Introduction of Porous Alpha
Water-saving agriculture technology
16 January, 2017
Tottori Resource Recycling, Inc.
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- Introduction of our company and “Porous Alpha”
  - The application of “Porous Alpha” for agriculture to save the water and to increase the yield
- Case studies
- Project in Somalia with IOM
Tottori Resource Recycling is a venture company focused on foamed glass as core technology

- Name: Tottori Resource Recycling Inc.
- President: Yoshiaki Takeuchi (Mr.)
- Establishment: December, 2001
- Capital: 40 million JPY
- Location: Tottori, Japan
- Number of employees: 10
- Business area: Glass recycling based on foaming technology and its R&D

Municipalities

Raw materials are brought to our factory

Used glass bottles

Glass powder

Porous Alpha Foamed glass

Customer

Value addition by foaming waste glass
Under the Japanese regulation, Porous Alpha can be used as a soil for agriculture safely

Result of leaching test based on the “Environmental regulation regarding the soil pollution”, 23 August 191, Ministry of Environment, analyzed by Tottori Health Association

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Result</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Alkyl mercury</td>
<td>Not detected</td>
<td>Not detected</td>
</tr>
<tr>
<td>2</td>
<td>Total mercury</td>
<td>&lt; 0.0005 mg/l</td>
<td>0.0005mg/l</td>
</tr>
<tr>
<td>3</td>
<td>Cadmium</td>
<td>&lt; 0.001 mg/l</td>
<td>0.01mg/l</td>
</tr>
<tr>
<td>4</td>
<td>Lead</td>
<td>0.001 mg/l</td>
<td>0.01mg/l</td>
</tr>
<tr>
<td>5</td>
<td>Organophosphorus</td>
<td>Not detected</td>
<td>Not detected</td>
</tr>
<tr>
<td>6</td>
<td>Hexavalent chromium</td>
<td>0.014mg/l</td>
<td>0.05mg/l</td>
</tr>
<tr>
<td>7</td>
<td>Arsenic</td>
<td>&lt; 0.001mg/l</td>
<td>0.01mg/l</td>
</tr>
<tr>
<td>8</td>
<td>Total cyanogen</td>
<td>Not detected</td>
<td>Not detected</td>
</tr>
<tr>
<td>9</td>
<td>PCB</td>
<td>Not detected</td>
<td>Not detected</td>
</tr>
<tr>
<td>10</td>
<td>Trichloroethylene</td>
<td>&lt; 0.03 mg/l</td>
<td>0.03mg/l</td>
</tr>
<tr>
<td>11</td>
<td>Tetrachloroethylene</td>
<td>&lt; 0.01 mg/l</td>
<td>0.01mg/l</td>
</tr>
<tr>
<td>12</td>
<td>Dichloromethane</td>
<td>&lt; 0.02 mg/l</td>
<td>0.02mg/l</td>
</tr>
<tr>
<td>13</td>
<td>Carbon tetrachloride</td>
<td>&lt; 0.002mg/l</td>
<td>0.002mg/l</td>
</tr>
<tr>
<td>14</td>
<td>1,2 – Dichloroethane</td>
<td>&lt; 0.004 mg/l</td>
<td>0.004mg/l</td>
</tr>
<tr>
<td>15</td>
<td>1,1 – Dichloroethane</td>
<td>&lt; 0.02mg/l</td>
<td>0.1mg/l</td>
</tr>
<tr>
<td>16</td>
<td>Cis1,2 – Dichloroethylene</td>
<td>&lt; 0.04 mg/l</td>
<td>0.04mg/l</td>
</tr>
<tr>
<td>17</td>
<td>1,1,1 – Trichloroethane</td>
<td>&lt; 0.3 mg/l</td>
<td>1mg/l</td>
</tr>
<tr>
<td>18</td>
<td>1,1,2 – Trichloroethane</td>
<td>&lt; 0.006 mg/l</td>
<td>0.006mg/l</td>
</tr>
<tr>
<td>19</td>
<td>1,3 – Dichloropropene</td>
<td>&lt; 0.002 mg/l</td>
<td>0.002mg/l</td>
</tr>
<tr>
<td>20</td>
<td>Thiuram</td>
<td>&lt; 0.006 mg/l</td>
<td>0.006mg/l</td>
</tr>
<tr>
<td>21</td>
<td>Simazine</td>
<td>&lt; 0.003 mg/l</td>
<td>0.003mg/l</td>
</tr>
<tr>
<td>22</td>
<td>Thiobencarb</td>
<td>&lt; 0.02 mg/l</td>
<td>0.02mg/l</td>
</tr>
<tr>
<td>23</td>
<td>Benzene</td>
<td>&lt; 0.01 mg/l</td>
<td>0.01mg/l</td>
</tr>
<tr>
<td>24</td>
<td>Selenium</td>
<td>&lt; 0.001 mg/l</td>
<td>0.01mg/l</td>
</tr>
<tr>
<td>25</td>
<td>Fluorine</td>
<td>&lt; 0.08 mg/l</td>
<td>0.8mg/l</td>
</tr>
<tr>
<td>26</td>
<td>Boron</td>
<td>&lt; 0.1 mg/l</td>
<td>1mg/l</td>
</tr>
<tr>
<td>27</td>
<td>Carbon</td>
<td>&lt; 0.5 mg/kg</td>
<td>125mg/kg</td>
</tr>
</tbody>
</table>
The chemical composition of Porous Alpha is quite similar to natural sand.

