WASTE GENERATION IN PRIMARY AND SECONDARY ALUMINUM SECTOR IN TURKEY

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OUTLINE

• Introduction

• Methods

• Results and Discussion
  o Determination of WGFs and Responsible Processes for Waste Generation
  o Development and Evaluation of Management Strategies

• Conclusion
INTRODUCTION

Aluminum

❖ the most produced and used metal following steel in the world

❖ commonly used in different industrial applications
  ❖ Construction industry
  ❖ Chemical industry
  ❖ Metal industry
  ❖ Transportation
  ❖ Electrical and electronics
  ❖ Manufacture of machinery and equipment
INTRODUCTION

Aluminum is produced in two ways;

- Primary aluminum production
- Secondary aluminum production
PRIMARY ALUMINUM PRODUCTION

1. **Mining of Bauxite**
2. **Alumina Production (Bayer Process)**
3. **Crushing and Grinding**
4. **Digestion**
5. **Crystallization**
6. **Calcination**
7. **Electrolysis (Hall-Hérault Process)**
8. **Smelting**
INTRODUCTION

Aluminum is produced in two ways;

- Primary aluminum production
- Secondary aluminum production
SECONDARY ALUMINUM PRODUCTION

Raw Material

Pretreatment

Melting Furnace

Holding Furnace

Smelting
## PRIMARY VS SECONDARY ALUMINUM PRODUCTION

<table>
<thead>
<tr>
<th>Primary Aluminum Industry</th>
<th>Secondary Aluminum Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>High investment cost</td>
<td>Low investment cost</td>
</tr>
<tr>
<td><strong>High energy consumption</strong></td>
<td>Low energy consumption</td>
</tr>
<tr>
<td>Long start-up period</td>
<td>Short start-up period</td>
</tr>
<tr>
<td><strong>Consumption of bauxite resources</strong></td>
<td>Preservation of bauxite resources</td>
</tr>
<tr>
<td>High level emission</td>
<td>Low level emission</td>
</tr>
</tbody>
</table>

Secondary aluminum production can be categorized as more environmentally friendly than primary production.
AIM

- To obtain a solid waste inventory for aluminum production

- To determine waste generation factors (WGFs, kg waste per ton of production)

- To develop and evaluate management strategies
METHODS

Primary and Secondary Aluminum Production

PHASE-I
- HWDS
  - Sectoral Data Analysis
    - Determination of WGFs

PHASE-II
- Field Studies
  - Process Analysis
    - Generation of Waste List
      - Determination of WGFs

PHASE-III
- Literature Review
  - Process Analysis
    - Generation of Waste List
      - Determination of WGFs

Determination of BATs
### RESULTS AND DISCUSSION

1. Determination of WGFs and Responsible Processes for Waste Generation—Primary Aluminum Production

<table>
<thead>
<tr>
<th>Code</th>
<th>Wastes from primary aluminum production</th>
<th>WGF (kg t(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 03</td>
<td>wastes from physical and chemical processing of metalliferous minerals</td>
<td></td>
</tr>
<tr>
<td>01 03 07*</td>
<td>other wastes containing dangerous substances from physical and chemical processing of metalliferous minerals</td>
<td>nd</td>
</tr>
<tr>
<td>01 03 09</td>
<td>red mud from alumina production other than the wastes mentioned in 01 03 10</td>
<td>300-2500</td>
</tr>
<tr>
<td>01 03 10*</td>
<td>red mud from alumina production containing hazardous substances other than the wastes mentioned in 01 03 07</td>
<td>nd</td>
</tr>
<tr>
<td>10 03</td>
<td>wastes from aluminum thermal metallurgy</td>
<td></td>
</tr>
<tr>
<td>10 03 02</td>
<td>anode scraps</td>
<td>10-450</td>
</tr>
<tr>
<td>10 03 04*</td>
<td>primary production slags</td>
<td>0.20-20</td>
</tr>
<tr>
<td>10 10</td>
<td>wastes from casting of non-ferrous pieces</td>
<td></td>
</tr>
<tr>
<td>10 10 03</td>
<td>furnace slag</td>
<td>nd</td>
</tr>
</tbody>
</table>

**TOTAL**                                                                 | 310.2-2970
RESULTS AND DISCUSSION

- Sources of waste generated in primary aluminum production

- **Mining of Bauxite**
  - 01 03 07* other wastes containing dangerous substances from physical and chemical processing of metalliferous minerals

- **Alumina Production (Bayer Process)**

- **Crushing and Grounding**

- **Digestion**

- **Electrolysis (Hall-Hérault Process)**
  - 10 03 02 Anode scraps
  - 10 03 04* primary production slags
  - 10 10 03 furnace slag

- **Calcination**

- **Crystallization**

- **Smelting**
  - 01 03 09 red mud from alumina production other than the wastes mentioned in 01 03 10
  - 01 03 10* red mud from alumina production containing hazardous substances other than the wastes mentioned in 01 03 07
RESULTS AND DISCUSSION

Determination of WGFs and Responsible Processes for Waste Generation - Secondary Aluminum Production

