# Stones versus organics in wicking beds

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## Many requests

I get many requests asking about stones and membranes in wicking beds. There is a fundamental issue here of how wicking beds work so let me try and explain this in more detail by looking a the history of the development of wicking beds.

## Phase 1 wicking beds for water storage

The idea of wicking beds came to me while working in Ethiopia looking for a way of providing subsistence food when the rains failed. The problem was not so much lack of rain but erratic rainfall. If there was a break in the rains when the seeds heads were supposed to be filling there would be no food. I needed a seriously cheap way of storing water which could be used by people with an income of less than a dollar a day.

The idea of just digging a hole, putting in some form of water container and putting the soil back was both cheap and highly effective. I have seen all sorts of ingenious implementations of this simple idea, from old car tires with a plastic layer, old bath tubs, drums etc. as well as the normal plastic liner. Ok wicking beds have developed a long way from this simple concept but this crude system is still simple, cheap and highly effective.

## How it works

It is worth looking at how this works. Normally soil will hold water by surface tension, if the amount of water exceeds the amount of water that can be held by surface tension it simply drains away. This amount of water is referred to as the field capacity; - the amount of water which the soil can hold without draining.

Plants will extract water from the soil until holds of the soil on the water is so strong that the plant can no longer extract any more water. This is referred to as the wilt point. The available water is the difference between the field and wilt points, typically about 10% of the soil volume (e.g. not very much).

With the water reservoir; - liner, bucket, bath or whatever, the water cannot drain away so the soil becomes saturated holding much more water than at field capacity, often giving two to three times the available water.

## Comparison with conventional wicking beds

Wicking is a natural process which has been used for many years. For example the traditional flower pot standing in a saucer of water uses the wicking principle. The principle of wicking has been used commercially for small applications like planer pots in many ways. Typically these systems use two chambers, one for water and one for the soil with some connection between the two such as literally a wick. These two chambers are typically made from rigid plastics mouldings which limit the size of the wicking bed and are quite expensive.

My original idea only uses one chamber and relies on the difference between saturated soil and soil at field capacity. This single chamber system has the big advantage of being cheap and practical for large areas.

Many people have seen my very simple single chamber system and tried to convert it back to the much more complex two chamber system by filling the bottom half with stones which are then covered with a geotextile fabric.

After a time the soil will still get through the geotextile fabric to fill all the holes between the stones which then turns into a form of concrete. The only advantage I can see for this system is that you will get much slimmer from the large amount of energy used to dig out this concrete.

My original thinking was purely on how to store water cheaply. This is what I call phase 1 of the wicking bed story. However it was pretty obvious to me that the soils in Ethiopia were old and worn out with very little nutrients. I could see that nutrient could be added by collecting the weeds which were happily growing on even the most impoverished soils and putting in the bottom of the beds. These would slowly rot down to give a compost tea which would wick up to the root zone providing both water and nutrients to the plants.

These weeds gave a much more effective wicking action than just soil, after all plants have developed to exploit the wicking action. They also give a much bigger free volume so can store much more water.

## Phase 2 Wicking beds as a biological system

Weeds are tough, that why they are such a nuisance, they have the ability to grow in impoverished soils and still extract nutrients. They also are prolific breeders so there is an abundant supply to provide nutrients for food production in the wicking beds.

But why stop with just harvesting natural weeds? Why not go one step further and deliberately grew so called 'weeds' to provide nutrients? Australian soils are old and often devoid of nutrients, particularly phosphorous, so our natural plants have developed highly efficient mechanisms for extracting nutrients. Some of our Acacias will put down roots many meters deep into the ground, I have been in underground caves and seen Acacia roots over a hundred meters down.

So I thought why not grow these plants deliberately as a way of 'mining' nutrients. They can be regularly pruned to provide nutrients for the food producing wicking beds. But we can go one step further, and use waste and sewage water in a wicking bed to grow these nutrient giving plants.

In most countries sewage is considered a problem in agriculture as it contains harmful pathogens which must be kept separate from food plants. However it is quite safe to grow non-food plants whose pruning can be used to provide nutrients for food production in the wicking beds.

