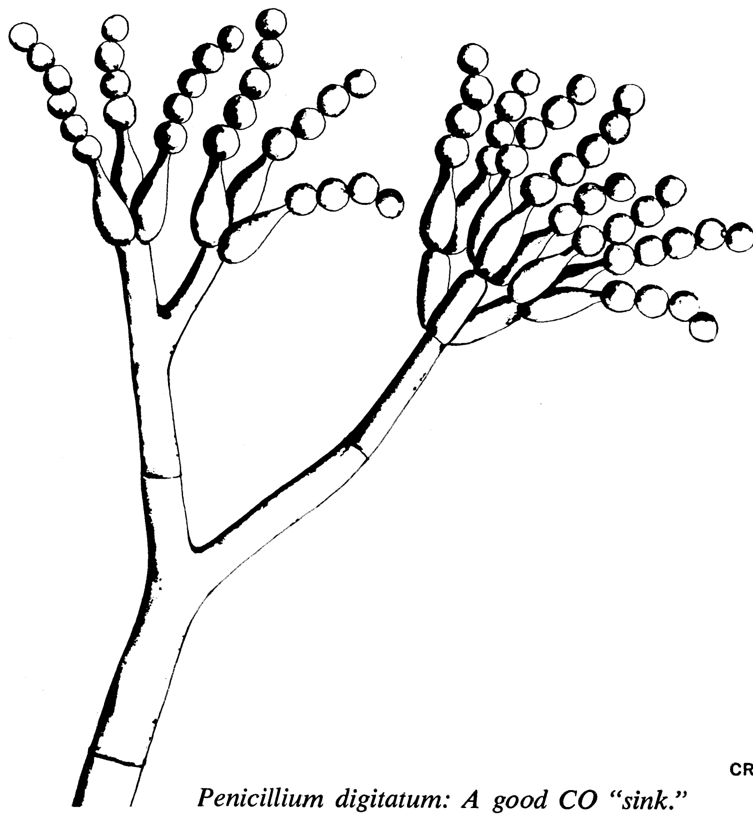
A soil 'sink' for atmospheric CO

Carbon monoxide is not a worldwide pollutant; it appears that soil fungi remove it and convert it to CO_2



CRC

Penicillium digitatum: A good CO "sink."

by Richard H. Gilluly

Figures on the growing quantities of carbon monoxide released into the air by internal-combustion engines have indicated that the levels of the poisonous gas should double in ambient air every four to five years. In fact, measurements have shown no such increase. What happens to all the carbon monoxide has been an intriguing, and important, ecological question.

Now scientists at the Stanford Research Institute have completed work showing that carbon monoxide is apparently being absorbed by aerobic microorganisms in soil that may oxidize CO to carbon dioxide.

The study is not a cause for unrestrained optimism, however, for it also shows that the microorganisms, if exposed long enough to CO, lose this ability. "Constant and prolonged exposure of soil to carbon monoxide reduced the soil's microflora population and also reduced the soil's capacity to deplete carbon monoxide from the atmosphere," says the SRI report's summary.

Also, "ambient air" is a tricky concept. Although measurements of CO at locations remote from dense human habitation show there have been no significant increases, there are daily cycles of CO concentration in urban areas. The levels sometimes get high enough to be dangerous. "During a recent study in Los Angeles," says the SRI report, "the CO level at one station along the Harbor Freeway measured 3 parts per million at 4 a.m., when traffic intensity was lowest, and 15 ppm at 8:30 a.m. during the morning rush hour. . . . During prolonged periods of air stagnation, CO levels in Los Angeles have exceeded 30 ppm for an 8-hour period. In London, CO concentrations at street level on a calm day have reached 360 ppm." Additionally, although worldwide ambient air levels of CO are not yet significantly affected by increasing emissions, nonetheless values over the Pacific Ocean at 50 degrees south latitude were found in one study to be 0.04 ppm, while 90 degrees farther north, at 40 degrees north latitude, values were 0.2 ppm. Researchers point out that although neither figure has any human health implications, the higher figure in the Northern Hemisphere is probably due to pollution.

The fate of CO has perplexed scientists for years. Once it was believed that the oceans might be a sink, but research indicated just the opposite: Net exchange of CO is from oceans to atmosphere. One diatom, *Chaetoceros galvestonensis* was shown to produce CO, and other experiments indicated that a photochemical reaction could produce CO from dissolved organic carbon in sterile ocean water. Other ocean organisms are also able to produce CO, and " . . . The process of death and decay in nature can be suspected of being a prime natural source of CO," says the SRI report. But it adds that these natural sources probably account for only about 5 percent of the total atmospheric CO, with the rest coming from man, about 90 percent of the man-caused CO (at least in the United States) coming from gasoline engines.

