FREQUENTLY ASKED QUESTIONS (IN PLAIN ENGLISH)

Relating to

HOW POT PLANTS REALLY CAN HELP CLEAN INDOOR AIR

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Question 1. **What is urban air pollution (UAP) made of?**

Answer.

About 90% of UAP comes from fossil fuel emissions - a mixture of waste materials of combustion:

a) Carbon dioxide (CO2)
b) Carbon monoxide (CO);
c) Nitrogen oxides (NO_x) eg nitrogen dioxide (NO_2);
d) Sulfur oxides (SOx), eg sulfur dioxide (SO_2);
e) Ozone (O_3)
f) Particulate Matter (ultra-fine black 'dust') (PM10/2.5/1.0);
g) Organic air toxics, ie volatile organic compounds -VOCs. These are left-over remnants of burnt fuel – the commonest BIG 4 are – 'BTEX': Benzene, Toluene, Ethylbenzene; Xylene; plus Polyaromatic Hydrocarbons [PAHs])

Indoor air pollution is almost always higher than outdoors, even in the CBD, because, as the polluted air enters it mixes with more pollutants that are emitted from indoor sources - more CO_2 from us all breathing out, (and from any flueless gas appliances); and more VOCs, outgassing from plastic/synthetic (ie petroleum-based) furniture, fabrics, fittings, paints, varnishes, solvents, etc.

Question 2. **How can pot-plants clean the air?**

Answer.

As to the manner born – it's part of what plants and their root-zones do:

a) **Plant leaves can absorb all of the gaseous UAP pollutants listed above, under light conditions, when their pores (stomates) are open for photosynthesis.**

   The pollutants are broken down and mostly utilised as more nutrients; ie the pollutant molecules are destroyed; they do not accumulate in the leaves.

b) **CO2 is not an air pollutant from a plant's point of view, but one of the two vital ingredients of photosynthesis, on which almost all life on earth depends** (the other ingredient is H2O).

c) **Ozone is probably the most difficult air pollutant for the plant to deal with** – it damages the chlorophyll/photosynthetic apparatus and hence the leaves; but nevertheless, it's broken down.

d) **Potting mix root-zone microorganisms of various types also take up and utilise all these UAP contaminants.**

e) **Particulate matter collects on surfaces of shoots and potting mix, reducing aerial concentrations.**

The particulates are attracted by slight electrical charges on the leaves, and may also get stuck on waxy or hairy surfaces. As dead leaves drop (but prune them to avoid moulds!), the material is broken down in the potting mix with the aid of root-zone microorganisms. Any inorganic materials (metals/silica) also become part of the potting mix and, again with help of the microbes, are broken down, and elements like calcium, manganese, potassium etc. can be taken up by the plant as nutrients again.

Question 3. **What are Volatile Organic Compounds?**

Answer.

They are carbon-containing compounds that readily evaporate at room temperatures (and are likely to be a bit smelly).

a) ***Organic Compounds* are substances that are, or once were, part of a living organism (alive, dead, or fossilised - eg petroleum, coal, peat, natural gas).**

Molecules of these substances have a 'backbone' framework of *carbon* atoms (so 'organic chemistry' is also called 'carbon chemistry'*).* The carbon is brought into living ecosystems as CO_2 from the air, which is incorporated into sugars by plant photosynthesis (and from there all other organic compounds). We animals eat plants and/or other plant-eating animals – so the carbon cycles round and round. Organic compounds found in all *living organisms* (carbohydrates, fats/oils, proteins, vitamins, DNA, pigments like haemoglobin, chlorophyll, carotene, etc) are *basically non-toxic* (apart from special exceptions, eg curare, belladonna, digitalis; or insect, spider & snake venoms, etc). In contrast, organic compounds found in *fossilised material* (petroleum etc), have been transformed in the putrification and geologically compressive processes, and are *all toxic*.

b) ***Volatile Organic Compounds* – VOCs are defined by the US Geological Survey (USGS) as "compounds that have a 'high vapour pressure' [ie evaporate more or less rapidly at air temperatures] and low water solubility".**

