# Biochar
# – for the safe and long-term sequestration of $CO_2$ carbon

Presentation to the

CRSES Forum on

Carbon Capture and Storage [CCS]

By

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# Critical comments on Carbon Capture and Storage [CCS]

1. Most of the proposed methods of carbon capture and storage [CCS] aim to separate and capture $CO_2$ directly from exhaust emissions before entering the atmosphere. The $CO_2$ is then pumped into and stored in deep subterranean geological formations.
2. These methods represent strategies to reduce emissions rather than remove $CO_2$ from the atmosphere.
3. Where conventional CCS [as in 1.] is used to capture and sequester $CO_2$ from biomass combustion – the complete system, including photosynthesis to provide biomass, becomes a net carbon sink.
4. An even better option is the production and sequestration of biochar, for example, in the soil

$CO_2$ → photosynthesis → biomass → pyrolysis → biochar → soil

A safe and effective method for carbon capture and storage

# What is Biochar?

- *"Biochar is a fine-grained charcoal high in organic carbon and largely resistant to decomposition.*
- *It is produced from pyrolysis of plant and waste feedstocks.*
- *As a soil amendment biochar creates a recalcitrant soil carbon pool that is carbon-negative, serving as a net withdrawal of atmospheric carbon dioxide stored in highly recalcitrant soil carbon stocks.*
- *The enhanced nutrient capacity of biochar-amended soil not only reduces the total fertilizer requirements, but also the climate and environmental impact of croplands."*

*[International Biochar Initiative Scientific Advisory Committee]*

# The production of biochar: the process of pyrolysis – combustion, ideally in the absence of oxygen

- Efficient pyrolysis converts 50% of biomass to char
- 40% is converted to bio-oil and bio-gas :– feedstocks for energy to electricity
- 10% is released as $CO_2$
- At 62% efficient energy production:
- ➢ Pyrolysis of 1 Gt of biomass carbon would provide energy equivalent of about 0.3 Gt fossil carbon, which
- ➢ Could be used to <u>offset</u> that amount of fossil carbon, while
- ➢ <u>Sequestering</u> 0.5 Gt as biochar

# Important factors to assess the potential of biochar

- What is the longevity of the char in the soil?
  - Will it resist oxidation to $CO_2$?
  - Will it resist reduction to $CH_4$?
- What is the avoided rate of greenhouse gas emissions?
- How much biochar could be added to the soil?
- How much biochar could be produced by economically and environmentally acceptable means?
- It is a known fact that biochar worked into the soil dramatically increases the productivity of the soil.
  - How to optimize this effect?
  - If done on a mega-scale, what will the potential increase in global biomass and food crop production be?
  - To what extent will increased photosynthesis result in escalating $CO_2$ capture from the atmosphere?

# The global situation – a big picture

- Current atmospheric increase of carbon: 4.0 Gt/y ±

[G = Giga = 1 billion = $10^9$]

- Of which 7.1 Gt/y from fossil fuel combustion and cement manufacturing
- Removed from the atmosphere:

| | |
|---|---|
| Oceans | 2.2 Gt/y |
| Terrestrial processes | 0.9 Gt/y |
| TOTAL | 3.1 Gt/y |
| REMAINING | 4.0 Gt/y |

- The uptake by terrestrial processes can be increased significantly by managing the 60.6 Gt/y of biomass carbon fixed by photosynthesis [net primary productivity] of which 59.0 Gt/y is ultimately decomposed and 1.6 Gt/y is combusted

# So, what if……

- Of the 60.6 Gt/y that is fixed in usable form, 10% or 6.1 Gt/y could become available for pyrolysis [with additional biomass crops planted for the purpose]
- Pyrolysis would offset 1.8 Gt/y of fossil carbon and sequester 3.0 Gt/y as biochar
- Combined, enough to halt the increase and actually decrease the level of atmospheric carbon by 0.7 Gt/y.
- Even at half this level [i.e. 5% of annually fixed biomass] pyrolysis would be sufficient to decrease the global carbon cycle imbalance by 2.4 Gt/y.
- In combination with other sequestration options, the minimum goal of carbon neutrality could be achieved.