But the residence time of CO in the atmosphere is estimated at from 0.1 to 0.3 years. This was circumstantial evidence (along with low measurements at remote locations) that CO sinks exist, even if they are not in the oceans. So the SRI scientists hypothesized the sinks were in the soil and set up experiments to test the hypothesis.

SRI's principal investigators, Robert Inman and Royal Ingersoll, conducted their tests in plastic chambers containing soil and CO-contaminated air. The soil was sterile in some chambers and unsterile in others. In the unsterile chambers, the concentrations of CO in the air dropped from 120 ppm to zero within three hours. In the sterile chambers, levels stayed about the same. Then when unsterile soil was sterilized with salt or antibiotics, its ability to oxidize CO dropped sharply.

Consistent with this, when unsterile soil was added to sterile soil, ability to deplete CO increased steadily. This was probably an indication of proliferating microorganisms. In the unsterile soil, CO depletion was fairly linear, at a rate of about 6 milligrams of CO per hour per square meter of soil surface. Control chambers with neither sterile nor unsterile soil showed no significant change in CO level. Raising CO levels to as high as 1,000 ppm in the unsterile chambers did not significantly change the rate of absorption over chambers with 120 ppm. Soils with low pH and high organic content generally were the best CO sinks.

The next step was to determine which organisms in the soil were absorbing the CO. Previous studies had shown that there was virtually no CO uptake by higher plants, so microorganisms were the focus. Soil organisms were cultured, then the isolated microorganisms were separately placed in flasks in culture media and exposed to 100 ppm CO. Among the bacteria and fungi thus isolated, 14 strains of fungi (belonging to several species) were found to be able to take up CO at rates ranging from 0.959 micrograms per hour per square meter of surface exposure in the lowest, up to 2.373 in the highest. The latter absorption rate was by a strain of *Penicillium digitatum*. The researchers caution that the figures should not be taken as absolute, because of difficulties in standardization. Nor should it be assumed that because none of the bacteria tested seemed to have ability to take up CO, that they might not be able to do so under different circumstances.

There are some other caveats implicit in the study. First, prolonged exposure to the levels of CO sometimes found in urban air—50 ppm—greatly reduced the ability of soil to take up CO after about 35 to 40 days' exposure. Next, "The CO uptake rate of soil was found to be very sensitive to temperature changes," says the SRI report. The CO uptake process works best at about 85 degrees F.; at 50 degrees F. there is almost no uptake. Thus soil in urban areas heavily polluted by CO might lose its ability to absorb CO, and in northern cities would have this ability only during warm seasons. The researchers also caution that they are not certain that oxidation of CO to CO_2 is the mechanism of depletion by the organisms. They did only one study with carbon-14-labeled CO to determine this. The study indicated this was the mechanism, but a single study may not be conclusive. Finally, soils from various locations varied significantly in ability to deplete CO.

A new complication is added to the discussion of worldwide CO by a study reported in the April 21 SCIENCE by Bernard Weinstock and Hiromi Niki of the Ford Motor Co. sciefitific research staff. Weinstock and Niki say there is very significant generation of CO in the atmosphere resulting from a reaction of naturally occurring methane and free hydroxyl radicals, the latter perhaps partly natural and partly a smog product. Happily, however, "Hydroxyl radicals are shown to account for both the production of this large amount of carbon monoxide by methane oxidation and for its removal by carbon monoxide oxidation." Weinstock estimates that worldwide the hydroxyl-methane CO may exceed by a factor of 25 that which is produced by combustion, but the hydroxyl reaction also ultimately converts the CO to CO_2, and thus serves as its own corrective. Weinstock says his finding in no way contradicts Inman's. Given the magnitudes of CO generation and disposal involved, plus man's imprecise knowledge of these magnitudes, there is plenty of room theoretically for two sinks. The Weinstock findings and computations indicate a tremendously larger source of CO, as well as a tremendously larger sink, than does the Inman combustion-fungi source and sink. However, the Weinstock model can, for purposes of considering Inman's work, be placed in a black box and ignored, since it appears to consume about as much CO as it produces.

Inman's study was commissioned by the Coordinating Research Council, a non-profit venture that administers joint Government-industry air pollution research. Most of CRC's studies, like this one, are jointly funded by the Environmental Protection Agency, the American Petroleum Institute and the Automobile Manufacturers Association. □