If you can smell something it is a volatile, and its air-borne molecules have reached your nose. Some types you can't smell, either because they don't smell much anyway, or because they're in concentrations too low for us to detect (though a dog might well pick up the 'scent'). Plants and animals produce what can be thought of as 'fresh' or 'living' VOCs – from sweat/hair of animals; lovely aromas of plants, etc –they are all *basically non-toxic*. But, the USGS goes on: "Many VOCs are human-made chemicals [from fossil fuels] that are used and produced in the manufacture of paints, pharmaceuticals, and refrigerants. VOCs typically are industrial solvents… and … components of petroleum fuels, hydraulic fluids, paint thinners, and dry cleaning agents." They are also components in 'plastic' or 'synthetic' furnishings and building materials (and computers etc). These fossil-derived types are *all toxic* ,and some are carcinogenic (eg benzene, xylene, PAHs, etc). Over 900 VOCs have been identified by the US EPA in indoor air – fortunately not all at once. Cocktails of 15 – 20 VOCs are commonly found in indoor air, the composition of the mixture depending on the emissions in the city, and the fittings in the particular building.

Question 4. **<u>How does a plant actually get rid of the VOC's? Do they suck VOCs in through the leaves and transport them through the stem to the roots where the bacteria can eat them?</u>**

Answer.

No, that's not what happens. It works like this:

a) **The most rapid direct removal agents of VOCs are indeed normal bacteria of the potting mix of indoor plants, but the air diffuses directly into the pot-mix, where bacteria absorb the VOCs, and use them as food, ie digest them.**

The digested products are used either in bacterial respiration, giving off CO2 and H2O as end products (the same as we breathe out); or, to build other cell materials, eg enzymes, DNA etc. The VOCs are thus destroyed – they no longer exist (any more than the pie-and-peas we eat turn up in our blood stream – it's their digestion products – different compounds - that get conveyed via the blood to our tissues). As the VOCs diffuses into the pot-mix and are destroyed, more of their molecules diffuse in from the surrounding air – in effect the removal provides a gentle but significant 'pull' towards the VOC 'sink' (or 'black hole').

b) **Plant leaves do take up some VOCs, during daylight hours (when their pores/ stomates are open), but much more slowly than by the bacterial community, so the plant's direct VOC removal is pretty negligible.**

However, the plant is part of the process by selecting and nourishing its root-zone microbial community – so it is the mutualistic/symbiotic pot-plant microcosm that achieves VOC removal.

Question 5. **<u>What happens to the VOCs once the plant has gobbled them up. Do they disappear completely?</u>**

Answer.

As outlined above, it is mainly the potting mix bacteria that actually gobble up the VOCs – and yes, they disappear completely – they get destroyed!

They get digested, and the digestion products are utilised in bacterial cell processes (just as our pie-and-peas meal helps support our respiration and/or tissue maintenance processes).

Question 6. **<u>How do VOCs get to the potting mix from all corners of the room?</u>**

Answer.

The VOC disappears in the potting mix because the bacteria digest it into other products, and then use those for something else.

This results in what is known in physical chemistry as a ‘diffusion gradient’ into the potting mix. As the VOC is broken down, more molecules of the substance will tend to diffuse ‘down’ a concentration gradient, from every corner of the room, into the pot, which acts as a ‘sink’ or ‘black hole’, of annihilation of that substance.

(This is just another bit of cosmic magic. My other cosmic favourites are: how on earth [or anywhere else] did life begin?’ and - how can an entire Beethoven symphony be captured in glorious sound as grooves on a little silvery disc?).

Question 7. **<u>Do Volatile Organic Compounds float around a whole room or do they congregate in certain areas?</u>**

Answer.

They definitely tend not to congregate – rather, to disperse - read on.

a) **In general - molecules of any gaseous substance eg (CO2, H2O, O2, benzene vapour, whatever) tend to move about randomly,** zotting around, bumping into each other, bouncing off in other directions, hitting the walls, bouncing back, etc.

The net result is that their various individual concentrations all tend to spread out evenly in the air of the whole room (tending towards a final equilibrium, as chemists put it). But - if there is a ‘sink’ for some substance sitting somewhere in the room, as mentioned above, molecules of that substance will tend to diffuse into it, where they disappear, because they are chemically turned into something else. That is, there is a concentration gradient established down towards the sink. The potting mix is such a sink for VOCs – the bacteria eat the molecules as they arrive –those molecules are gone forever, so more follow. (The same sort of diffusion process happens as CO_2 moves into the leaves, under light conditions – the chloroplasts grab the CO_2, weave it together with water molecules into sugar [$C_6H_{12}O_6$], and so more CO_2 molecules continues to diffuse into the leaf ‘sink’.)

b) **If the VOCs are outgassing from furniture, fittings, carpets, desks, paints, varnishes, etc, they will be pretty well distributed around the room in the first place, however, sometimes there is a ‘point source’ of VOCs** – eg an open bottle of kerosene, acetone, some other solvent.

