LINK "SOIL - PLANT" AS CRITICAL IN FORMATION COMMITTED DOSES FROM UPTAKE OF LONG-LIVED RADIONUCLIDES

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Summary

General algorithm of calculation dose from intake ^{137}Cs and ^{90}Sr depending upon level of pollution and agrochemical type of soil where trophycal chains to begin with, have been proposed. This methods consider link "soil->plant" as critical in formation of doses from the intake long-lived radionuclides. Calculation of committed dose as function of type of soil and level of radionuclide pollution have been realized for seven main soil types of the White Russian and Ukrainian Wooded district.

Introduction

Chernobyl accident to the great extent determine quality of the life and health of the public in the polluted territory for a long time. Significant factors determinative public doses change and ones receive from long-lived radionuclides intake from food moving forward.

Two types are known of pollution of the food and agricultural production in general. First type is connected with the surface pollution of vegetation (Miller and Hoffman, 1982). Second one, structural pollution, is connected with absorption chemical elements from soil by the plant roots (Ney and Tenker, 1980, Alexachin et al, 1991).

So why, soil as enormous adsorbent and reservoir for different forms of radionuclides is source of all types of the pollution trophycal chains too.

Total harvest of the development biogeochemistry (Orlow, 1992), biology of mineral nutrition plants by the

roots (Ney and Tenker, 1980; Barber, 1988) and radioecology before Chernobyl accident (Marey et al, 1974; Prochorov, 1981; Kulikov and Molchanova, 1985; Alexahin et al, 1991) is understanding complicated interconnections in system soil-plant that determinate intensity flows and absorption mineral elements, including radionuclides. Both main components this system - soil and its agrochemical characteristics, plant , and it's physiological property, have determined intensity flow of pollution and one inclusion in biological circuit. From radiological point of view it means that just link soil->plant is critical in formation level of pollution all type of trophycal chains ,total radioactivity of human rations and determination committed doses from incorporated long-lived radionuclides.
This must be taken into consideration for evaluation and forecast doses in condition of big scale and long term accident.

Dates of monitoring first years after Chernobyl accident have shown the paradoxical phenomenon of high pollution of agricultural products in conditions of low level land surface pollution. However this contradiction is quite solved by analysis some specific features radionuclides anomaly which arise.

It is known, characteristic property of Chernobyl accident is not only it's enormous scale, aggregate and chemical variety state of radionuclides that have been released, complicated space structure, but high variety, "gaudiness" of soil composition the land that have been polluted. Specific soil characteristic Norther Ukraine, special peculiarity of radionuclides in that biogeochemical province as Wooded district rich soil of biogenic origin have been object of radiecological investigation since the global fall out (Marey et al, 1974).

More than once, idea that level of ration pollution is not only determined by the level of surface land pollution, but by the agrochemical type of soil, degree of biological accessi-

bility radionuclides and structure of agricultural production have been formulated (Marey et al, 1974; Alexahin et al, 1991; ICC, 1989). However this point of view was based on harvests of many years investigations leading radioecological laboratories have not proper development and not make use in evaluation and forecast radiological situation. Method of forecast doses have been used now take into account uptake radioactivity only from two main products - milk and potato, without registration and analysis radioecological causes that determinate given level of its pollution. It is known that the registration and analysis of causes of phenomenon raise accuracy of forecasts.

That's why, purpose our investigation is development of such methods of calculation and forecast dose permitting to account different level of ration pollution to be based on different levels of pollution and type soil.

Realistic valuation this function is possible by means of account main radioecological coefficient - transfer factors in soil different type to the plants of different types and a large body of other radioecological information about kinetic of radionuclides migration in soil and theirs influence to possible alterations of transfer factors in soil->plant and then to all another trophycal chains, such as soil->plant->harvest of grain, soil->plant->harvest of potato, soil->plant->harvest of edible vegetables roots, soil->harvest of leafy vegetables, soil->plant->feed->milk, soil->plant->feed->meat.

