

# EVALUATION OF THE SOLID AND HAZARDOUS WASTES GENERATED BY THE AUTOMOTIVE INDUSTRY IN TURKEY

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## **Abstract**

**Purpose:** The objective of this study was to evaluate the types and amounts of solid and hazardous wastes generated by the automotive industry relating especially to the supplier companies supporting the automotive manufacturers in Turkey.

**Methods:** A survey was conducted with representative numbers of automotive manufacturers and suppliers located in Bursa, Turkey, to obtain data on the waste types and amounts generated. 105 different parts of an automobile were examined in the framework of the study. Interviews were also conducted with automotive suppliers about the details on each item produced.

**Results:** Resource usage, solid and hazardous waste generation during the production of each component of an automobile were calculated. Environmental load of the automotive sector in Turkey were roughly calculated in terms of waste generation and resource usage.

## **Key Words**

Main industry, supplier companies, questionnaire, automobile components

## **Introduction**

Automotive manufacturing process results in consumption of several natural sources such as water, natural gas, raw material etc. and generation of various hazardous and non-hazardous types of wastes. The global vehicle production has been increasing at a constant rate and this increase is expected to continue [1], which implies that the environmental load of the automotive manufacturing process needs to be assessed and managed.

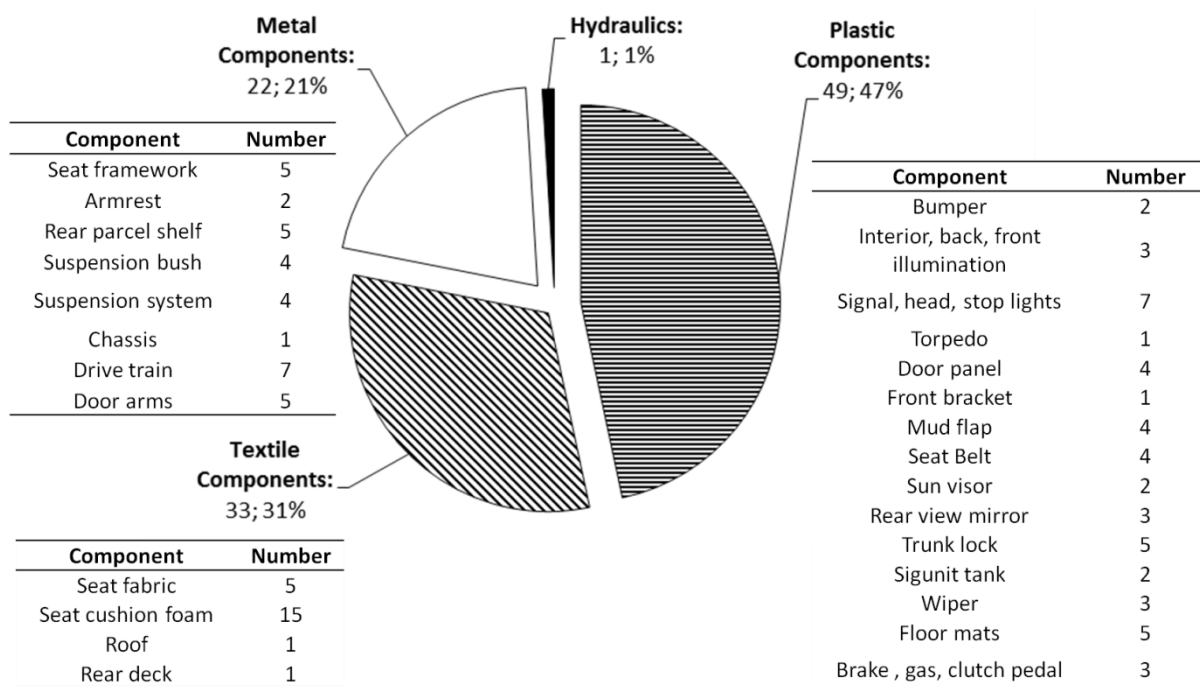
Automotive industry consists of not only the main industry but the great variety of suppliers that support the main industry as well. The number and capacity of the facilities serving to the Main industry has been improving according to the demand for the automobiles; and the number, capacity, and the diversity of the supplier companies has been increasing in parallel. Limited studies have been published on the wastes generated by automotive main industry [1]; however the environmental impact of the automotive supplier companies have not been researched as a whole. Although known automotive companies publish sustainability reports [2-7] to promulgate their environmental impact, they do not mention the supplier companies that support them. The objective of this study was to evaluate the types and amounts of solid and hazardous wastes generated by the automotive industry by relating especially supplier companies supporting the automotive manufacturers in Turkey.

