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Contamination Limits for Real and Personal Property

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by

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CONTAMINATION LIMITS FOR REAL AND PERSONAL PROPERTY

PROGRESS REPORT FOR THE PERIOD OF

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ABSTRACT

Data for the movement of various contaminants from several different surfaces have been examined and the fractional amount removed per unit time fitted to an arbitrary scale of level of action. Both the nature of the contaminant and the nature of the surface appear to affect the fractional removal although data are not available to define the dependence in any detail.

I. FIXATION OF CONTAMINANTS TO SURFACES

Most of the data on degree of fixation to surfaces were obtained from liquid contaminants either after evaporation on the surface or by immersion of a surface in a solution. These data show that a higher percentage of the contaminant becomes more firmly fixed with time after at least two or three days. In one series of experiments,[1] the fraction that could be removed with water (defined in these experiments as loose contamination) was remarkably consistent for the same surface contamination with such diverse materials as ^{89}Sr, ^{131}I, or a one-year old fission product mixture. On glass, the removal varied from about 80% for the fission products to about 88% for the ^{89}Sr at 30 min after contamination to about 55-50% after 15 days. Tompkins[2] has shown that the frosted end of a microscope glass slide adsorbs ^{32}P from a phosphoric acid solution with several components of half-life ranging from a few minutes to several hours.

The implications of this work are that the degree of fixation of contamination to the surface will change with time in the period immediately following the contamination event. Therefore, the transfer to the air, the body, or another object during this period may slowly decrease. In general, this would not seem to be an important factor in estimating contamination limits for real or personal property because the time since contamination of these objects would generally be in the week to year range, but this effect could be of importance in interpreting or planning controlled experiments.

As is well known, the nature of the surface also affects its ability to absorb and retain the contaminant. Thus, most laboratory surfaces are constructed to be as smooth and free of cracks as possible. A number of experiments[3,4] on the decontaminability of surfaces and the initial susceptability of the surface in retaining the contamination have been examined. As was expected, a smooth, hard surface is less susceptible and the contamination easier to remove than when a surface is rough or porous. In general, it appears that there is an inverse relation between the susceptibility to contamination and the ease of removal. This suggests that transfers of contamination from wooden or fiber objects to humans from normal actions of using and handling may be smaller than for glass or metal objects. However, this may be insignificant when actions with an object such as burning are considered. Final balance on this will depend upon quantitative relations developed for each of the pathways of exposure.

The decontamination experiments have also revealed a general pattern of ease of removal which, it appears, may be characteristic of the surface and, perhaps, the contaminant. In general, this can be represented by "rate" constants where the variable is number of steps of decontamination rather than time. We are currently interpreting these data with an assumption of exponential removal to see if some quantitative relations between type and number of decontamination steps can be formulated. At the moment, it appears that two, or possibly three, rate constants will suffice to represent the loose and fixed components on a surface.

II. TRANSFER OF CONTAMINANTS

A major goal of the work during this period was the derivation of an overall, semi-quantitative pattern describing the transfer of contaminants from various surfaces to air, to other objects or to humans when the surface is subjected to various actions. It was recognized at the start that the information available was inadequate to fully define this transfer under all of the conditions to be encountered. However, the lack of such a relation has been a major stumbling block in past derivations and even a crude relationship would be valuable in assessing its usefulness and in better defining the types of experimental investigation needed.

In order to provide a mathematical framework, an initial assumption has been made that the removal from a surface (and, hence, transfer elsewhere) follows linear kinetics.[5] This permits the definition of the term f_{sl} as the quantity of contaminant lost from a surface per unit time under the influence of a specified action. It can then be used in a description of the quantity transferred and remaining with the familiar exponential relations. It is apparent that more than one value of f_{sl} will be needed for a complete description of the total transfer from a given surface since some experiments on decontamination have shown that removal becomes more difficult as the treatment persists (i.e., a smaller fraction of that remaining is removed for a given additional treatment). However, for the present study only the initial value of f_{sl} was used, representing the rate of removal when the first action is taken, in order to provide consistency among all experiments including those for which information on the later change of slope is not available. In some experiments, particularly those involving decontamination and smear tests, the data represent the removal from a unit application of a given procedure (such as smearing a given area or washing an object). In these cases the value of f_{sl} was derived for the unit step and compared to the data for unit time in other experiments. Thus, the tacit assumption was made that the action lasted for one minute.

An action scale to permit correlation with the values of f_{sl} was particularly difficult since it is impossible to obtain a scientifically definable measure of the degree of action resulting in the measured value of f_{sl}. A completely arbitrary scale was finally chosen with the values of f_{sl} placed on the scale at positions where they produced the best fit to a straight line (on a semi-log scale) between the values for the maximum and minimum action levels. While such a procedure is arbitrary it does produce a relation whereby the action foreseen on an object can be related to the actions of the scale by subjective judgment and used in estimating transfer.

