Cost-Benefit Analysis of the Agricultural Use of Coal Ash

Methodological considerations

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Outline

• Coal ash production - scale and quantities marketed to farmers in Israel
• Uses of coal ash in agriculture
• Advantages and Disadvantages of coal ash
• Cost-benefit analysis of the use of coal ash in agriculture (economic terms)
• Israel's electric power plants produce **1250 thousand tons** annually.
• **Agriculture utilizes only 38 thousand tons**.
• Most of the ash is utilized in the **construction industry (92%)**.
• The **expected** population growth in Israel will result in an increase in electricity production and almost **doubling of ash production** (1950 thousand ton in 2026)
• **Growth medium for growing plants** - combined with composts or by its own a soil-less growth medium for plants

• **Bedding for livestock** - replacement for sawdust, preventing polluting leachates

• **Stabilization of sewage sludge** - Certification as a usable, safe product, reduces the organic matter content as well as pathogens.

• **Improving soil quality** - mostly combined with sludge to improve soil’s hydraulic properties
Potential use of Fly Ash (Ton/Hec in Israel)

<table>
<thead>
<tr>
<th>Agricultural use Fly Ash</th>
<th>Fly ash per hectare</th>
<th>Years of implementation</th>
<th>Hectare</th>
<th>Demand tons per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sludge Stabilization</td>
<td>20</td>
<td>5</td>
<td>45,000</td>
<td>180,000</td>
</tr>
<tr>
<td>Plants Growth medium</td>
<td>200</td>
<td>15</td>
<td>1,000</td>
<td>13,000</td>
</tr>
<tr>
<td>Soil stabilization</td>
<td>900</td>
<td>15</td>
<td>14,000</td>
<td>840,000</td>
</tr>
<tr>
<td>Improving soil quality</td>
<td>950</td>
<td>10</td>
<td>2,000</td>
<td>190,000</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>62,000</td>
<td>1,223,000</td>
</tr>
</tbody>
</table>

*Note: implementation in the field will be one-time only*
### Agricultural growth

<table>
<thead>
<tr>
<th></th>
<th>Cost of chemical fertilizer $/Hec</th>
<th>Sludge with Fly Ash Ton/Hec</th>
<th>Cost of Fly Ash $/Hec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables in the open fields</td>
<td>1,050</td>
<td>45</td>
<td>460</td>
</tr>
<tr>
<td>Irrigated field crops</td>
<td>470</td>
<td>27</td>
<td>280</td>
</tr>
<tr>
<td>Non Irrigated field crops</td>
<td>200</td>
<td>15</td>
<td>150</td>
</tr>
</tbody>
</table>

- Prices of chemical fertilizer NPK Unit (n=1.84$, p=1.48$, k=0.83$)
- Lime stabilized sludge costs $ 10 per ton including transportation and distribution in the field
Advantages of coal ash - Economic terms

- **Raising soil’s water holding capacity** - Comparison of crops in different climatic regions
- **Reducing the amount of needed irrigation water** - Water and cost saving
- **Creating bio-membrane** – reducing wind erosion losses and fertile land coverage by shifting sand
- **Raising soil temperature** - enhancing germination and raising crop yield by 8%
Advantages of coal ash - Economic terms

- **Contribution of nutrients** - value in terms of cost of chemical fertilizer
- **Reduction in leaching of nutrients** - Improved fertilizers efficiency by 5% and the respective reduction in cost
- **Reduction of pathogens** - a saving of one spray per growth season
- **Contribution of trace elements** - saves extra fertilization with trace minerals
Disadvantages of coal ash- Economic terms

- **Raising salinity** - damage to soil quality in terms of the cost of removing salt from water (desalination)
- **Raising pH of the soil** - reduction in the availability of phosphorus, cost of adding one unit.
- **Added toxic elements** – predominantly in vegetative parts but not in fruit – in wheat can sell grain but not stock for few years after ash application
Disadvantages of coal ash- Economic terms

- **Addition of boron** - reduction in diversity of crops but the risk is small
- **Reduced Hydraulic conductivity** - will reduce water uptake by the soil, crop loss followed by up to 10%
- **Damage to reputation** - the main concern of the regulator comes from lack of understanding of the subject of radioactivity which may result in prohibition of marketing from fields to which coal ash was applied.
Economic principles for the calculations

- **Present Value** PV is the value of an expected income stream
- **Interest Rate** – A dollar today is worth more than a dollar tomorrow.
- **Net Present Value**- NPV - present value stream of cash flows
- **Payment** – PMT - expected income or payment in each season
- **Risk** - Implementation rate exposure to danger
## Environmental assessment vs Economic Price

<table>
<thead>
<tr>
<th>Benefit</th>
<th>ha/$</th>
<th>Cost</th>
<th>ha/$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in soil water content</td>
<td>23</td>
<td>Rise in soil salinity</td>
<td>21</td>
</tr>
<tr>
<td>Decreases of irrigation</td>
<td>38</td>
<td>Rise in soil pH</td>
<td>15</td>
</tr>
<tr>
<td>Improving soil productivity</td>
<td>85</td>
<td>Addition of heavy metals</td>
<td>23</td>
</tr>
<tr>
<td>Raising the temperature of the soil</td>
<td>15</td>
<td>Addition of boron</td>
<td>8</td>
</tr>
<tr>
<td>Addition of fertilizers</td>
<td>38</td>
<td>Change in hydraulic conductivity of the soil</td>
<td>8</td>
</tr>
<tr>
<td>Reduction of leaching fertilizers</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced disease severity</td>
<td>26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Addition of trace elements</td>
<td>51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>284</td>
<td></td>
<td>75</td>
</tr>
</tbody>
</table>

Unknown long-term damage 126 $/He
Conclusions

- Support for fly ash application to soil comes mainly from its role as a replacement fertilizers and contribution to soil improvement.
- Other benefits include increasing water content, reduction in soil borne pathogens, addition of micronutrients.
- The main concern is unknown long-term consequences on agricultural land.
  - Other disadvantages are raising salinity, heavy metals and boron content, irrational fear of radioactivity.
  - The benefits from the addition of coal ash combined with sludge far outweigh its costs.
And What’s Next?

In the 21st century we need to learn to recycle wastes, agricultural use of Coal ash is one possible solution.

thanks