The development of the automotive industry in Turkey dates back to 1960s [8]. Currently, there are 14 automotive manufacturing companies in Turkey, where 1.235.000 automobiles were manufactured in 2016 [8]. Automotive companies are mostly located in cities of Bursa, Istanbul, Kocaeli, and Ankara. In the city of Bursa, there are 3 automotive manufacturers

(main industry) and a considerable number of suppliers (334) for every components of an automobile. As the vehicle production capacity is considered, the potential environmental load of the supplier companies would be obvious, which needs to be assessed.

## Materials & Methods

A survey was conducted with representative numbers of automotive manufacturers and suppliers located in Bursa to obtain data on the waste types and amounts generated. A questionnaire was prepared and applied to 25 companies in Bursa. Data on the raw materials used, consumption of natural resources, wastes generated (EWC codes, types, amounts) and waste disposal routes were collected via the questionnaire. The questionnaire used is given as Annex 1. 105 different parts of an automobile were examined in the framework of the study. Only the automobile engine, which is not produced in Turkey, and very small items such as pin bolts, screws, and ring nuts were excluded from this study. Of the items constituting an automobile, 47% is made of plastics, 31% is made of textile, and 21% is made of metals. Interviews were also conducted with automotive suppliers about the details on each item produced. Fig. 1 shows the automobile components, of which manufacturing waste data were collected in this study.



**Fig. 1 Automobile components investigated**

## Results & Discussion

### Raw Material Usage by Automotive Supplier Companies

Supplier companies serve to a variety of needs of an automobile. Plastic parts are required for components such as door panel, hood, illuminations, wiper, sun visor, and textile products are necessary for seat, roof, seat fabric and foam, rear parcel shelf. Furthermore metal products are used for seat structure, roof, chassis and drive train. More specifically, metal raw materials

can be listed as cold-rolled iron, hot-rolled iron, and various sizes of screws, iron pipes, aluminum pipes and plates, composite materials, tin plates, steel plates. Plastics and chemicals used can be grouped as PVC plates, polyethylene, polypropylene, ABS, polyamide, rubber, woodstock plate, isocyanate, and polyol. Textile components used consist of glass fiber, glue, foam, felting, and fabric. Table 1 lists raw materials used by supplier companies and the waste generated per product; the data was collected via the questionnaire. It can be seen from the table that sometimes many different types of raw materials can be used for very small items. Highest amount of raw material, which is about 7 kg, is spent for the production of seat structure, followed by drive train.