In the preparation of the curves, it was noted that there appeared to be a reasonable relationship between the value of f_{sl} and the type of surface and contaminant in those experiments where the same action level was carried out under different conditions. In general, contaminants such as a particulate oxide on a smooth surface appeared to have a higher value of f_{sl} than a soluble salt applied as liquid to an absorbent surface. However, the amount of quantitative data obtained for the various conditions was not adequate to permit definition of this factor over the full range of actions and the curves were drawn as boundaries to a range with the upper one presumably representing a particulate contamination on a smooth surface and the lower representing a soluble salt on a rough or fibrous surface.

The resulting formulation between f_{sl} and actions are given in Fig. 1. Data were obtained from eleven references[1-4, 6-12] and represent a range of diverse conditions such as walking on a contaminated floor through actual reageant decontamination in controlled tests. We have not attempted to indicate on

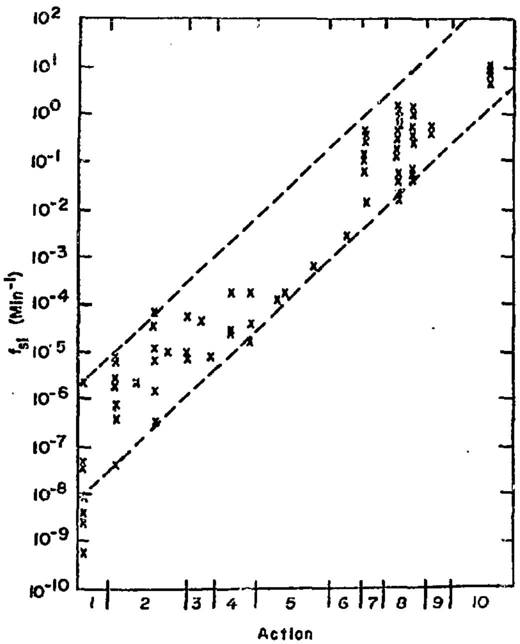

Fig. 1. Plot of fraction lost per unit time versus arbitrarily assigned scale of action on a contaminated surface. Numbers on the action scale represent the following:

1. No action in a room with contaminated floor but differing ventilation rates.
2. Walking on a contaminated floor at various speeds from 14 steps per minute to 200 steps per minute.
3. Carrying out vigorous work on contaminated floor.
4. Strong air currents in a contaminated area caused by fan and light sweeping.
5. Vigorous sweeping of contaminated floor.
6. Damp smear of a surface after it has been washed.
7. Smair (A technique using strong and reproducible air currents on a small surface to measure removable contamination).[4]
8. Dry smear of surface or water wash.
9. Acid wash of surface.
10. Hard scrubbing of surface or liquid decontamination with chelating agents.

this curve the wide range of surfaces (concrete, asphalt tile, linoleum, paper, cast steel, glass, and enamel) or the contaminants used (PuO_2, $PuNO_3$, UO_2, BeO, ZnS, ThO_2, ^{131}I, ^{89}Sr, ^{32}P, CuO, and mixed fission products). Instead each test is shown by a single point to illustrate the spread.

Considering the number of variables present, the relatively narrow band of about two orders of magnitude is encouraging and may indicate that an approach such as this with more controlled experimentation could lead to a series of curves for use with different contaminant properties, surface properties, and action levels. One point of interest is the wide spread of data at the "no action" condition. These points all represent conditions of floor contamination in non-occupied rooms where no work or movement is occurring. However, the different room sizes and ventilation at this range may represent various degrees of action even in this condition.

III. SOIL STANDARDS

Little additional work was done on the plutonium in soil standard although some additional references on resuspension were obtained. Several of these indicated that resuspension rates may increase to a much greater degree with wind speed than was assumed in the report on the plutonium standard. A start was made on preparing equations to calculate average air concentration resulting from resuspension over a uniform rectangular area by using the wind rose data of direction and wind speed for various stabilities. Such a scheme will be useful for examining data from extended periods of sampling as well as indicating changes due to area size or meteorological differences.

IV. PLANS FOR FUTURE WORK

Attention on surface contamination will be focused on an attempt to perform a complete calculation of a limit for one or several isotopes based upon all modes of potential exposure and using the transfer curve derived during this period (Fig. 1) to characterize the movement. This exercise will be primarily for the purpose of seeing how the pieces fit and developing the calculational techniques. As a part of this exercise, some effort will be made to consolidate the studies to date in terms of a potential experimental program to better define some of the uncertain or unknown factors.

The plutonium in soil limit will be reviewed in light of more recent information and the calculation of resuspension over long periods continued. It is hoped that this review will result in a rewrite in a simpler, more easily understood format

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