We should like to consider in this article the first step of our investigation - the most simple "static" variant of method of calculation: meaning transfers factors for each type of the soil and each type of the plant are equal ones in 1991 (DAU, 1992), level of pollution of the soil is alterating by natural break-up radionuclides only.

Materials and methods

A large body of diverse and vast radiobiological and radioecological information is being processed under development of this algorithm evaluation function dose loading and agrochemical type of soil. Such basis data have been accounted:

-Our own data and data other radioecological laboratories about transfer factors in trophycal chains to begin with other type of soil in conditions Chernobyl accident (Alexahin, 1991; DAU, 1991; Frissel, 1992);

-data about level of pollution harvest and single production from different collective farms. We take into consideration if can indicate exactly agricultural type and soil composition of the land that is source of formation production that type (DAU, 1991);

-data (maps) about level of ^{137}Cs and ^{90}Sr pollution land of Ukraine (USCG, 1992);

-data about main type of soil composition of the land. This information have been account in radiological passport of the lands (DAU, 1991) ;

-data about age-dependent structure and modification of ration; we take into consideration six age intervals: 0-1, 1-2, 2-7, 7-12, 12-17, 17-70 (ICRP, 1977; Kozlov, 1991);

-modern clinicoepidemiological and radiobiological data about action intake long-life radionuclides (Moskalev Y.I. 1989; ICRP, 1990; Moiseev and Ivanov, 1991);

-general principles calculation of the committed dose according recommendations of ICRP and modern dosimetric models

-modern values of dose coefficient for caesium and strontium (ICRP, 1990);

-physical specific action (type and energy of emission) radionuclide (Kozlov, 1991; Moiseev and Ivanov, 1991);

-modern information about level of assimilation, distribution, rate exchange (biological half-time) and

other biokinetic parameters of long-lived radionuclides ^{137}Cs and ^{90}Sr. We take into consideration modern knowledge about complex structure biokinetic behavior of ^{90}Sr, according ones this element have few fraction deposition in organizm. Soft tissues and blood have insignificant retention ability, cortical, trabecular surfaces, trabecular bone have more prolonged half time and finally cortical bone have high ability of retention. We have proposed to use for calculation kinetic of accumulation in tissues, organs or organisms activity of radionuclides with biological long-time compartments formula such as:

$$A_{ef}(t)=EXP(-0.693/T_{ef})*A(t-1)+EXP(-0.693*t/T_{1/2})*A\ (t); \quad (1)$$

t=0 is time of determination activity in soil; $T_{ef}=T_{1/2}*T_b/(T_{1/2}+T_b)$; T_b - biologycal half-time for compartment; $T_{1/2}$ - half-time of radionuclides life.

We have calculated age-dependent dose coefficients per years based to values dose coefficient to age 70 years and age-dependent biokinetic model (ICRP, Publication 56, 1990;ICRP, Publication 60, 1990). This approach is convenient in condition of uninterrupted reception of dietary radionuclides and accumulation radionuclides with long biological half- time .

If dose coefficient per one year is used, it is easy to turn from formular (1) to a formula taking into account the factor of it's accumulation during life from long biological half-time compartment of strontium-90:

$$H_{ef}(t)=EXP(-0.693/T_{ef})*H(t-1)+EXP(-0.693t/T_{1/2})*H(t); \quad (2)$$

Calculation of dose from intake caesium have been realized with equilibrium activity (Moskalev, 1989; ICRP, 1990, Kozlow, 1991, Moiseev and Ivanov, 1991).

Organization chart this data are presented in Fig.1.