But we can go one step further and deliberately introduce beneficial micro organisms into the beds. When first constructed the organic material is placed in the base of the bed. This will inevitably slowly decompose and dirt will filter through to fill up the voids. We so not want the beds to become solid and neither do we want to destroy the structure of the soil by excessive working.

Adding further organic material at the surface in piles or bins will top the beds up with fresh organic material and worms will naturally take this down deeper into the soil so aerating the soil.

Mycrorrhyzal fungi are another amazing result of nature. Fungi have no means of photosynthesis so they depend on plants to provide a source of energy (sugars). Most fungi obtain their energy from decaying vegetation but mycrorrhyzal fungi strike a special deal with plants (symbiotic relationship).

They will bore into the plants roots and extract the energy giving sugars. In return the fungi provide a special service. The hyphae are much finer than plant roots and as small size is important in the ability to extract moisture they are much better at it than roots e.g. They can extract much more water from dry soil than plants. But also, the tips of the hyphae exude enzymes which are highly effective at breaking down hard substances such as the rocks and stones.

Often soils contain nutrients locked up in rocks are soil particles but the plants simply cannot access these nutrients. Mycrorrhyzal fungi can release these nutrients and make them available to the plants.

Mycrorrhyzal fungi significantly increase plant growth depending on plant type; for example wheat is almost totally dependent on mycrorrhyzal fungi.

However they are easily damaged by excessive working of the soil hence the need to employ worms to do the tillage and which appear to spread the fungi.

So phase 2 is the development of the wicking beds as a microbiological system coupled with wicking beds in low grade land to 'mine' for nutrients.

Phase 3 started on one Saturday morning having a relaxing cup of tea and biscuit and reading a good book in bed, as is my habit. Not so relaxing in fact, a moment which was to change my life.

# Phase 3 wicking beds and climate change

Going back over five years I don't think climate change was a big issue in my life. I had seen Al Gore's film but was far more concerned about immediate environmental issues like the drought which was then getting quite serious in Australia. To be honest I thought a couple of degrees rise in temperature was no big deal so it was all a bit of a storm in a tea cup.

But as I read more about it and gradually realised that the threat was not a small rise in temperature but the amplification of the flood and drought cycle which was a feature of Australian (and many other countries) weather. Yes I should be taken climate change seriously but it seemed there was nothing much I could do about it, there were plenty of experts around so it was a problem for the mythical 'them' to solve. Presumably 'they' were competent and it would all get sorted out in good time.

But on that magical Saturday morning I read that totally arresting phrase that plants absorbed some thirty times all man made emissions. My first reaction was disbelieve, if plants were absorbing so much carbon why weren't we suffering from global freezing as our insulating blanket of carbon dioxide was gobbled up.

Then I connected this with the Keeling curves which showed that in the Northern summers the atmospheric carbon levels actually drop only to rise again to a higher level in the next year. The only way that this can happen is if there is massive absorption of carbon by vegetation in the Northern hemisphere. For the carbon level to drop this has to exceed all global man made emissions and all the emissions from decaying vegetation (which is highest in summers) and without any help from the Southern hemisphere which in winter.

The only way for atmospheric carbon to drop is if vegetation is absorbing massive amounts of carbon.

Yes it was pretty clear that the absorption of carbon by plants was massive, overriding everything else. The other dramatic issue which was self-evident was the massive return of carbon by the breakdown of this organic material. This occurs by a combination of factors, burning of organic material and UV degradation are significant but the bacteria breaking down organic material is simply huge.

Bacteria are just like miniature cows, they survive by breathing in air, feeding on organic waste and emitting just huge quantities of carbon dioxide. Forget about all those power stations, cars and aeroplanes belching out carbon dioxide, they are just overwhelmed by the activities of bacteria munching away on an unbelievable scale.

Now not only was this understanding pretty startling for me but what was really double jaw dropping was the realisation that I was sitting, without realising it, on the solution to what our the then then Prime Minister referred to as the greatest moral challenge of our time. The simple solution is to reduce the amount of carbon dioxide re-entering the atmosphere by slowing the rate at which bacteria decompose organic waste.

All the coal and oil were formed by a combination of conditions which prevented bacteria from decomposing organic waste, immersing in water is critical, these conditions still exist naturally in

some places where vegetation is immersed in bogs which are slowly turning in peat and will eventually end up as coal. These condition can be precisely replicated in a wicking bed.

