abundant rainfall. Our results indicate that in the presence of water containing strongly complexing organic species, plutonium can be mobilized to a significant degree as a soluble organic complex that can withstand submicrometer filtration, $Fe(OH)_3$ carrier precipitation, and surface adsorption on sediments. [Means *et al.* (*9*) have described the drastic decrease in K_d values for trace metals in the presence of even very small concentrations of strong complexing agents.] Whether these complexes existed in the waste at the time of disposal or were formed in the trenches after disposal is not known, but it is likely that there are some complexes from both sources. Hence it is important that all organic matter in transuranium wastes be destroyed in order to prevent the formation of stable, potentially mobile complexes of plutonium. Moreover, ground water in the area should be free of strongly complexing ligands. For this reason, it is highly inadvisable to locate a chemical waste disposal site adjacent to a radioactive waste disposal site. Naturally occurring organic substances in ground water appear less likely to mobilize plutonium than organic matter in the wastes. Results of an earlier study (*10*) indicate that plutonium is not appreciably solubilized by fulvic compounds in natural waters.

Although the results of this study indicate that the plutonium is in true solution, a previous investigation (*11*) of plutonium in a pond water indicated that the solubilized plutonium was predominantly colloidal. Hence it is clear that the chemical and physical form of plutonium, and therefore its migration behavior, varies widely with the composition of the water. Subsequent studies with different types of ground water should establish a more precise relation between plutonium speciation and ground water composition.

JESS M. CLEVELAND
TERRY F. REES
U.S. Geological Survey, Denver, Colorado 80225

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Organic Fluorine in Human Serum: Natural Versus Industrial Sources

Abstract. *The concentration of organic fluorine in human serum has been reported to vary from 0.0 to 0.13 part per million in persons not exposed to industrial fluorochemicals. To help ascertain whether the natural environment is a source of organic fluorine in human serum, samples from a group of rural Chinese were analyzed. The samples contained low levels of organic fluorine as well as the expected inorganic fluoride.*

It has been observed (*1*) that there are two forms of fluorine in human serum: exchangeable and nonexchangeable with $^{18}F^-$. Research (*2*) has been directed toward identifying the nonexchangeable or organic form. Organic fluorine has been detected in human plasma (*3*); in one study it was not detected in the serum of a variety of animals (*4*), although in other studies it was found in bovine (*5*) and rat (*6*) serum. Since it has been suggested that organic fluorocompounds in human blood are derived from commercial sources (*2*), we analyzed serum from humans who live in a rural area in the People's Republic of China and compared the results with reported values for people in urban areas of the United States.

Several methods have been used to measure total fluorine in serum and plasma. Most samples have been analyzed by open ashing, which causes a variable loss of fluorine (*5*). For example, only 21 percent of the fluorine in perfluorooctanoic acid is recovered as inorganic fluoride by this method (*2*). The use of the closed oxygen bomb technique (*5–7*) avoids most of these losses. With this technique, recovery of fluorine from perfluorooctanoic acid is > 90 percent (*7*). The method yields a mean blank of 0.02 μg, which corresponds to 0.002 part per million (ppm) in a 10-ml serum sample.

Table 1. Concentrations of organic fluorine and inorganic fluoride in eight rural Chinese.

Person	Organic fluorine (ppm)	Inorganic fluoride (ppm)
1	0.008	0.051
2	0.013	0.054
3	0.011	0.046
4	0.014	0.046
5	0.009	0.044
6	0.009	0.049
7	0.004	0.046
8	0.017	0.076

Eight samples of human serum were obtained from Chinese donors who live in a rural commune, with little chance for exposure to industrial fluorochemicals. The samples were analyzed for organic fluorine and inorganic fluoride (F^-) by the oxygen bomb method. As shown in Table 1, all the samples from the Chinese contained detectable concentrations of organic fluorine. These concentrations are at the low end of the range compared to those in groups representing a more urban environment. Ash analysis of 65 plasma samples from residents of New York State gave an average value for organic fluorine of 0.03 ppm (lowest value, 0.005 ppm) (*3*). In plasma samples from 106 individuals living in five cities in two states, a mean organic fluorine concentration of 0.025 ppm (ashing) was observed, with two samples estimated to contain < 0.005 ppm (*2*). In plasma samples from 264 people in one Minnesota community, the average concentration of organic fluorine was 0.045 ppm (ashing); one sample contained no detectable organic fluorine (0.00 ppm) (*8*). Ash analysis of a pooled serum sample from Argentinians showed an organic fluorine concentration of 0.085 ppm (*9*). Oxygen bomb analysis of serum samples from nine Minnesota residents gave an average value of 0.02 ppm (lowest value, 0.01 ppm) (*7*).