The main components of Porous Alpha:

- SiO$_2$: 62.0%
- CaO: 24.7%
- NaO$_2$: 8.6%
- KO$_2$: 2.0%
- Al$_2$O$_3$: 1.7%
- Fe$_2$O$_3$: 1.0%
- Other minor components: Ti, Cr, Mn, Ni, S, etc.

The main components of the sand in Takuramakan desert in China:

- SiO$_2$: 66.8%
- CaO: 9.0%
- Al$_2$O$_3$: 10.4%
- KO$_2$: 2.2%
- NaO$_2$: 2.1%
- Fe$_2$O$_3$: 1.0%
- MgO: 2.1%
(Ref.) The other specification of Porous Alpha

- Visual appearance: Achroma or light green etc.
- Odor: Odorless
- True density: ca 2.5 g/cm³
- Size density: 0.5〜1.2 g/cm³
- Hydraulic transmissivity: $10^{-3} \sim 10^{-2}$
- Grain size: 50〜2,000 μm
- Grain shape: Abrasive infinite shape
- pH: Max. pH 10.3 or pH 7 (after water washing)
- Solubility: Not identified
- Softening temperature: 720〜730°C (unresolved)
- Volatile: not identified
Introduction of our company and “Porous Alpha”

The application of “Porous Alpha” for agriculture to save the water and to increase the yield

Case studies

Project in Somalia with IOM
The global food production should be significantly increased with limited expandable arable land.

- Required food increase by 2050: 70%
- Expandable arable land for agriculture: 5%

Yield-increase and transformation of arid-zone into agriculture area are part of the keys to achieve increase of food production.

Source: How to Feed the World in 2050, FAO
However, the agriculture is already consuming lots of water, with the future outlook of further limited rainfall.

**Agriculture consumes lots of water**

Utilisation of water all over the world (2005)*²

- Manufacturing: 2% (4%)
- Electricity & Gas: 7% (7%)
- Water supply: 8% (8%)
- Households: 9% (9%)
- Agriculture: 67% (67%)
- Mining Other: 3% (3%)

**The precipitation will be decreased in some area**

- Recent droughts
  - Horn of Africa
  - South Africa
  - Mozambique
  - ...

