



Plant Growths on the Land Restored with Coal Combustion Byproduct Aggregates



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ABSTRACT

Open pit may adversely affect health and safety of human beings if not appropriately managed or restored. Restored land can be used in many different ways depending on the purpose of restoration. Some disturbed land can be restored and used as agricultural lots. In this regard, laboratory research was conducted to assess phyto-viability on the land restored partially with coal combustion byproduct aggregates. Phyto-viability was evaluated in terms of seed germination, plant survival and the extent and rate of growth. Plants tested in the study include beans, pumpkins, papayas, and coco plumoso (palms). Coal combustion byproduct aggregates used were a solidified mixture of fly and bottom ashes with water. A series of experiments were conducted such as, but are not limited to: seed germination and growth assessment with multiple environmental factors, physical interference of aggregates, and effect of hardness. Based on the preliminary results, it can be said that coal combustion byproduct aggregates can be used as an amendment for restoration of disturbed land which will be used for agricultural purposes

OBJECTIVES

- ❖ To investigate the effectiveness of coal combustion byproduct aggregates based refill in the open pits in Santa Isabel, PR.
- ❖ To evaluate the bio-viability on the land after restoration.

STUDY AREA

- ❖ Santa Isabel, Puerto Rico
- ❖ Old sites have been restored approximately 420 acres of the open pits at the site.



MATERIALS

-CAA

- ❖ (51% of SiO₂+ Al₂O₃+ Fe₂O₃, 30% lime, 15% SO₃)
- ❖ Collected from a local coal burning power plant in Guayama, PR
- ❖ Oven dried at 105 °C overnight, crushed with mechanical mixer, and sieved to collect sizes of 2.36"-9.53 mm.
- ❖ It is a solidified mixture of fly and bottom ashes with water.



- ❖ **TOP SOIL AND BOTTOM SOIL**
- ❖ From Coamo Lake, PR (TS) and Guayama Bay (BS)
- ❖ Sieve size = 3/8"



ANALYSIS AND MONITORING

- ✓ pH
- ✓ Turbidity
- ✓ Conductivity
- ✓ Alkalinity
- ✓ Hardness
- ✓ Heights
- ✓ Chlorophyll
- ✓ Heavy metals
- ✓ Nitrate
- ✓ Root Shoot ratio



CONCLUSIONS

- ✓ Exists a notable difference between two waters (tap and rain) hardness concentration; tap water being greater than rain.
- ✓ Germination and growth of plants sprayed with tap water was better.
- ✓ Cd and Pb were not detected in roots, shoot, and leaves.
- ✓ Presence of CAAs in reactors show a better growing and healthiness in the plants.
- ✓ With the presence of vegetation, the concentration of nitrate is lower.

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EXPERIMENTS

-FIRST GERMINATION EXPERIMENT

- Four reactors with a height of 11" and 4" diameter were put in an environmental chamber (Thermo NESLAB RTE-10 Digital One) at 30°C.
- GRO-LUX, Sylvania- 20 W lighting system was schedule to turn on from 1pm to 10pm
- Distribution of the reactors

| REACTORS | GRAVEL (GRAMS) | TOP SOIL (GRAMS) | TYPE OF SEEDS |
|----------|----------------|------------------|---------------|
| 1 | 201 | 1262 | BEANS |
| 2 | 202 | 1264 | BEANS |
| 3 | 200 | 1270 | PUMPKIN |
| 4 | 196 | 1262 | PUMPKIN |

- Water infiltrated from the CAAs was sprayed to the reactor
 - The separate column system was a porcelain funnel of 6" of diameter and 8" long. It has a distribution of 1,080 g of CAAs layered on 835 g of gravel, and 1,500 g of sand covered the CAAs layer.
 - Total of water added to each reactor= 105 mL (according to maximum average precipitation in Santa Isabel)

➢ Time of experiment= 2 weeks

-SECOND GERMINATION EXPERIMENT

- In this part, the parameter monitored is the product of germination rate and shoot root.

➢ Sixteen reactors and four control reactors with 2.5" of diameter and 6" long were used..

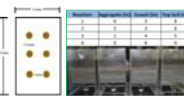
➢ Five seeds were placed to each reactor at a depth of 1.5" below surface.

➢ 40 mL of water was added 3 times per week for 2 weeks.

- Factors evaluated: mixed or layered application of the Top Soil and CAAs, type of seeds (beans or pumpkins), ratio of the TS to the CAAs, type of water (rain or tap water)

-PHYSICAL HINDRANCE

- Four reactors with 8" of width, 13" long from top view.



- Each one has the following distribution of TS and CAAs, and also 6 beans.

| Sample | Hardness (ppm) | pH | Conductivity (µS/cm) | Nitrate (ppm) |
|--------|----------------|-------|----------------------|---------------|
| 1 | 61.5 | 7.938 | 42.4 | 10.1 |
| 2 | 67.2 | 7.871 | 42.7 | 10.7 |

- 140 mL of tap water to each single seed spot with a syringe, on Mondays, Wednesdays, and Fridays.