<table>
<thead>
<tr>
<th>Code</th>
<th>Wastes from secondary aluminum production</th>
<th>WGF (kg t(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 03</td>
<td>wastes from aluminum thermal metallurgy</td>
<td></td>
</tr>
<tr>
<td>10 03 05</td>
<td>waste alumina</td>
<td>nd</td>
</tr>
<tr>
<td>10 03 08*</td>
<td>salt slags from secondary production</td>
<td>0.20-500</td>
</tr>
<tr>
<td>10 03 09*</td>
<td>black drosses from secondary production</td>
<td>5-676</td>
</tr>
<tr>
<td>10 03 15*</td>
<td>skimmings that are flammable or emit, upon contact with water, flammable gases in dangerous quantities</td>
<td>80-120</td>
</tr>
<tr>
<td>10 03 16</td>
<td>skimmings other than those mentioned in 10 03 15</td>
<td></td>
</tr>
<tr>
<td>10 03 19*</td>
<td>flue-gas dust containing dangerous substances</td>
<td>0.1-80</td>
</tr>
<tr>
<td>10 03 20</td>
<td>flue-gas dust other than those mentioned in 10 03 19</td>
<td></td>
</tr>
<tr>
<td>10 03 21*</td>
<td>other particulates and dust (including ball-mill dust) containing dangerous substances</td>
<td>0.2-1130</td>
</tr>
<tr>
<td>10 03 22</td>
<td>other particulates and dust (including ball-mill dust) other than those mentioned in 10 03 21</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>85.5-2506</td>
</tr>
</tbody>
</table>
RESULTS AND DISCUSSION

Sources of waste generated in secondary aluminum production

Raw Material

- 10 03 05 Waste alumina
  - 10 03 08* Salt slags from secondary production
  - 10 03 09* Black drosses from secondary production
  - 10 03 15* Skimmings that are flammable or emit, upon contact with water, flammable gases in dangerous quantities
  - 10 03 16 Skimmings other than those mentioned in 10 03 15
  - 10 03 19* flue-gas dust containing dangerous substances
  - 10 03 20 flue-gas dust other than those mentioned in 10 03 19

Pretreatment

- 10 03 21* other particulates and dust (including ball-mill dust) containing dangerous substances
- 10 03 22 other particulates and dust (including ball-mill dust) other than those mentioned in 10 03 21

Melting Furnace

Holding Furnace

Smelting

Secondary Aluminum

5th International Conference on Sustainable Solid Waste Management, ATHENS 2017
RESULTS AND DISCUSSION

2. Development and Evaluation of Management Strategies

- The aim in this part of the study is to investigate the best available techniques (BATs) that can be adopted to the Turkish aluminum industry for a better management of the wastes generated.

- Both in-plant and end-of-pipe BAT alternatives were considered.
### RESULTS AND DISCUSSION

**Best Available Techniques (BAT)**

<table>
<thead>
<tr>
<th>BEST</th>
<th>AVAILABLE</th>
<th>TECHNIQUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>most effective in achieving a high level of protection of the environment as a whole</td>
<td>developed on a scale to be implemented in the relevant industrial sector, under economically and technically viable conditions, advantages balanced against costs</td>
<td>the technology used and the way the installation is designed, built, maintained, operated and decommissioned</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Utilization</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 01 03 07* | other wastes containing dangerous substances from physical and chemical processing of metalliferous minerals | • Used as an alternative raw material in ceramic industry, building material,  
• catalyst in chemical industry |
| 01 03 09 | red mud from alumina production other than the wastes mentioned in 01 03 10 |                                                                              |
| 01 03 10* | red mud from alumina production containing hazardous substances other than the wastes mentioned in 01 03 07 | • Using inert anodes instead of anodes that include carbon |
| 10 03 02 | anode scraps                                                                | • Used in:  
• secondary alumina production  
• cement industry as additive material  
• iron and steel industry as synthetic slag maker. |
| 10 03 04* | primary production slags                                                     |                                                                              |
| 10 10 03 | furnace slag                                                                |                                                                              |
### BATs for Secondary Aluminum Production

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 03 08*</td>
<td>Salt slags from secondary production</td>
</tr>
<tr>
<td>10 03 05</td>
<td>Waste alumina</td>
</tr>
<tr>
<td>10 03 09*</td>
<td>Black drosses from secondary production</td>
</tr>
<tr>
<td>10 03 15*</td>
<td>Skimmings that are flammable or emit, upon contact with water, flammable gases in dangerous quantities</td>
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<td>Other particulates and dust (including ball-mill dust) other than those mentioned in 10 03 21</td>
</tr>
<tr>
<td>10 03 19</td>
<td>Flue-gas dust containing dangerous substances</td>
</tr>
</tbody>
</table>

**Used in:**
- secondary alumina production,
- cement industry as additive material
- iron and steel industry as synthetic slag maker,
- as salt flux in aluminum industry
- catalyst production in chemical industry

The use of metal pumping or a stirring system and use of a tilting rotary furnace to improve efficiency and reduce salt usage.

**Used in:**
- secondary alumina production
- cement industry as additive material
- iron and steel industry as synthetic slag maker
- aluminum industry as salt fluxes
- chemical industry for catalyst production

The use of bag filters as in-plant BAT.
CONCLUSIONS

- Three phase approach which considers literature review, field studies and waste declaration system was followed.
- Situation of both primary and secondary aluminum production sector in Turkey was revealed by providing a summary of their production processes and generated wastes from each process.
- Range for the amount of waste generated per unit aluminum production, WGFs, was identified.
- Although total amount of waste generated is substantially higher in primary production, secondary production is dominant sector in terms of hazardous waste generation.
- In-plant and end-of-pipe BAT alternatives can be applied to the aluminum production wastes.
- In cases where BATs cannot be applicable, metals can be recovered from waste because of its aluminum content.