In a standard wicking bed the reservoir is typically cycled from wet to dry and back to wet again. The bacterial activity is partially replaced by fungal decay which emits much less carbon dioxide.

Is this the best way to operate a wicking bed for carbon sequestration, how best to top up a wicking bed with fresh organic waste, how much carbon can be actually absorbed? These were clearly critical questions.

I once made the mistake of using the colloquium ' so out came the slide rule at a lecture to University students only to find out that no one had the faintest idea what a slide rule was. A bit sad as the realisation that you could multiply and divide by the simply adding or subtracting length with a stick with a logarithmic scale seemed to me one of the great moments in science. So I better say out came the calculator to see just how much carbon we could absorb on a global scale.

Simply amazing, allowing for a depth of bed of 300mm (0.3 metres) over half the area say 5,000 square metres per hectare 1,500 cubic metre per hectare. Allow a factor for air space 60% solid content is generous gives 900 cubic metres per hectare, convert to tonnes by assuming a density of 0.8 gives 720 tonnes. All pretty easy and reliable so far, now estimate how much carbon dioxide is going to be retained, that's a bit trickier so let see what 20% conversion gives 144 tonnes of carbon dioxide absorbed in one hectare. (This figure of 20% came from measuring reduction in volume of decaying material). Ok that still is a huge figure lets downgrade this with a safety factor say of say 4 that still gives 36 tonnes per hectare.

Compared with the 1 or two tonnes usually quoted for carbon farming say 1 to 2 tonnes per hectare this is still huge. At this rate we could readily absorb all of the ten billion tonnes of carbon we are emitting annually only using a small proportion of our agricultural land. I estimated that if China were just to convert one third of its irrigated farm land that the entire emissions of the world's largest emitter could be absorbed bringing China into carbon balance.

Developed countries with limited farm land could achieve carbon balance by trading carbon with developing nations who have large agricultural land areas.

Just contrast this scenario of achieving carbon balance with the current state of negations on climate change where they are talking about aiming for minor reductions in emission, failing to reach any agreement while emission continue to rise (5% increase last year).

Here we are talking about a a carbon neutral world achieved by changing our agricultural system at minor cost.

With this idea in my head it is no wonder my life has been so changed.

This almost sounds too good to be true there has got to be a snag; there usually is when things seem just too good.

May be the snag is the supply of organic waste. May be it is true that we could absorb into the soil all the carbon that needed to bring the world into carbon balance. Is the snag that we still have to deliver large quantities of organic waste to the farms? Will there be enough?

I have found a few interesting statistics. The actual amount of food produced is typically only 20 to 30% of total plant volume. For every tonnes of food produced we generate some 5 tonnes of organic waste. Promising but not enough! OK what about deliberately growing waste on poor ground, yes that may double the supply but still not enough to ward of climate change.

We need to look off farm. Forests are a major fire danger in Australia and many other parts of the world. Often these are managed by controlled burning. Now think about this for a moment. We are deliberately starting small fires just to avoid a major bush fire. Yes that may make some sense but we are still putting significant amounts of carbon into the atmosphere.

This could easily be avoided by going into forest with mulchers and producing tonnes of wood chips. Now that makes sense.

But we are still missing a major source of organic waste;- this may not be a big deal in a low population country but right now I am writing this in China (the world's largest polluter) in one of the minor cities of a mere 5 million people. Now look at all the major cities along the Yangtze and Yellow rivers, cities like Chongqing with a population of some 32 million. How many tonnes of organic waste do they produce? Well the web indicates millions of tonnes per day.

So where does that leave us; - sitting on the potential solution to Kevin Rudd's 'greatest moral challenge'.

So what am I doing about it, I am here in China working with the major scientific organisation in this field trying to get scientific evidence to present to our politician and powers that be.

What can you do about it, well if you are a home gardener and don't want to be involved with all this global warming hype you can at least forget about using stones and start setting up biological beds. It may not seem much but every home gardener is making a contribution to spreading the word.

Now the question that you asked was 'What size stones to use in a wicking bed?' Well you must admit that this must be the longest answer to a short question. I could have said don't use stones just use organic waste. I hope the long answer pays off.

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