- In Morocco, UNDP projects that the annual precipitation will decrease by 52% in maximum by 2050*¹

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*² [http://www.climate.org/topics/water.html](http://www.climate.org/topics/water.html)
Porous Alpha realises Climate-Smart Agriculture to contribute increased food demand

In other words…

Agriculture can continue even with less rainfall

Development Impact

Resilient agriculture to climate change

Agriculture can be realized in the less rainfall land (Arid region)

Increased food production

The same amount of water currently consumed can cover x2 land

Porous Alpha realizes 50% water-saving with increased yield
The pores of Porous Alpha retain the water in the soil, which realizes water-saving and yield increase.

- Porous Alpha prevents part of the infiltration of the irrigated water.
- The soil with Porous Alpha has higher humidity.
- The liquid fertilizer (soluble fertiliser) is also retained in the Porous Alpha, which realize yield increase.
The advantage of Porous Alpha to superabsorbent polymer is longer duration and environmental safe

<table>
<thead>
<tr>
<th></th>
<th>Porous Alpha</th>
<th>Superabsorbent polymer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duration</strong></td>
<td>10 years</td>
<td>5 years</td>
</tr>
<tr>
<td><strong>After usage</strong></td>
<td>It is possible to leave them in the soil</td>
<td>It is necessary to remove from the soil, which is difficult to complete, as the product is changed like gel</td>
</tr>
<tr>
<td><strong>Environmental impact</strong></td>
<td>No, even after the period of usage</td>
<td>The product remaining in the soil negatively impact on soil</td>
</tr>
</tbody>
</table>
The application of Porous Alpha is quite simple
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- Introduction of our company and “Porous Alpha”
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In Mauritania, Porous Alpha set as layer in the soil almost doubled the yield and provided higher moisture.

Case in Mauritania

With Porous Alpha

Without Porous Alpha

Nov. 2008 Plantation of tomato
Feb. 2009 Harvesting

Comparison of the yield

Historical trend of soil moisture (15cm below surface)
In Senegal, Porous Alpha realized improved yield for green beans by higher than 70%.

Harvest of green beans in the field of 10m*10m

<table>
<thead>
<tr>
<th>Condition</th>
<th>1\textsuperscript{st} harvest 6/1/2014</th>
<th>2\textsuperscript{nd} harvest 12/1/2014</th>
<th>3\textsuperscript{rd} harvest(*) 21/1/2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Porous Alpha</td>
<td>x 1.88 (In average)</td>
<td>x 1.26</td>
<td>x 2.0</td>
</tr>
<tr>
<td>Without Porous Alpha</td>
<td>73 kg</td>
<td>57 kg</td>
<td>4kg</td>
</tr>
</tbody>
</table>

* 3rd harvest is only calculated for one of the six ridges for each condition.

Comparison: Two months after seeding
With Porous Alpha
Without Porous Alpha
In Morocco, Porous Alpha realized 50% water saving alongside with yield increase by 20+% for tomato.
No negative impact was identified on the size distribution of tomato by using Porous Alpha with less water in Morocco.
For the experimentation for green bean, Porous Alpha realized increased yield by 22% in the condition of 50% reduced irrigation.
No negative impact was identified on the size distribution of green bean by using Porous Alpha with less water in Morocco.

Comparison of the distribution of size of harvested green bean:

- 100% irrigation Without Porous Alpha:
  - Fin: 34.8%
  - Ex. Fin: 37.8%
  - Finne: 19.0%

- 50% irrigation With Porous Alpha:
  - Fin: 32.3%
  - Ex. Fin: 42.4%
  - Finne: 20.6%

Fin, Ex. Fin: 72.6%

Fin, Ex. Fin: 74.7%
No negative impact on the soil was identified by Porous Alpha

The comparison of the maximum content of heavy metals in the soil according to the Directive of EU and the result of the experimentation

