Toxic Compounds . . . in the Agricultural Environment:

• *Lead*
• *Mercury*

*by Roger L. Caldwell**

INTRODUCTION

Recently, particularly within the last two years, mercury and lead in the environment have become of great concern. Although poisoning by both materials has been known in special instances for years, possible reasons for recent concern are: 1) both are chemical elements, and therefore cannot be degraded, 2) new analytical methods allow low detection limits, 3) high levels of mercury have been discovered in certain fish and foods, 4) the observation that large amounts of mercury are discharged into certain water systems, 5) the increasingly high levels of lead being found in urban atmospheres and in vegetation along heavily traveled roadways, and 6) an increased general awareness of environmental problems by the public.

NATURAL SOURCES

Before considering man's contribution to the levels of lead and mercury, one must consider natural sources and levels. For lead, water averages .01 ppm**, with wide ranges occurring depending upon the specific area, food contains .2 to .5 ppm, soil contains 30 to 80 ppm, and uncontaminated air contains .001 to .01 ug/m^3. Urban and industrial air contains 2 to 5 ug/m^3. Soil levels near lead-containing ores may contain many times that of non-lead areas. Additional natural sources are due to radioactive decay of uranium type ores and volcanic eruptions.

For mercury, various water sources range from .0003 to .05 ppm, ocean plant life contains about .03 ppm, food contains .02 to .5 ppm, and coal and oil may contain up to 30 ppm. Soil contains on the average .01 to .05 ppm, with levels up to 500 times this amount not uncommon in mineralized areas, particularly in association with sulfide ores and silver, lead, antimony, zinc, and copper deposits. Levels of mercury in the air are quite variable, depending on location, temperature, wind, and moisture. Air over open sea contains around 0.7 ng/m^3.*** The normal range over land areas, where measured, appears to be 1-2 ng/m^3. Detection of atmospheric mercury has been used as a mining exploration tool for mercury, copper, silver, and gold, as air levels over these deposits may be 10-1000 times higher than background. It is therefore apparent that natural mercury is able to volatilize easily to become airborne.

Most probable methods of removal of both lead and mercury from the air are by rainfall or adsorption on dust particles.

MAN-MADE SOURCES

The major lead uses in the United States, in 1968, were classified as follows: 38.6% storage batteries, 19.7% gasoline additives, 8.3% paint pigments, 6.2% ammunition, 5.6% solder, and 4.0% cable coating. Lead-containing chemicals, including pesticides, account for less than .04% of the lead used.

Major mercury uses in the United States, in 1968, were classified as follows: 23% electrical controls, 23% chlorine-caustic soda production, 14% paint preservation, 4.5% agricultural (including industrial slimicides, algacides, and bactercides), 2.8% dental, 2.5% catalysts, and 0.6% pharmaceutical materials.

The greatest contamination problems due to lead have been in its use as a gasoline additive and as a base for paint. Problems with mercury have been primarily due to its use for chlorine-caustic soda production and as catalysts in certain plastics production.

EFFECTS

Lead poisoning has been known for years. Severe poisoning, and sometimes death, has occurred as a result of children eating lead-containing paint, solder in contact with food, occupational exposure, and lead particulate matter from smelting operations deposited in range feed, followed by consumption by animals.

Higher levels of lead are being found in urban atmospheres; these levels result in higher lead levels deposited on vegetation growing in these areas. It has been shown that vegetation near heavily traveled roads contains as much as 100 times the lead of vegetation in more remote areas (this increased level is normally within 100 feet of the roadway). It has also been shown that the greatest amount of this additional lead near roadways is adsorbed onto the surface of the plants; therefore, vigorous washing essentially removes all of the lead. Levels of lead normally will be higher in the soil in fields that were formerly sprayed with lead-containing insecticides, with the possibility of a resulting higher level in the plants grown in the area.

Mercury poisoning has also been known for years, but has only recently become of widespread concern. About 1960, a condition called Minamata Disease (Japan) in humans was traced to fish poisoned by mercury from a plastics company in Japan. More recently, in January 1970, there was a mercury poisoning incident in New Mexico. Three children became ill after eating pork from hogs that had been fed mercury-treated grain. It is instructive to go over some details of this incident as this was probably the major reason for subsequent cancellation of registration for several mercurial seed treatments. Four families in Alamogordo obtained waste grain for hog feed in August 1969. Apparently, in this area, waste grain that has been treated is normally disposed of by burning. However, pre-

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**ppm equals parts per million; ug/m^3 means microgram for cubic meter.