The concentrations of F^- in the Chinese were slightly higher than the 0.02 ppm reported by Belisle and Hagen (*7*)

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for a group of Minnesotans. However, in another study (*8*), an average value of 0.058 ppm was reported for Minnesotans. Guy (*3*) reported a mean of 0.015 ppm F^- in inhabitants of New York State, and later showed the concentration of F^- in plasma to be dependent on the level of F^- in the drinking water. Therefore, the slightly higher concentrations of F^- in the Chinese may be due to fluoride in their food and drinking water.

It is difficult to compare reported fluorine values due to the variety of analytical procedures used. Negative factors (such as volatility and incomplete sample decomposition), positive factors [such as contamination with F^- and Freons (*3*)], and the method itself (*10, 11*) influence the reported values. Due to the paucity of values determined with the oxygen bomb method, it is necessary to use results obtained by ashing for comparing levels of organic fluorine in serum.

Many compounds containing organic fluorine have useful industrial and medical applications (*12*); the wide use of these compounds implies widespread exposure to them. Reviews have been written on the role of organic fluorine in biochemistry (*13*), psychiatry (*14*), and toxicology (*15, 16*). The fluoroorganic compounds methoxyflurane and halothane are anesthetics (*17*), and artificial blood contains perfluorocarbons (*18, 19*). Several natural sources have also been suggested (*3*).

In a recent study on the exposure of industrial workers to fluorochemicals (*20*), elevated concentrations of organic fluorine (1 to 71 ppm) were found in the serum of chemical employees handling a specific fluorochemical (ammonium salt of perfluorooctanoic acid, $C_7F_{15}CO_2^-NH_4^+$). It was also found that this fluorochemical is slowly eliminated from the body. Therefore, it appears that blood levels of organic fluorine are dependent on the frequency of exposure to specific fluorochemicals.

If man (*20*), rat, or monkey (*21*) is exposed to ammonium perfluorooctanoate, the compound is subsequently found in the blood serum. This is not surprising when one considers the results of a study on the binding of perfluorooctanoic acid to human serum (*6*): more than 99 percent of this added organic fluorine was bound to serum constituents.

It is clear that nearly everyone (> 98 percent) has both forms of fluorine in his blood and that the reported values are somewhat dependent on the method of analysis. The value for F^- depends on diet and drinking water while the value for organic fluorine could be influenced by exposure to certain fluorine-containing compounds from both natural and synthetic sources.

While it was originally suggested (*2*) that the prevalence of organic fluorine in human plasma is due to commercial sources, there now is evidence that the concentrations have been decreasing over the past 15 years (*2*)—although the trend may be due to the methods used to analyze the blood samples. As yet, we find no conclusive evidence to indicate that the prevalence of trace amounts of organic fluorine in human blood is primarily the result of industrial fluorochemicals. Rather, the main source may be some naturally occurring organic fluorine.

JON BELISLE

Central Research Laboratories,
3M Company,
St. Paul, Minnesota 55133

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Niacin Reduces Paraquat Toxicity in Rats

Abstract. *Rats poisoned with paraquat benefited from daily niacin therapy. Niacin-treated rats showed delayed and reduced dyspnea. Deaths began approximately 30 hours later. The time required for niacin-treated rats to reach 50 percent mortality increased from 60 to 120 hours, and the death rate was reduced from 75 to 55 percent. The benefit by niacin is consistent with the demonstrated role of niacin in preventing cellular decreases of nicotinamide adenine dinucleotide during poisoning of bacteria by paraquat and by hyperbaric oxygen.*

Paraquat [1,1′-dimethyl-4,4′-bipyridinium (cation) dichloride] is a nonselective postemergence herbicide and defoliant used on a wide variety of crops. Although paraquat is one of the safer herbicides as applied agriculturally, it has caused over 400 human deaths from accidental and suicidal ingestions (*1*). Paraquat also has allegedly caused lung damage to drug users who smoked marijuana obtained from Mexico (*2*). Human fatalities generally are caused by pulmonary impairment, regardless of the method of contact. We have found that niacin is beneficial to rats poisoned by paraquat.

This finding developed from earlier research which had disclosed common sites of damage at the enzyme level in bacteria poisoned by paraquat and by hyperbaric oxygen (*3–8*). The evidence included the discovery that niacin and thiamine were beneficial for the growth of *Escherichia coli* poisoned by hyperbaric oxygen (*5*) or by paraquat (*8*). The mechanism of thiamine protection remains unknown, but there is evidence (*6–8*) that niacin protects *E. coli* because it circumvents the consequences of the poisoning of quinolinate phosphoribosyltransferase. This enzyme is universally required for the de novo synthesis of nicotinamide adenine dinucleotide (NAD); therefore, there is reason to believe that the results may apply to higher life forms.

Consequently, we studied the effects of niacin on paraquat-poisoned rats. The paraquat was given intraperitoneally in two doses of 30 mg per kilogram of body weight, 24 hours apart. Rats that received only paraquat began to die after approximately 30 hours, and 50 percent of the animals were dead by 60 hours (Fig. 1). The group of rats that also received intraperitoneal injections of 500 mg of niacin per kilogram of body weight every 24 hours for 5 days, beginning with

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