### **Raw Material Usage by Automotive Main Industry**

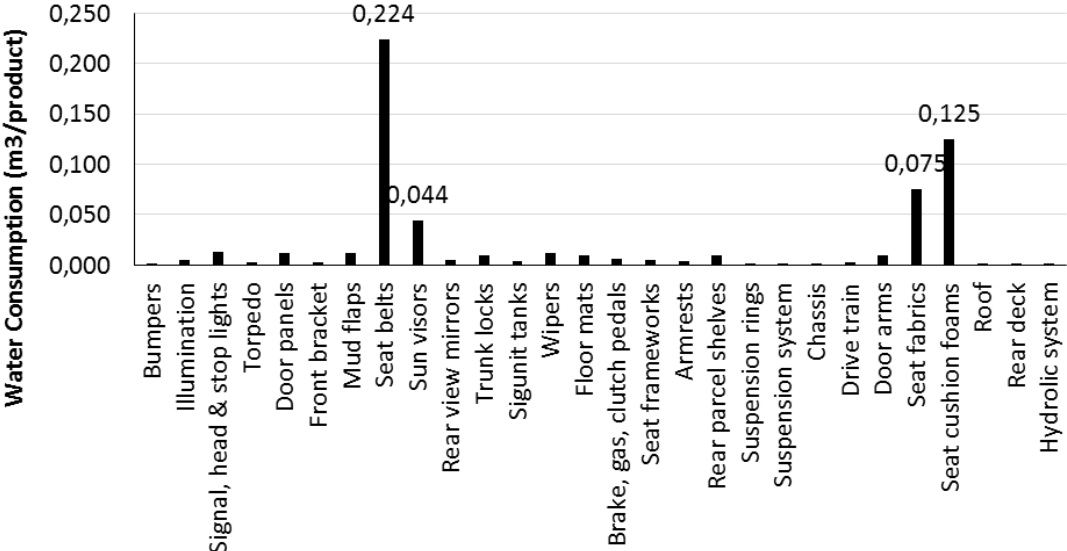
Automotive main industry assembles the semi-finished products produced by the supplier companies. The activities by the main industry can be grouped as stamping, welding, painting, and assembly [1]. Therefore the raw materials at this point are mostly the semi-finished products from the supplier companies. Besides, a variety of chemicals, fuel tanks, oil drums and compressed gas cylinders, and solvents are used for the process steps of stamping, welding, painting, and assembly by the main industry. According to the interviews made with an automotive manufacturer in Bursa, which produce 400,000 vehicles/year, the number of the chemicals used amounts to approximately 800. During the stamping step, 20 types of chemicals, which amount to 3.3 tons/year, are used. During the welding step, 43 different chemicals of 13 tons/year; during the painting step, 86 chemicals of 360 tons/year; and during the assembly step, 36 chemicals of 63 tons/year are used by the main industry. 481 supplementary chemicals of 416 tons/year are used as well. Besides, 26 chemicals of 2.2 tons/year are consumed for research and development activities.

**Table 1 Raw materials used by supplier companies and the waste generated per product**

<b>Name of the product</b>	<b>Amount of Raw Material Used (kg)</b>	<b>Raw Materials Used</b>	<b>Waste Generated (kg) (hazardous &amp; Non-hazardous)</b>
Bumpers	2.00	Polypropylene, Polyamide, ABS, Polyethylene	0.714
Lightings	0.99	Rear View Mirror, Polypropylene, Polyamide, ABS, Polyethylene	0.183
Door Panels	3.96	Polypropylene, Polyamide, ABS, Polyethylene	0.284
Door Pocket	0.79	Polypropylene, Polyamide, ABS, Polyethylene	0.051
Mud Flaps	1.80	Polypropylene, Polyamide, ABS, Polyethylene	0.144
Seat Belts	6.60	PE-Foam, PVC Plate, Polypropylene, Polyamide, ABS, Polyethylene	0.945
Sun Visor	2.24	PE-Foam, Polyethylene, Mirror	0.268
Rear View Mirror	0.27	Rear View Mirror, PVC Plate	0.061
Rear Parcel Shelf	1.10	Staple Sliver, Rigid Foam, Glue, Solvent Woodstock Plate, Felting	0.396
Suspension Ring	1.00	Cold-rolled Materials, Steel Tube, Round Steel, Flat Steel, Aluminum Pipe, Aluminum Plate, Rubber, Plastic Parts	0.039
Suspension Systems	1.00	Cold - rolled Materials, Hot - rolled Materials, Iron Pipe, Line Shaft, Composite Screw	0.763
Covering	0.02	Acetic Acid, Phenol, Phosphoric Acid, pH adjust, Wetting Materials, Liquid Caustic	0.008
Drive Train	4.28	Cold-rolled Materials, Hot-rolled Materials, Iron Pipe, Line Shaft, Composite Screw	0.763
Hood	1.42	Cold-rolled Materials, Hot-rolled Materials, Iron Pipe, Line Shaft, Composite Screw	0.763
Pedals, Door Lock, Water Tank	1.19	Sheet Metal, Plastic, Polypropylene, ABS, Polyethylene	0.107
Seat Structure	7.00	Cold-rolled Materials, Hot-rolled Materials, Iron Pipe, Line Shaft, Composite Screw	0.004
Seat Foam and Seat Fabric	2.00	Staple Sliver, Rigid Foam, Glue, Solvent, Woodstock Plate, Felting, Isocyanate, Polyol, glass fiber, fabric	0.025