# The situation in South Africa

- The purpose of this presentation is not to question the technological merits of conventional CCS, but rather to highlight the fact that there are other possibilities.
- If conventional CCS does not work as hoped, what is PLAN B?
- The time to start with PLAN B is NOW!
- Sequestering $CO_2$ as biochar into the soil should be considered as PLAN B.
- If PLAN A, i.e. conventional CCS, is allocated serious funding to develop, PLAN B should also warrant some funding.
- PLAN B will also have the benefit of improving agricultural productivity and on a large scale.
- Unproductive and marginal land could be brought into full production.
- Water utilization could be optimized.
- Long-term soil health and fertility could be achieved

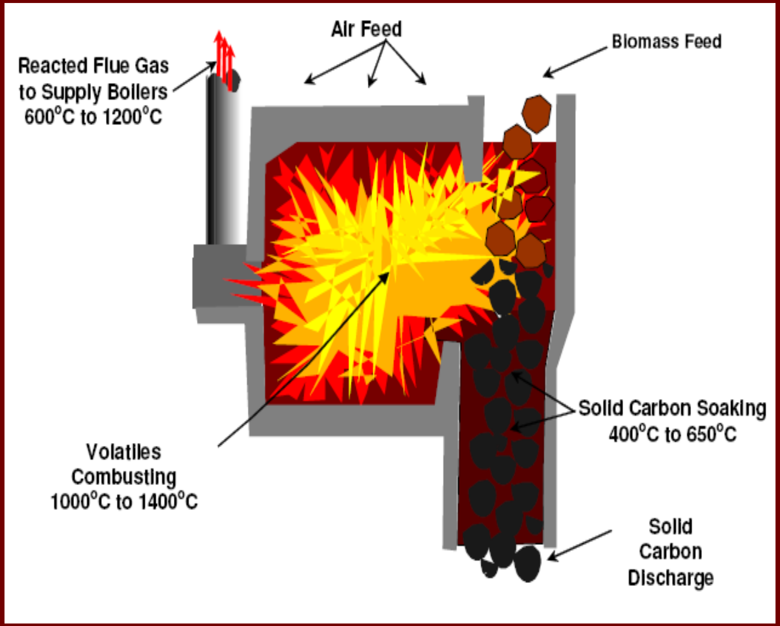
# PLAN B for $CO_2$ sequestration in South Africa [and the planet]

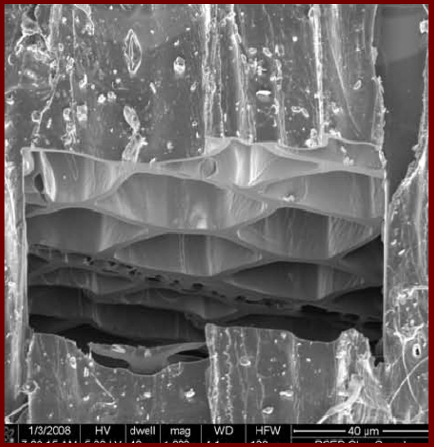
| Impact of biochar sequestration into the soil on a mega scale – a South African scenario | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
| Land | 1 000 | ha '000 | 1 000 | 2 000 | 3 000 | 4 000 | 5 000 |
| Biomass | 50 t/ha | t '000 | 50 000 | 100 000 | 150 000 | 200 000 | 250 000 |
| Biochar | 30% | t '000 | 15 000 | 30 000 | 45 000 | 60 000 | 75 000 |
| Carbon | 80% | t '000 | 12 000 | 24 000 | 36 000 | 48 000 | 60 000 |
| $CO_2$ sequestered | 3.6 | t '000 | 43 200 | 86 400 | 129 600 | 172 800 | 216 000 |
| Electricity output capacity | 21 | MW | 7 143 | 14 286 | 21 429 | 28 571 | 35 714 |
| $CO_2$ emitted during pyrolysis | 12% | t '000 | 6 000 | 12 000 | 18 000 | 24 000 | 30 000 |
| Net $CO_2$ sequestered | | t '000 | 37 200 | 74 400 | 111 600 | 148 800 | 186 000 |
| Trading value@€5/t $CO_2$ | | € | $186x10^6$ | $372x10^6$ | $558x10^6$ | $744x10^6$ | $930x10^6$ |
| Biomass for sequestering $CO_2$ during pyrolysis [NPP] | 1.46 | t '000 | 4 110 | 8 219 | 12 329 | 16 438 | 20 548 |
| Additional hectares needed towards carbon neutral | 50 t/ha | ha '000 | 82 | 164 | 247 | 329 | 411 |