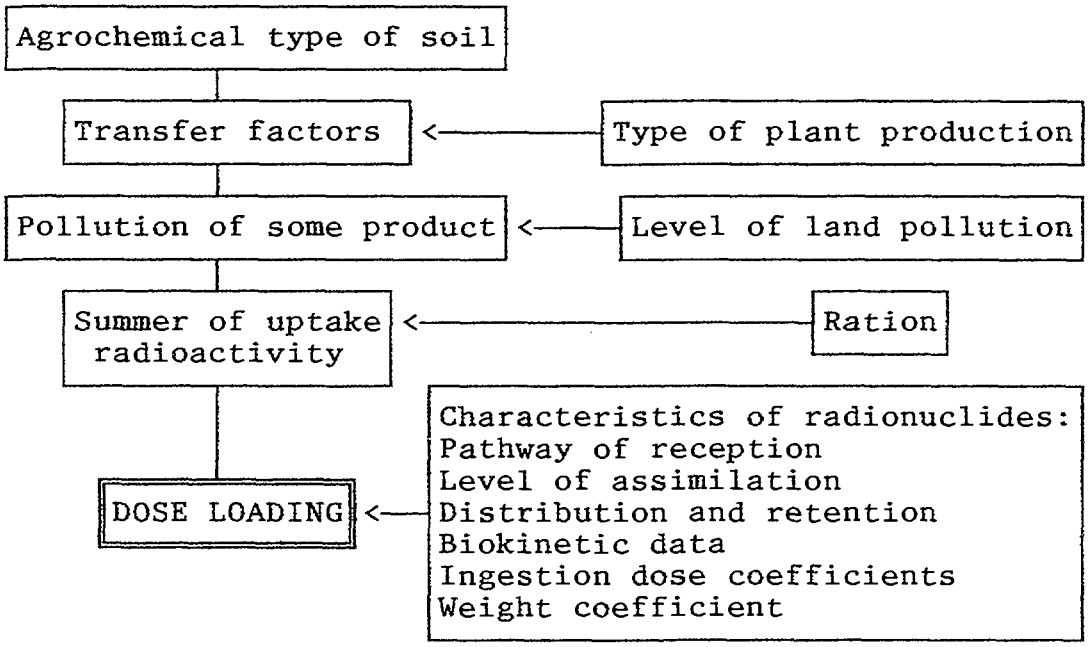

Fig.1 General algorithm valuation doses to members of public from intake of radionuclides

This valuations was realized in a spreadsheet form with Quattro Pro version 4.0.

Results and discussion

Valuation function "committed doses -agrochemical type of land trophycal chains to begin with" have been realized for seven types of soil: sod-podzolic sandy loam (A), sod-podzolic weakly gleyed and sod-podzolic medium gleyed (B), sod-podzolic heavy gleyed (C), sod meadow (D), sod-black soil (E) and black soil (chernozyom) (F).

Dynamic of age-dependent committed dose is demonstrated in the Fig.2, position A-G. Level of pollution is passing of 5 Ci/km^2 for ^{137}Cs and 0.5 for ^{90}Sr. This values is typical for the land of region of strengthened radiological control of Northern and Northern-East Ukraine after Chernobyl accident.

Dynamic of dose accumulation is monotonic function, minor disruption of smoothness is connected with modification two type: age-dependent ration and dose coefficient in condition of enough rough breaking of age intervals.