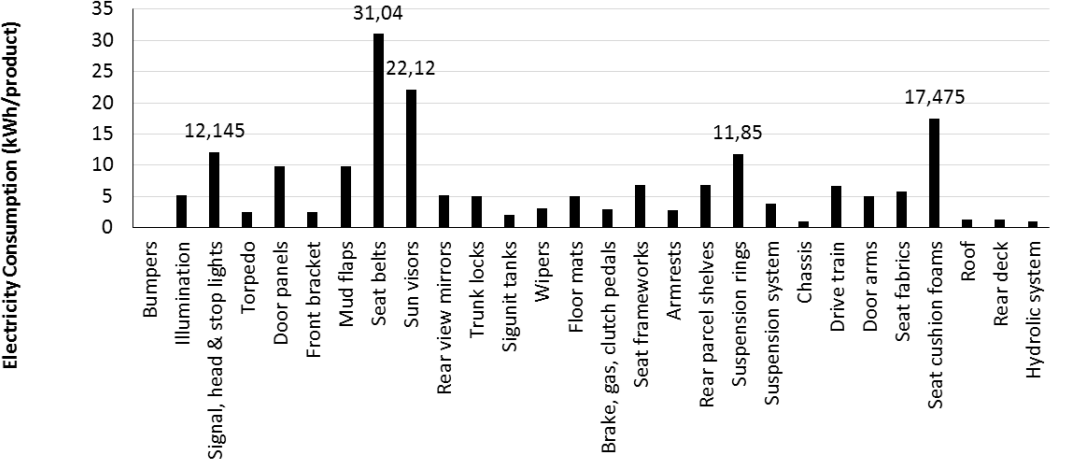
### Resource Usage by the Automotive Supplier Companies

Use of resources such as water and electricity consumption was investigated by evaluating the data collected via the questionnaire. Fig. 2 shows the amount of water consumed for each item produced by the supplier companies. Seat belt, followed by sun visor and seat fabric & foam are the products where water is consumed most. Production of suspension systems necessitated the least amount of water consumption among others. The amount of the water used for all the items by the supplier companies was found to be approximately 0.60 m<sup>3</sup>/car.



**Fig. 2** Water consumption per product by the automotive supplier companies investigated (m<sup>3</sup>/product)

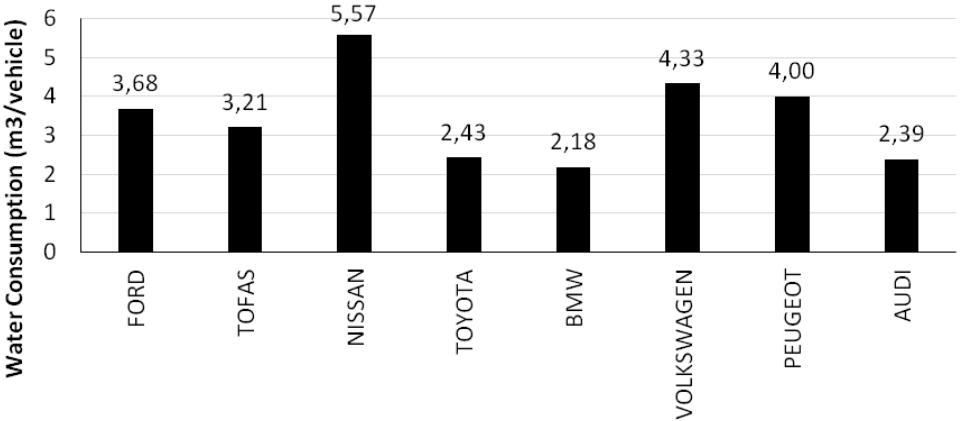
Fig. 3 shows the electricity consumption per product by the supplier companies. In parallel to the water consumption levels, highest electricity consumption among all items were found for the production of seat belts, followed by sun visor, and seat fabric & foam. The amount of the electricity used for all the items by the supplier companies was found to be approximately 190 kWh /car.