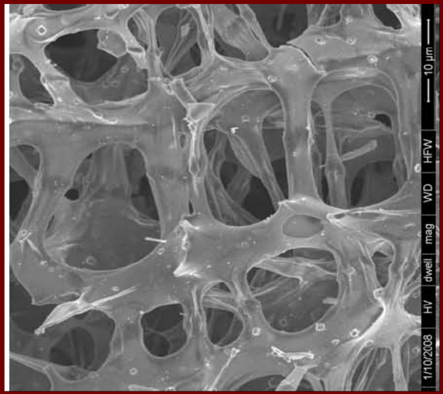
# PLAN B for $CO_2$ sequestration in South Africa – carbon trading potential by avoiding coal

| | | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|---|
| Biomass | Mt | 50 | 100 | 150 | 200 | 250 |
| Electricity | MW | 7 143 | 14 286 | 21 429 | 28 571 | 35 714 |
| Electricity | $MWh.10^6$ | 60 | 120 | 180 | 240 | 300 |
| | $kWh.10^9$ | 60 | 120 | 180 | 240 | 300 |
| Energy [1 GJ=0.278MWh] | $MJ.10^9$ | 216 | 432 | 648 | 863 | 1 070 |
| Coal needed [@1kWh per 30 MJ] | $kg.10^9$ | 7.2 | 14.4 | 21.6 | 28.8 | 35.7 |
| $CO_2$ emitted by coal [@1kWh»1kg$CO_2$] | $kg.10^9$ | 60 | 120 | 180 | 240 | 300 |
| | $t.10^6$ | 60 | 120 | 180 | 240 | 300 |
| Carbon trading potential@€5 per t $CO_2$ emitted by coal | $€.10^6$ | 300 | 600 | 900 | 1 200 | 1 500 |