***Nanograms per cubic meter; one nanogram is one billionth of a gram.

sumably due to poor weather, this was not done and some treated seed became mixed with untreated floor sweepings. Also, there was the possibility of a spillage of mercury concentrate that may have led to higher than normal levels of mercury in this material. This grain mixture was obtained by the hog raisers. In addition, because the sacked grain was rain soaked in an open truck, the mercury from treated grain may have been washed onto and contaminated non-treated grain. As a result of eating this grain, several pigs became ill in October. In December, after eating pork from a slaughtered hog, one child became ill. In January, two other children became ill; these children required the use of a rehabilitation institute, and suffer from varying degrees of brain damage and blindness; a baby born to the family in March is blind. While this was not the first time treated seed has been fed to animals, the consequences of this isolated and unusual case were most severe for this unfortunate family.

Recent studies have revealed that current mercury levels in most human tissue are around ten times less than they were in the 1913-1930 period. This is in contrast to the widely held view that many human tissues may now contain more mercury than in the past. Presumably this change in mercury content is due to a very much reduced use of coal as a home heatting fuel; coal contains variable amounts of mercury.

Occupational exposure effects of mercury for miners, painters, dentists, and seed treatment personnel have all been observed. Methyl mercury is the most toxic form, and may be formed from all other forms of mercury, primarily by biological conversion. This conversion may take place in mammals, fish, and certain microorganisms. It is this process that converts the inorganic mercury from industrial discharges found in river sediment into organic mercury. As larger animals consume smaller ones in the food chain, the larger amounts of mercury are found in the larger animals or fish, such as tuna or swordfish.

The agricultural uses of mercury have been studied, but much remains to be understood. It is known that the chemical can be translocated by plants but this is primarily as a result of foliar application with subsequent translocation to edible parts. Mercury-treated seed (and the possibility of translocation of the mercury to the germinated plant) is the subject of some controversy. Grains from treated rice in Japan contain about 50% more mercury than untreated rice which normally has about 0.2 ppm mercury. However, mercury levels in Japan's soil are not representative of soils of other agricultural areas partly because of poor drainage of the rice paddies. The only other report of which I am aware that would indicate mercury is translocated from seed to the germinated plant was issued from Sweden; this particular study has been widely quoted in relation to mercury poisoning. The experiment consisted of testing the mercury content of eggs from hens fed grain grown from treated seed. Eggs from hens receiving untreated seed gave 0.012 ppm, seed treated with a methoxyethyl mercury gave 0.010 ppm, and seed treated with a methyl mercury gave 0.027 ppm; this study, however, was clouded because fish meal, normally containing about 0.02 to 2 ppm mercury in Sweden, was used in the feeding trials. Other reports have shown that mercury on treated wheat and barley seed does not translocate through the plant to the harvest grain. It is interesting to note that the mercury content of treated seeds is around 10 ppm, a level that most likely would be undetectable or be below background levels when diluted throughout a mature plant.

A number of instances of mercury poisoning in wild animals, particularly birds, have been reported. There are some data, however, to indicate that these deaths may be caused not only by mercury, but by a combination of factors including other pesticides, diseases, and/or stress. It is not known at this time how much mercury in wildlife is "natural," that is, the amount ingested in the course of eating vegetation containing natural levels of mercury. Wildlife poisoning by treated seed occurs both by birds picking out planted seed and by eating of excess discarded seed.

DISCUSSION

The principal sources of lead (gasoline additives and smelting operations) and mercury (seed treatment) in the agricultral environment should produce less in the near future. Air pollution regulations, now in effect, require a reduction of lead in fuels and more strict control of particulate matter released by smelting operations. Several mercurial (primarily alkyl mercurials) seed treatments have been suspended and other fungicides substituted. Airborne levels of mercury from natural sources and fossil fuel combustion will most likely continue to increase.

One of the difficulties in working with toxic metals such as lead and mercury is in setting safety tolerances. Normally, the U.S. Food and Drug Administration allows a 2000 to 1 safety factor for pesticides and a 100 to 1 factor for food additives. This means, in the case of a pesticide, that the tolerance is 2000 times less than the smallest amount that will cause any effect on a test animal. In the case of mercury, for example, a 2000 to 1 safety factor would be many times lower than the naturally occurring levels. It is thus very important to keep levels of these types of chemicals as near to the natural level as possible. For mercury, there is a zero tolerance in all food although a "guideline" level of .5 ppm has been designated for fish only; with normal consumption rates of fish this allows the mercury intake for the average person to remain about .05 ppm, which is near the natural average level in food. The higher levels in fish appear to be natural, due to biological conversion via the food chain.

Recent public interest in environmental matters has often required answers before all the data were available. As a result, many misconceptions concerning such toxic elements as mercury and lead have been published. One must not forget that many of these elements occur naturally at levels that may or may not be cause for alarm. The very small differences between natural levels and toxic levels requires that man limit his contribution of these elements to the environment to the minimum possible amount.

Before we can fully understand the overall significance of these elements in the food chain, we must analyze air, water, and vegetation under different circumstances. In Arizona, mercury levels are higher near copper deposits than other areas. Lead levels are highest near smelter towns, followed by urban areas. Levels of both elements in vegetation at this time, in Arizona, are largely unknown.