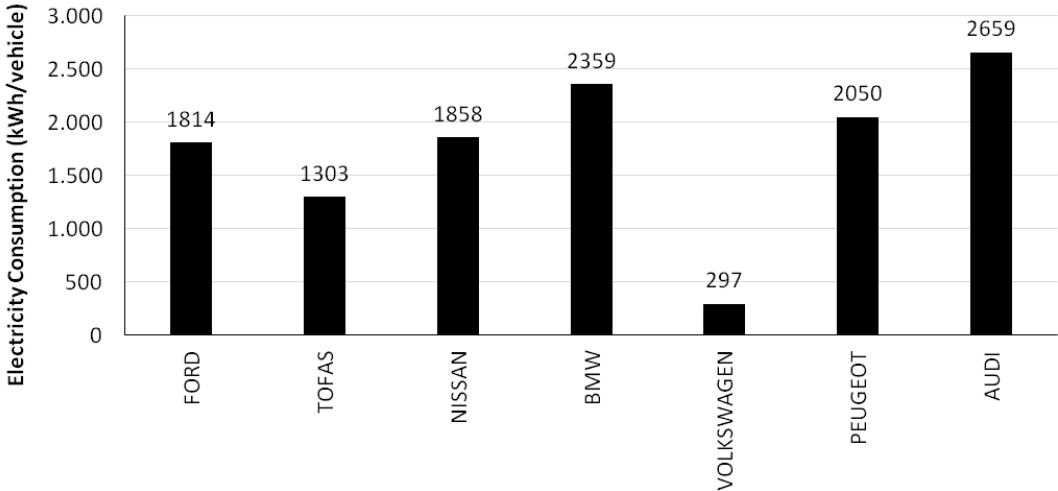
**Fig. 3** Electricity consumption per product by the automotive supplier companies investigated (kWh/product)

**Resource Usage by Automotive Main Industry**

Data from the sustainability reports [3-5,7,9-12] were compiled to evaluate the use of natural resources by the main industry. Fig. 4 shows the water consumption levels by several automotive manufacturers globally. Water usage during the production ranges between 2.18-5.57 m<sup>3</sup>/vehicle. Fig. 5 shows the electricity consumption levels by several automotive manufacturers. Electricity usage during production of a vehicle ranges between 297-2659 kWh.