- For this part, root shoot ratio was the main purpose, then another distribution was prepared.

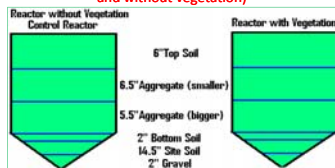
➢ 300 mL of tap water was added 3 times per week.

- After sacrificed beans (for heavy metals analysis), new papayas and pumpkins were included.

-VEGETATION ON WATER QUALITY

- 2 bigger reactors with the same distribution of gravel, site soil, bottom soil, CAAs, and top soil were prepared; one of them with vegetation (coco plumoso-syagrus romanzoffiana)
- 2 L of tap water 3 times per week were added to each reactor.
- Analyzed: turbidity, pH, conductivity, hardness, nitrate, and alkalinity.

Diagram of the distribution in each reactors (with and without vegetation)



RESULTS

For the first germination experiment, beans and pumpkins grew in a good shape.

- ✓ Roots, leaves and stems were analyzed, heavy metals were not detected.

| Samples | Cd (mg/L) | Pb (mg/L) |
|--------------|-----------|-----------|
| Leaves R1+R2 | 0.072 | 0.25 |
| Leaves R3+R4 | 0.068 | 0.258 |
| Stem R1+R2 | 0.007 | 0.059 |
| Stem R3+R4 | 0.003 | 0.069 |
| Roots R1+R2 | 0.1 | 0.326 |
| Roots R3+R4 | 0.042 | 0.062 |

- ✓ Water coming out from the reactor filled up with CAAs had not detected heavy metals.

| Water coming out from reactor filled up with CAAs | |
|---|-----------|
| Pb (mg/L) | Cd (mg/L) |
| 0.028 | 0.022 |

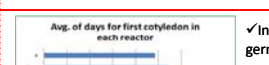


| Reactor | Mixed/Layered | Seed used | Distribution | Water | Top Soil (g) | Aggregate (g) |
|---------|---------------|-----------|--------------------|-------|--------------|---------------|
| R1 | Layered | Beans | 6" Top Soil (200g) | Tap | 835 | 1500 |
| R2 | Mixed | Beans | 6" Top Soil (200g) | Tap | 835 | 1500 |
| R3 | Mixed | Pumpkins | 6" Top Soil (200g) | Tap | 835 | 1500 |
| R4 | Layered | Pumpkins | 6" Top Soil (200g) | Tap | 835 | 1500 |
| R5 | Mixed | Beans | 6" Top Soil (200g) | Tap | 835 | 1500 |
| R6 | Mixed | Beans | 6" Top Soil (200g) | Tap | 835 | 1500 |
| R7 | Mixed | Beans | 6" Top Soil (200g) | Tap | 835 | 1500 |
| R8 | Mixed | Beans | 6" Top Soil (200g) | Tap | 835 | 1500 |
| R9 | Mixed | Beans | 6" Top Soil (200g) | Tap | 835 | 1500 |
| R10 | Mixed | Beans | 6" Top Soil (200g) | Tap | 835 | 1500 |
| R11 | Mixed | Pumpkins | 6" Top Soil (200g) | Tap | 835 | 1500 |
| R12 | Mixed | Pumpkins | 6" Top Soil (200g) | Tap | 835 | 1500 |
| R13 | Mixed | Pumpkins | 6" Top Soil (200g) | Tap | 835 | 1500 |
| R14 | Mixed | Pumpkins | 6" Top Soil (200g) | Tap | 835 | 1500 |
| R15 | Mixed | Pumpkins | 6" Top Soil (200g) | Tap | 835 | 1500 |
| R16 | Mixed | Pumpkins | 6" Top Soil (200g) | Tap | 835 | 1500 |

- ✓ Beans germinated and grew much better than pumpkins.

- ✓ Layered mode showed better results than a mixed mode.

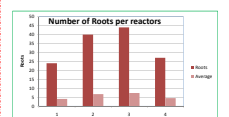
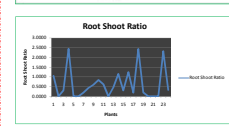
- ✓ Better results were obtained when their seeds were planted into the system that had more top soil than the CAAs.



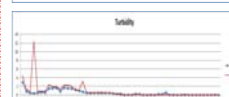
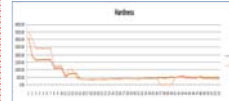
- ✓ In reactors 3 and 4, germination was quicker.

- ✓ In reactors 3 and 4 the number of roots were higher. (The ones with CAAs)

- ✓ Example of roots taken from phaseolus vulgaris plant



The graphs shows the measurements made during vegetation on water quality experiment..



Pictures of reactors (with and without vegetation)