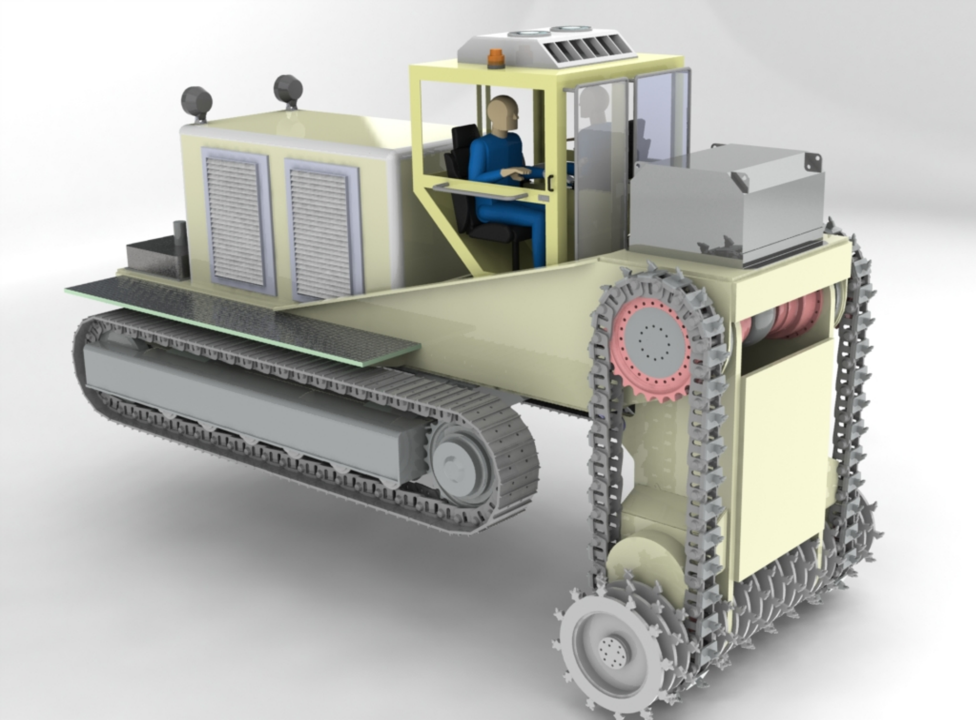
# Biochar: from biomass to recalcitrant carbon