<table>
<thead>
<tr>
<th>No.</th>
<th>Items</th>
<th>Maximum values defined in the directive of EU* (mg /kg)</th>
<th>Maximum content in the soil on 9/9/2015</th>
<th>Maximum content in the soil on 2/2/2016</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Without Porous Alpha</td>
<td>With Porous Alpha</td>
</tr>
<tr>
<td>1</td>
<td>Cadmium</td>
<td>3</td>
<td>0,2</td>
<td>0,18</td>
</tr>
<tr>
<td>2</td>
<td>Copper</td>
<td>140</td>
<td>&lt; 10,0</td>
<td>&lt; 10,0</td>
</tr>
<tr>
<td>3</td>
<td>Nickel</td>
<td>75</td>
<td>9,57</td>
<td>9,75</td>
</tr>
<tr>
<td>4</td>
<td>Lead</td>
<td>300</td>
<td>4,7</td>
<td>4,6</td>
</tr>
<tr>
<td>5</td>
<td>Zinc</td>
<td>300</td>
<td>30</td>
<td>27,5</td>
</tr>
<tr>
<td>6</td>
<td>Mercury</td>
<td>1,5</td>
<td>&lt; 0,10</td>
<td>&lt; 0,10</td>
</tr>
<tr>
<td>7</td>
<td>Chrome</td>
<td>-</td>
<td>16,6</td>
<td>16,9</td>
</tr>
</tbody>
</table>

No negative impact on the fruit was identified by Porous Alpha as well

The comparison of the maximum content of heavy metals between the CODEX* and the result of the experimentation

<table>
<thead>
<tr>
<th>Item</th>
<th>Target food</th>
<th>Standard (mg/kg)</th>
<th>Maximum quantity in the expérimentation (Tomato)</th>
<th>Maximum quantity in the expérimentation (Haricot Vert)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Without Porous Alpha</td>
<td>With Porous Alpha</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Fruiting vegetables, other than cucurbits</td>
<td>0,05</td>
<td>&lt; 0,01</td>
<td>&lt; 0,01</td>
</tr>
<tr>
<td></td>
<td>Legume vegetables</td>
<td>0,1</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Plomb</td>
<td>Fruiting vegetables, other than Cucurbits</td>
<td>0,1</td>
<td>0,06</td>
<td>0,04</td>
</tr>
<tr>
<td></td>
<td>Legume vegetables</td>
<td>0,2</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
</tbody>
</table>

*The standard of CODEX is based on CODEX GENERAL STANDARD FOR CONTAMINANTS AND TOXINS IN FOOD AND FEED (CODEX STAN 193-1995)
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› Project in Somalia with IOM
We launched a pilot project with IOM in Somlia

- **Timeline**
  November 2016 – April 2017

- **Objective**
  - Confirm the Porous Alpha’s performance on water-saving and yield increase
  - Confirm the non-existence of negative impact on soil and crop

- **Location:** Bosasso
- **Scale:** 1 acre
- **Crops**
  Spinach, Lettuce, Hot pepper
  Bell pepper

Signature of cooperation agreement between IOM and Tottori Resource Recycling
We provide technical session for the installation of Porous Alpha. IOM follows and evaluates the production.
We conducted a training session in JKUAT with IOM Somalia Mission and Somali Ministry of Agriculture

Lecture session on Porous Alpha the experimentation plan in JKUAT

Installation training in the field of JKUAT

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The expected impact is so significant. We make best effort to complete this project as a team for Somalia.

**As-Is**
- Persistent food insecurity fragile to climate change*
  - Severe climate
  - Scarce water resource
  - Few experience on agriculture

**This project**
- Verification of simple agriculture technology with 50% less water

**If this project succeeds…**
- Increased food security with resilience to climate change*
  - Less water consumption for agriculture
  - Increased and resilient food production to climate change
  - Adoptable by many IDPs

* http://humanitariancompendium.iom.int/somalia/2016
Our contacts

- **Tottori Resource Recycling**
  - 583 Higashisono, Hokuei-cho, Tohaku-gun, Tottori, 689-2202, Japon
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  - FAX. +81 858 49 6288
  - [http://t-rrl.jp](http://t-rrl.jp)

- **Director, International Business**
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  - TEL: +81 90 4720 8004
  - sato@t-rrl.jp

- **Contact person in Morocco**
  - Zakaria Assaid
  - TEL: 06 61 04 02 17
  - zakaria.assaid@t-rrl.jp