**Fig. 4** Water consumption per vehicle by several automotive companies globally (m<sup>3</sup>/vehicle)

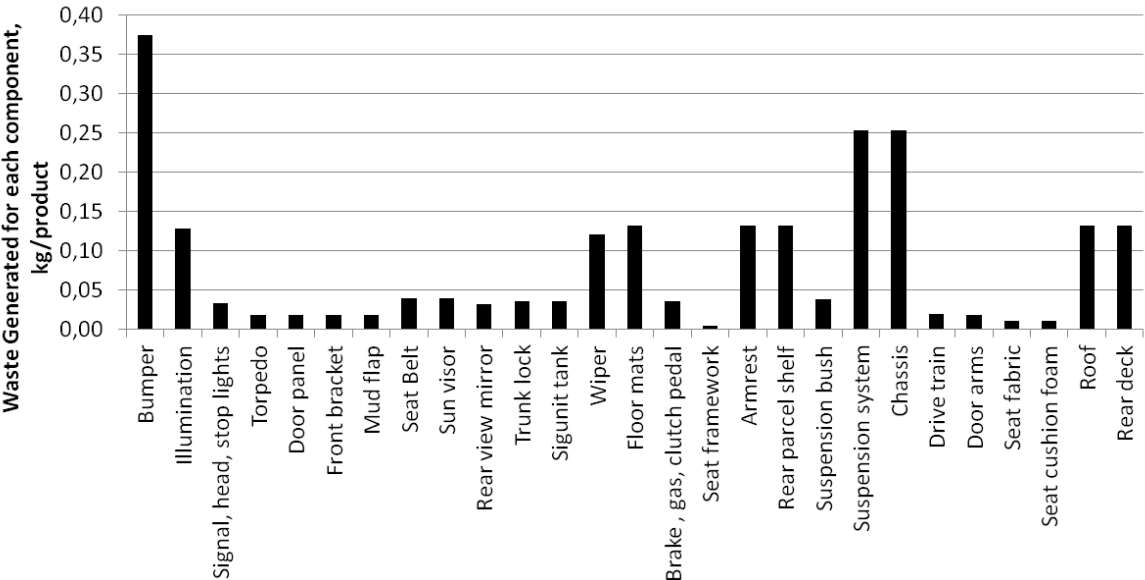


**Fig. 5** Electricity Consumption per vehicle by several automotive companies globally (kWh/vehicle)

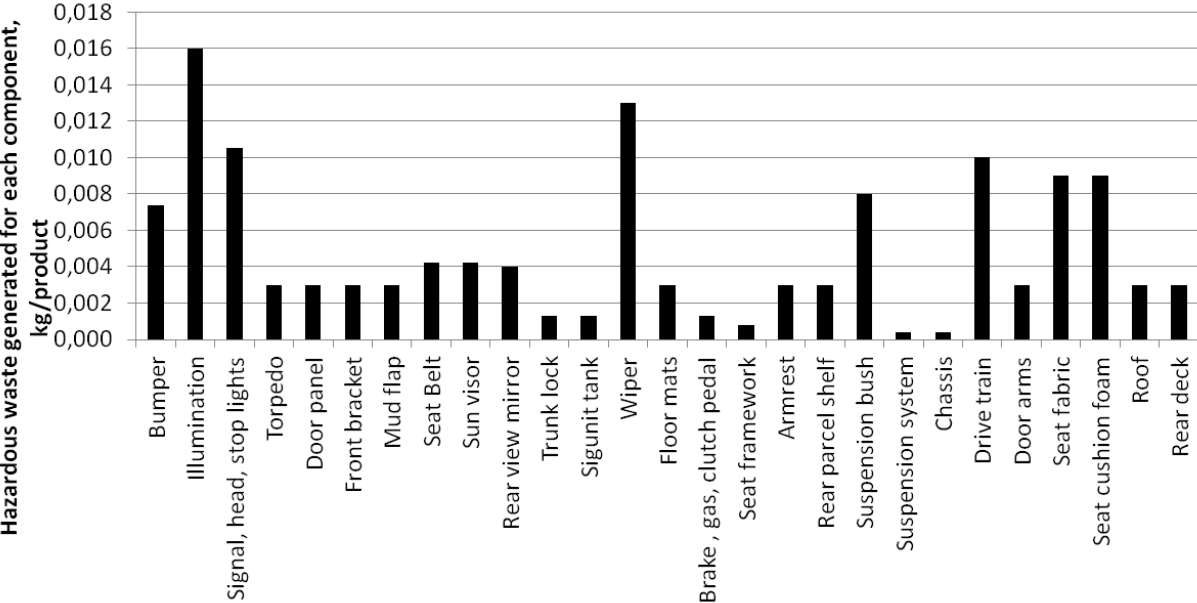
**Waste Generated by the Automotive Supplier Companies & Main Industry**

The sectors of automotive supplier companies can be grouped as metal, plastic, and textile industries. The distribution of the wastes according to these sectors is as follows: 45% of the total waste by suppliers is generated by plastics industry, whereas 28% and 26% are generated by metal and textile industries, respectively. 90.5% of the wastes generated by the supplier companies were found to be non-hazardous while 9.5% were hazardous. The amount of waste generated during the production of all items by supplier companies amounts to 6.31 kg/vehicle.

