio. tons hazardous wastes**  
3.9 Mio. tons treated in company  
**14.7 Mio. tons** in treatment plants

Minus: EWC 01 Mining  
EWC 17 Construction / Demolition (6 Mio. t)  
EWC 18 Health Care  
EWC 19 Waste + Waste Water Treatment (3 Mio. t)  
EWC 160104 End-of-live-vehicles  
EWC 200123/135 Electr. Equipment

**5.3 Mio. tons hazardous wastes from industry** inclusive car repair and separately collected fractions disposed or recovered in treatment plants

	Germany	Turkey	haz. waste extrapolated [Mio. tons]
Capita (Mio.)	82	74	4,7
GNP (Bill. US\$)	3.200	593	1,0
- of industry	960	142	0,8
GNP „power parity“	2.780	870	1,7
- of industry	834	208	<b>1,3</b>
Empl. Industry (Mio.) ~ 9 (companies ≥ 10 Empl.)		2,17	<b>1,3</b>

**Our result with 1,35 Mio. t fits very good to the value referring to industrial employees.**

To compare the Turkish with the German industrial hazardous waste situation by GNP, the industrial fractions of the GNP have to be compared, and because of the different purchasing power in Turkey and Germany, this values have to be adjusted by power parity.

**Our result also fits very good to the value referring to the industrial GNP adjusted by power parity.**

There are some factors of influence, which may diminish or increase these values:

1. In Germany the key sectors are the waste relevant sectors metal and chemistry, in Turkey besides metal industry the non waste relevant sectors textile/leather and food.
2. In Turkey productivity per employee is lower than in Germany.
3. In Germany the "dirty", waste relevant production declines, assembling prefabricated parts produced abroad increases. In Turkey the "dirty", waste relevant production increases.

Pos. 1+2 have a reducing, Pos. 3 an increasing effect on the waste amounts of Turkey.

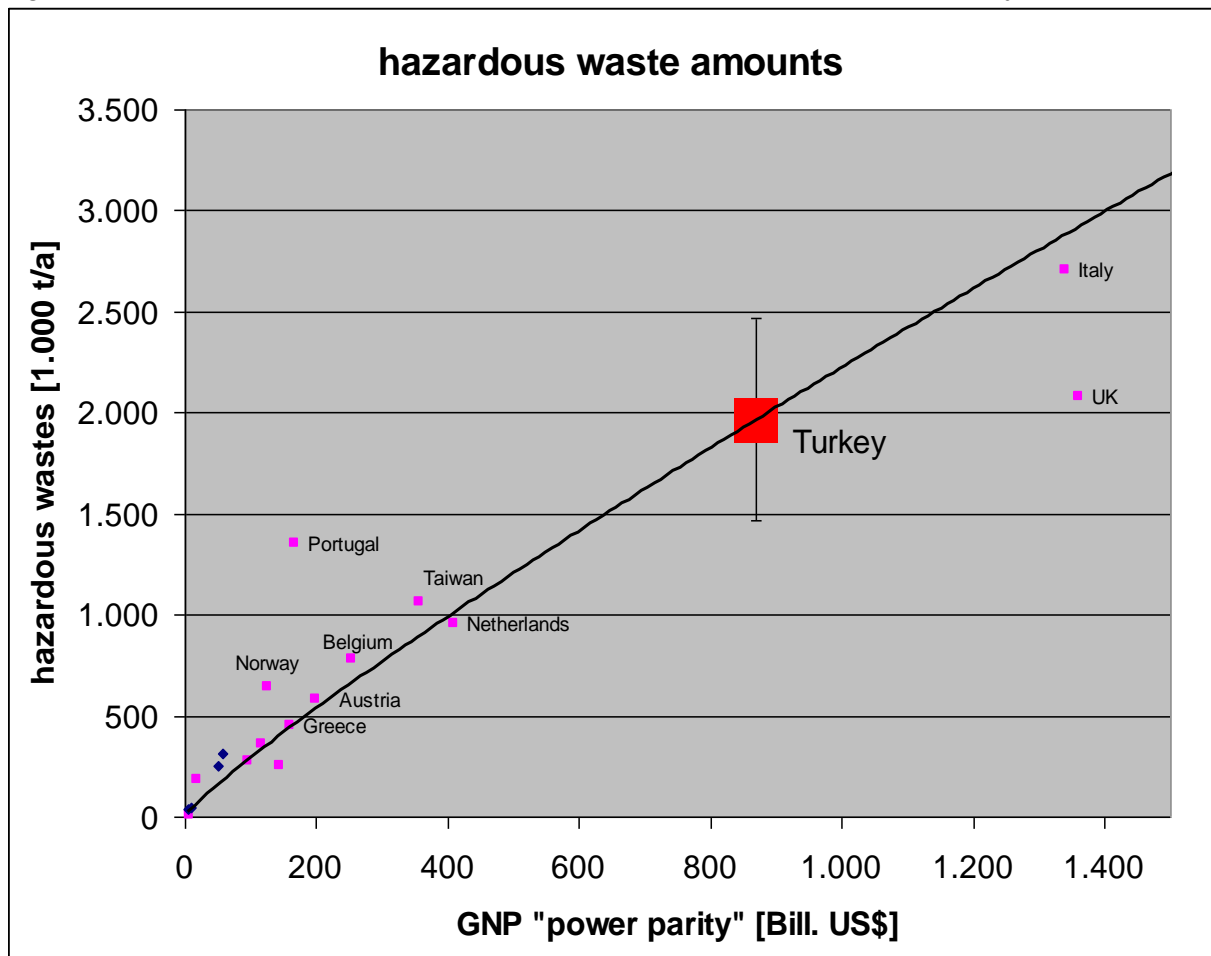
## 4.2 Comparison with other countries

The following figure shows the hazardous waste amounts of several countries. The data of the European countries originate from EU-statistics (pink dots) from the years around 2000, the data of the other countries from studies (estimated data, blue dots).

The dots with waste amounts lower than 400.000 t/a, which are not named, are related to the countries Botswana, Colombia (Region Bogota), Cyprus, Denmark, Finland, Iceland, Ireland, Luxembourg, Norway and Tunisia.

For Turkey we entered the GNP-value "power parity" from 2006 on the trendline (big red dot). For Turkey would result a value of about 2 million tons for all hazardous wastes.

Fig.: Hazardous waste amounts in several countries versus GNP "power parity"



It's important that in this case the data covers all kinds of hazardous waste, and not only the ones of the industry, that is that this in this way determined value can't be compared to ours.

The values of some countries deviates by the factor 2 from the trendline. In some countries and years great site remediation projects have caused more than 50% of the amount of hazardous waste.

### **4.3 Outlook: improvement of estimated data**

The waste situation in single companies can deviate significantly from the used statistic waste ratios. Thus it can be reasonable to analyse the waste situation of individual exceptionally waste relevant companies respectively of companies with very big amounts of hazardous waste and to integrate these values in our waste quantity estimation.

It's essential to make sure that these additional data are real data, that means data from wastes which are occurring and are treated in reality, and not estimated data.

#### **Annexes**

Tab1\_employees\_per\_sector\_and\_province.xls  
Tab2 additional data per province.xls  
Tab3 waste amounts per sector and province.xls  
Tab4 waste amounts per treatment and province.xls  
Tab5 amounts per waste and province.xls  
Tab6 TOBB-Code to industrial sector analysis groups.xls

Annexes are available from MoEF by request.