In this case the molecules of the liquid will be vapourising from the mouth of the bottle, and their concentration is higher there than anywhere else in the room. However, if after a few minutes you enter by opening a far door, you will probably be able to smell it –some of the vapour will already have diffused right across the room to meet you. The air-borne molecules will bumble about (see above), tending to equalise concentrations throughout the room. But again, if there is a potted-plant in the room (and preferably several), the potting mix bacteria will have a feast of the VOC, and there will be a diffusion gradient created towards the pot(s).

Question 8. **<u>What benefits do employers or building owners get by having plants in their office?</u>**

Answer.

As I said in a letter to the Editor of the *Australian* newspaper yesterday (but I am not sure they will publish it):

“Indoor plants have a ‘negative cost’ – that is, they more than repay the cost of their installation and maintenance in terms of occupant health and wellbeing.

International research, including our own at UTS, has conclusively demonstrated that indoor plants not only reduce urban indoor air pollution overall; with adequate lighting they also reduce CO_2 levels, which are always significantly higher indoors than outside.

Cleaner air is healthier air, and gives to clearer thinking.

In addition, they have directly measurable benefits for personal wellbeing and productivity.

A recent study from this laboratory found that indoor plant presence resulted in significant reductions among staff surveyed, in feelings of hostility, anger, anxiety, depression and confusion, and increases in feelings of vigour and/or enthusiasm."

A number of overseas studies have also shown that sick leave absences are reduced and productivity, as measured by computer tasks well completed etc. is increased, where indoor plants are present in the workplace.

Question 9. **<u>What does Indoor Environment Quality (IEQ) actually mean?</u>**

Answer.

The term IEQ refers to the entire environment presented by building spaces (particularly in office workplaces).

This includes considerations not only of good indoor air quality (IAQ), but also of many other aspects, including ergonomically appropriate work stations, appropriate lighting, comfortable range of temperature (21-23^{0}C) and humidity (30 – 60%), reasonable noise levels, and aesthetically pleasing or inoffensive surroundings and colour schemes.

Research shows pot-plants contribute positively to every one of these factors of IEQ apart from the ergonomic furniture and lighting; and if the lighting is appropriate to plants it is probably appropriate for staff as well.

Question 10. **<u>How can an 8"/200mm plant do the same work as a 10"/250mm or 12"/300mm plant?</u>**

Answer.

Well, it turns out that, for VOC removal, a 200 mm pot is as effective as a 300 mm one, as we have recently found in tests with 3 plant species.

This has to be because the 200 mm pot has a surplus of bacterial ammunition to do the job fast, so having more capacity cannot bring about an even faster result (like a small boy who can eat an ice-cream at least as fast as his Dad can).

Question 11. **<u>Are employees in older buildings at risk of getting ill if their office has no plants at all?</u>**

Answer.

This could well be so, because older buildings tend to have furniture, fittings etc which have higher concentrations of VOCs in their manufacture than the newest buildings, where efforts are being made to use materials that outgas smaller amounts of VOCs.

However, not all new buildings are being so fitted, so they can have problems too. Also, the BTEX and related pollutants from outdoor UAP also contribute to indoor air pollution, and very few buildings have air conditioning systems that filter our gaseous pollutants in any way (though they do catch particulates). Pot-plants for VOC removal are not redundant in city office blocks.

Question 12. **<u>How many plants are needed to achieve good IEQ?</u>**

Answer.

Perhaps fewer than currently indicated by the GBC (though as many as commensurate with good design would contribute positively to overall IEQ).

The results mentioned in the previous Question, showing that **a 200 mm pot is as good as a 300 mm pot for VOC reduction**, suggests the GBC could be a bit more flexible about how many plants of what size are needed for this purpose (not that a specific purpose is stated in the GBC awards documentation). When the HAL/UTS/Ambius Final Report is available from HAL on this project (projected date, December, 2009) we will submit it to the GBC for their consideration.

However, VOC removal is not the only air quality consideration. With adequate lighting - ie when placed appropriately to their shade tolerance requirements, plants can help reduce CO_2 levels. And **for CO_2 reduction, the larger the foliage area the more effective it will be** (ie, more, larger plants, with best placement).

There are also aesthetic/psychological issues. The scattered literature on this topic suggests that the species used do not matter – just having (any sort of) plants in the immediate surroundings is of direct benefit. The matter of the number/size of plants for psychological benefit has as yet received no research. (Watch this space.)