The amounts and types of the wastes generated by the supplier companies were determined by evaluating the data from the results of the questionnaire. Total amount of waste and hazardous waste generated for production of each item by the supplier companies are given in Fig. 6 and Fig. 7, respectively. Table 1 also gives the waste amounts along with the raw materials used for each item produced by the supplier companies.



**Fig. 6** Total amount of waste per product (kg/product)



**Fig. 7** Total amount of hazardous waste per product (kg/product)

According to the Fig. 6, the amount of the solid waste generated for bumper production was found to be the highest among all items produced by the suppliers, which is followed by the amount of the waste to produce suspension systems and chassis. Bumper is a big sized product compared to the other components; therefore high amount of waste for this item is reasonable.

Fig. 7 shows that highest amount of hazardous waste among all items, which is 0.016 kg/product, is generated during the production of illumination items, which is followed by wipers and wiper system. The amount of the hazardous waste generated during the production of signal, head & stop lights are the third after illumination and wipers. The variety of the raw material for these items is also more than that of the others.

Total amount of waste generated during the stamping, welding, painting, and assembly processes by the automotive main industry amounts to 56 kg/vehicle, of which 12.5% is hazardous [1]. In total, 62.3 kg/vehicle solid waste is generated for the production of a standard vehicle by supplier companies and the main industry. Approximately 10% of the total solid waste is generated by the supplier companies. It can be inferred that despite the large variety of the supplier companies and their sectors, automotive main industry is still the predominant source of waste from automotive sector.

## **Conclusions**

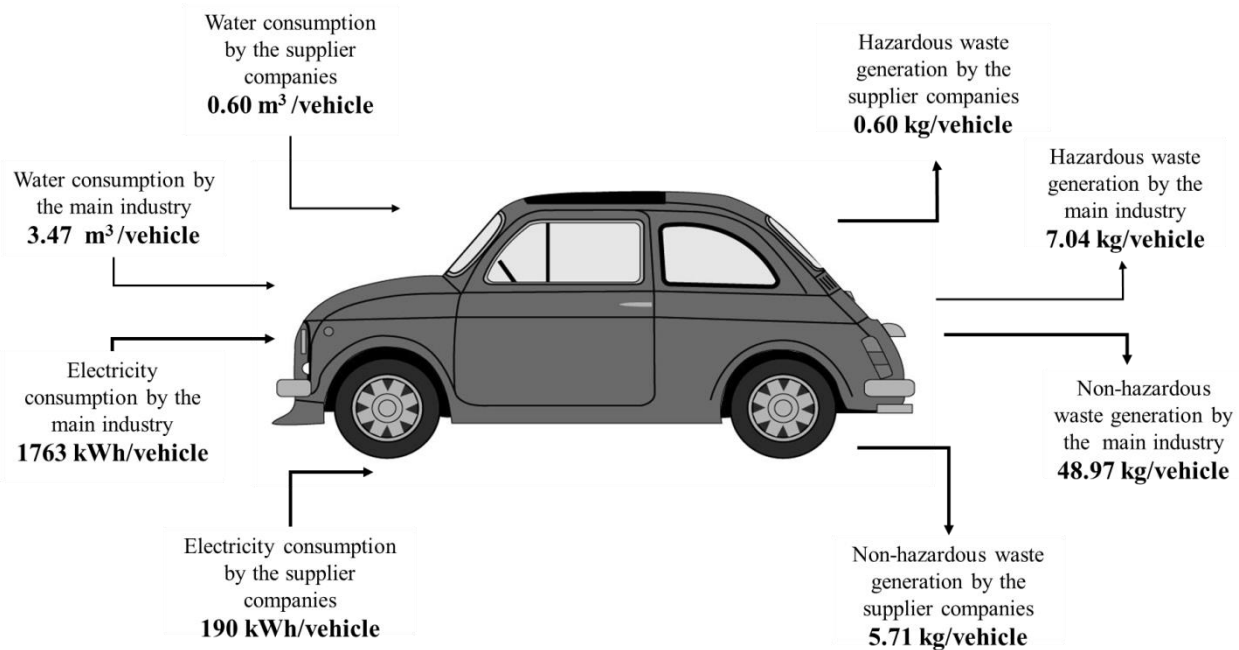
The results of the study implied that despite the large variety of the supplier companies and their sectors, automotive main industry is the predominant source of waste. Since the supplier companies adapt themselves to the needs of the main sector, the main sector has the role to define the environmental standards for the supplier companies.