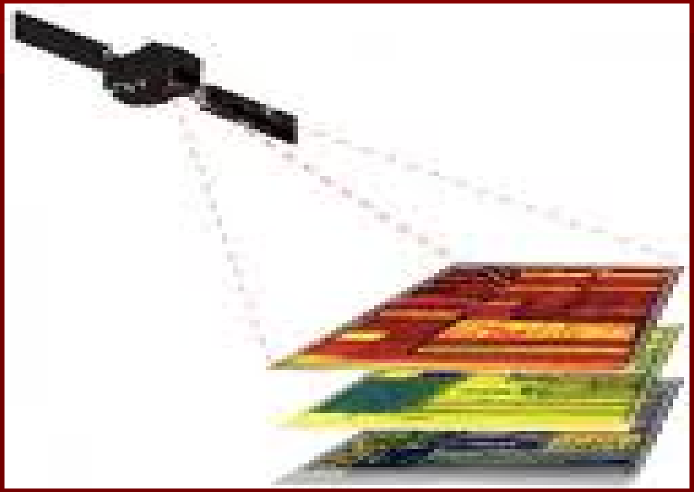



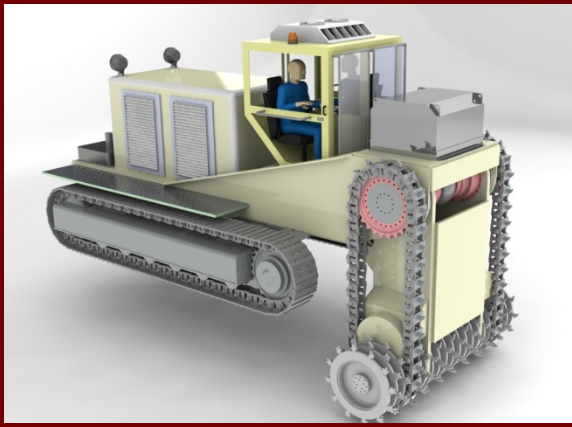



# The DT Mac-4 Machine – deep-till biochar into the soil

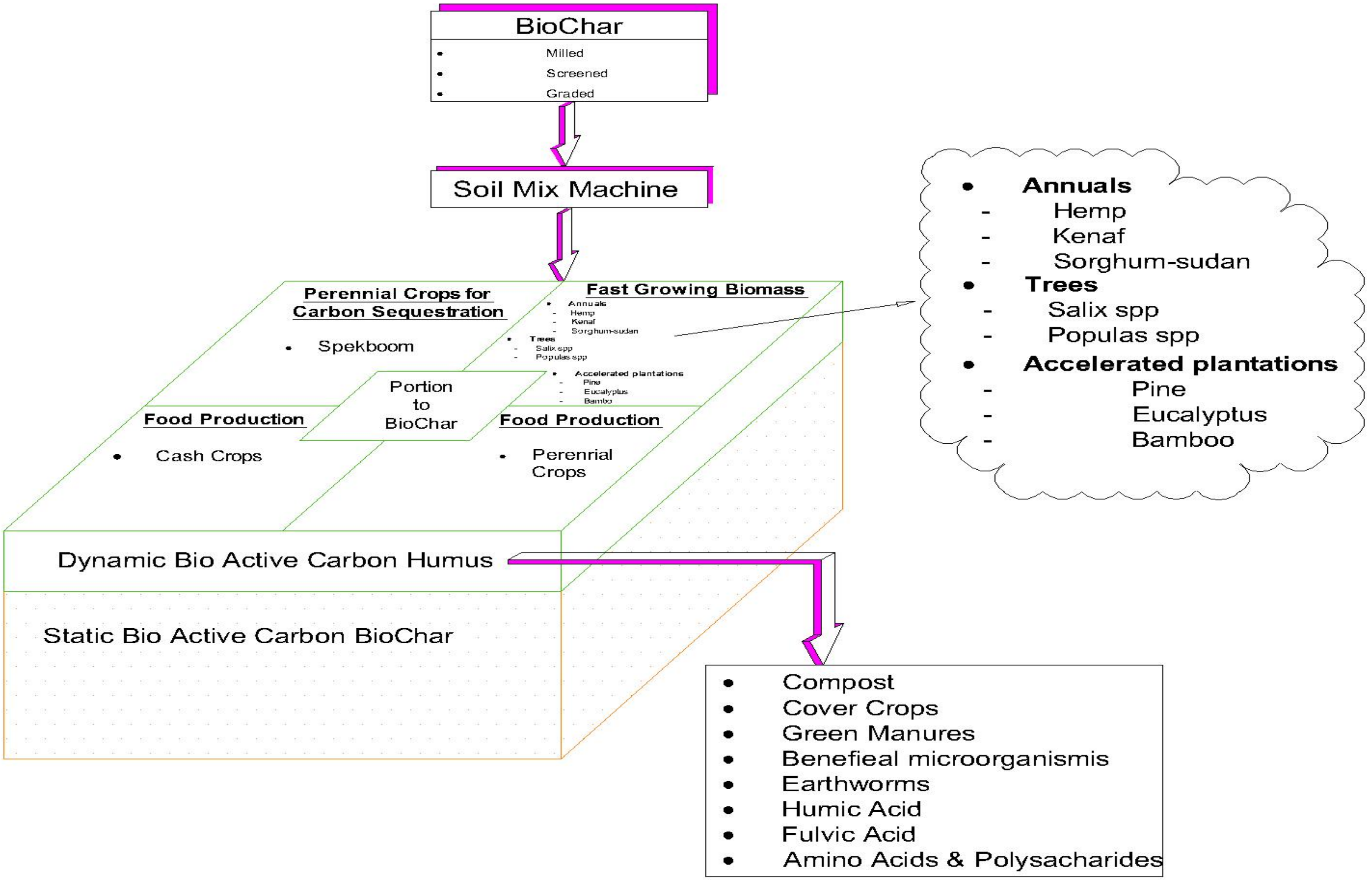


# The technology for PLAN B exists – images from Precision Farming

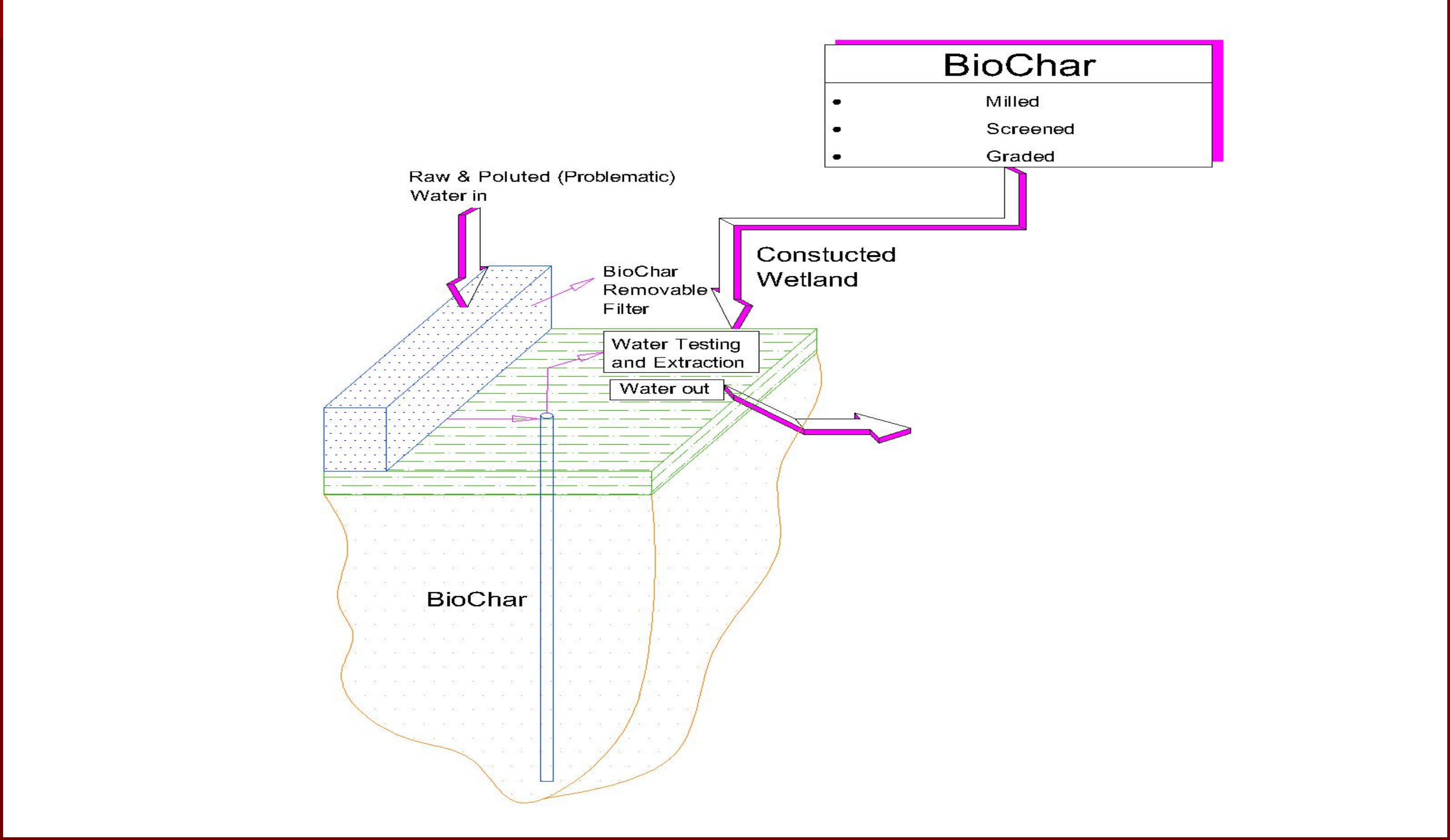




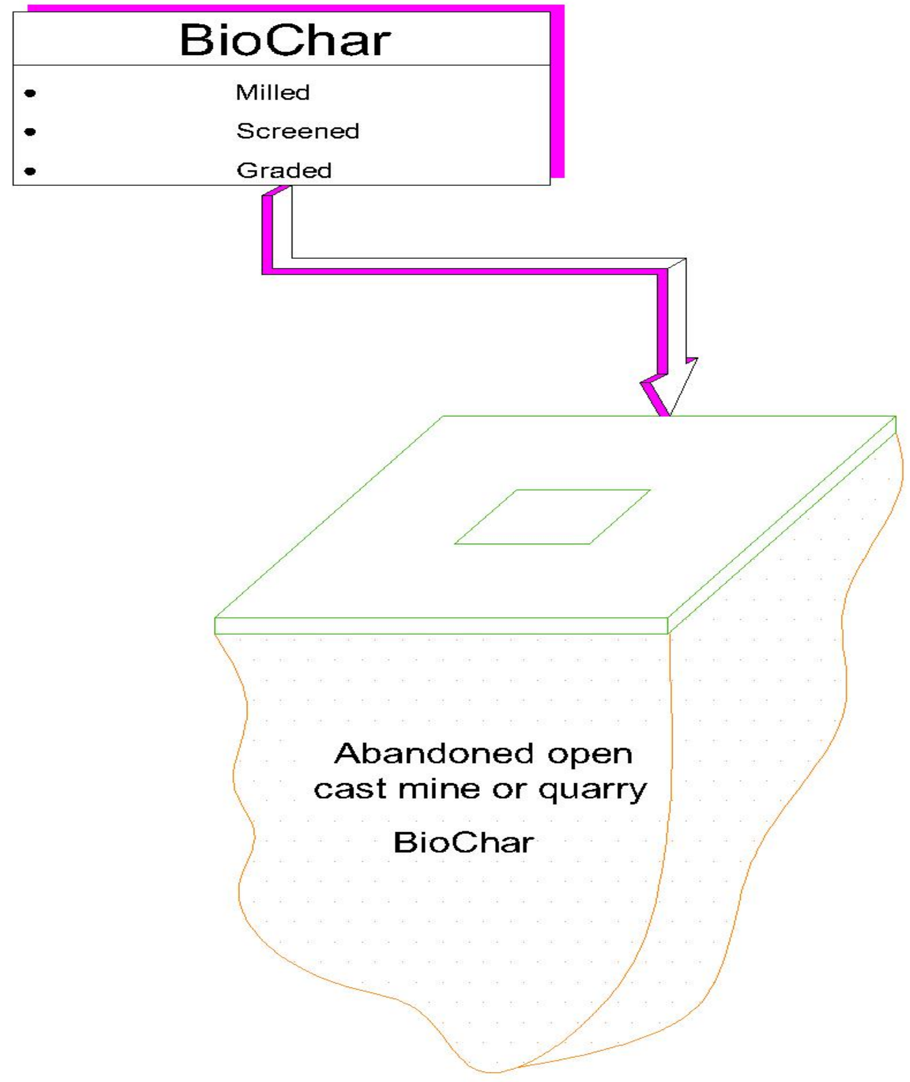
# Biochar deep-tilled into the soil: enhanced soil health and fertility



# Biochar in water purification including constructed wetlands



# Biochar stored in holes in the soil – farming on top



# Conclusion

1. Biochar production and utilization systems is carbon-negative: it removes carbon dioxide from the atmosphere and stores it in stable soil carbon “sinks”.
2. Biochar and bio-energy co-production from biomass can help combat climate change by a number of pathways, including:
   - Direct sequestration of biochar in stable soil carbon pools
   - Displacement of carbon positive fossil fuel energy
   - Increase in global Net Primary Production [NPP] from increased soil fertility
   - Reduction in nitrous oxide emissions
3. The scale of CCS using biochar into the soil is within reach.
4. The global CCS community should joint forces to achieve a goal of carbon negative for the planet.
5. Do not ignore PLAN B!!

SUDOR

CARBON

SCIENCES

$1s^2 2s^2 2p^2$ = LIFE

Thanks for your attention and constructive participation, and remember….

…tread lightly…