The detailed analysis of the raw material usage and waste generation by the supplier companies showed that these two parameters are not proportional. Waste generation not only depends on the amount of the raw material usage, but on the efficiency of the process and the characteristics of the item as well.

More than 100 different parts are produced by the supplier companies. It was seen that 47% of the items constituting an automobile is made of plastics, 31% is made of textile, and 21% is made of metals. Although a high variety of raw materials and chemicals are being used by the supplier companies, the number and amount of the chemicals used by the main industry excessive. It was found that more than 800 tons/year chemicals is consumed by an automotive manufacturer (main industry) that produces 400,000 vehicles/year.

The resource usage and waste generation during the production of a vehicle is summarized as Fig. 8. Automobile engine, which is not produced in Turkey, is excluded from the boundaries of this study. Approximately, 840,000 vehicles/year are produced in Turkey. When the findings of this study taken into account, the total amount of solid waste produced during the production of these vehicles will be 52,340 tonnes of which 6,417 tonnes are hazardous. Water usage by the automotive sector amounts to 3.42 million m<sup>3</sup>/year, and electricity consumption is about 1,640,520 MWh.





**Fig. 8** Levels for resource usage and waste generation during the production of a vehicle by the supplier companies and the main industry

## References

1. Salihoglu, G., Salihoglu, N.K.: A review on pant sludge from automotive industries: Generation, characteristics and management. *J Environ Manage* **169**, 223-235 (2016).
2. Tata: Corporate Sustainability Report. Tata Motors Limited, 72 Pages (2013).
3. Nissan: Sustainability Report. Nissan Motor Company, 143 Pages (2014).
4. Volkswagen: Sustainability Report. Volkswagen Company, 160 pages (2013).
5. Toyota: Sustainability Report. Toyota Company, p. 154. (2014).
6. Volkswagen: Sustainability Report. Volkswagen Company, p. 160. (2013).
7. Fiat: Sustainability Report: Economic, Environmental and Social Responsibility. Fiat Company, 197 Pages (2013).
8. ISPAT, T.: Turkey's Automotive Industry Report. Republic of Turkey Prime Ministry Investment Support and Promotion Agency, [www.invest.gov.tr](http://www.invest.gov.tr) (2014).
9. USEPA: Introduction to United States Environmental Protection Agency Land Disposal Restrictions (40 CFR Part 268). Solid Waste and Emergency Response (5305W), EPA530-K-05-013, 26 p. (2005).
10. BMW: Working Together: Sustainable Value Report 2013. BMW Group, p. 231. (2013).
11. PSA: Sustainable Development Performance Indicators. PSA Peugeot Citroen, p. 180. (2010).
12. Audi: Corporate Responsibility Report, Update 2013: CR Program and Key Figures. Audi, Germany, p. 13. (2013).

**Annex 1. Questionnaire Applied**

COMPANY INFORMATION						
Name of the Company						
Area of the Activity						
Production Capacity						
Number of Employees				Is there Environmental Management Unit?		
Is there an environmental engineer at the company?						
Quality Certificate		ISO 14001	ISO 9001	TS16949	Other (WCM, Q1, Ecovadis etc.)	
Permission License Scope		Annex 1	Annex 2		Out of Scope	
Water Consumption (m3/month)						
Natural Gas Consumption (kWh/month)						
Electricity Consumption (kWh/month)						
Raw Material Consumption						
Source for the Raw Material						
Is there a temporary waste storage area at the company?						
HAZARDOUS AND NON HAZARDOUS WASTE IN 2016						
Name of Waste	Code of Waste	Process	Total Amount of Waste (tons/year)	Disposal Method	Licensed Company	
Amount of packaging waste in 2016 (ton/year, kg/year)						
EXPLANATION						