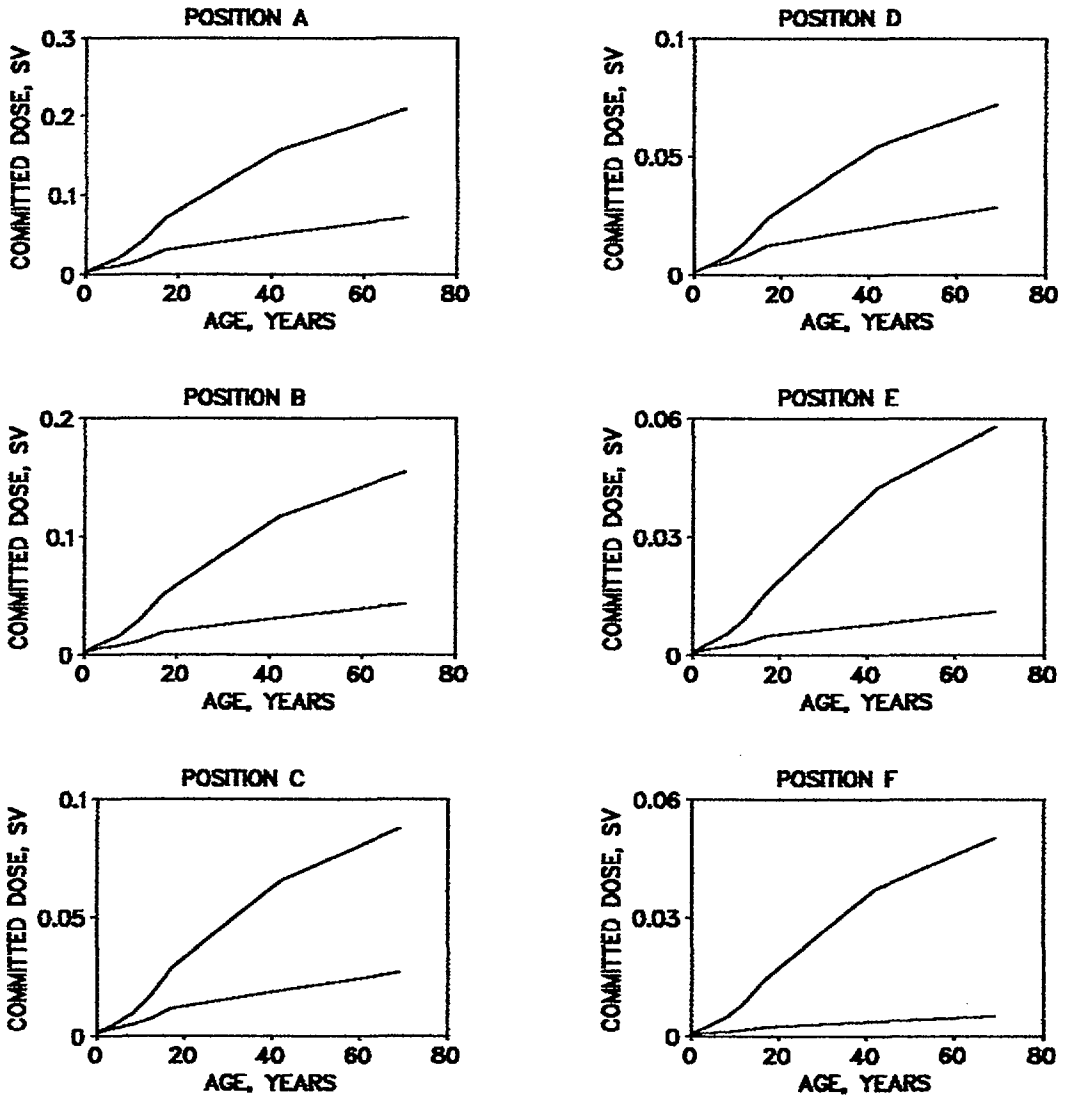

Fig.2. Committed doses accumulation

Therefore, committed dose from intake caesium (level of pollution - 5 Ci /km^2) and strontium (0.5 Ci /km^2) for sod-podzolic sandy loam is 0.16 Sv and 0.07 Sv per life accordingly, for sod-podzolic weakly gleyed at that level of pollution - 0.10 and 0.45 Sv, for sod-podzolic heavy gleyed - 0.065 and 0.025 Sv, for grey forest soil - 0.09 and - 0.028, for black soil (chernozyom) - 0.058 and 0.05 Sv. Very high committed dose have been calculated for turfary soil- 0.8 and 0.1 Sv per life. This type of soil is composed from 15 to 60% of the land of region of strengthened radiological control.

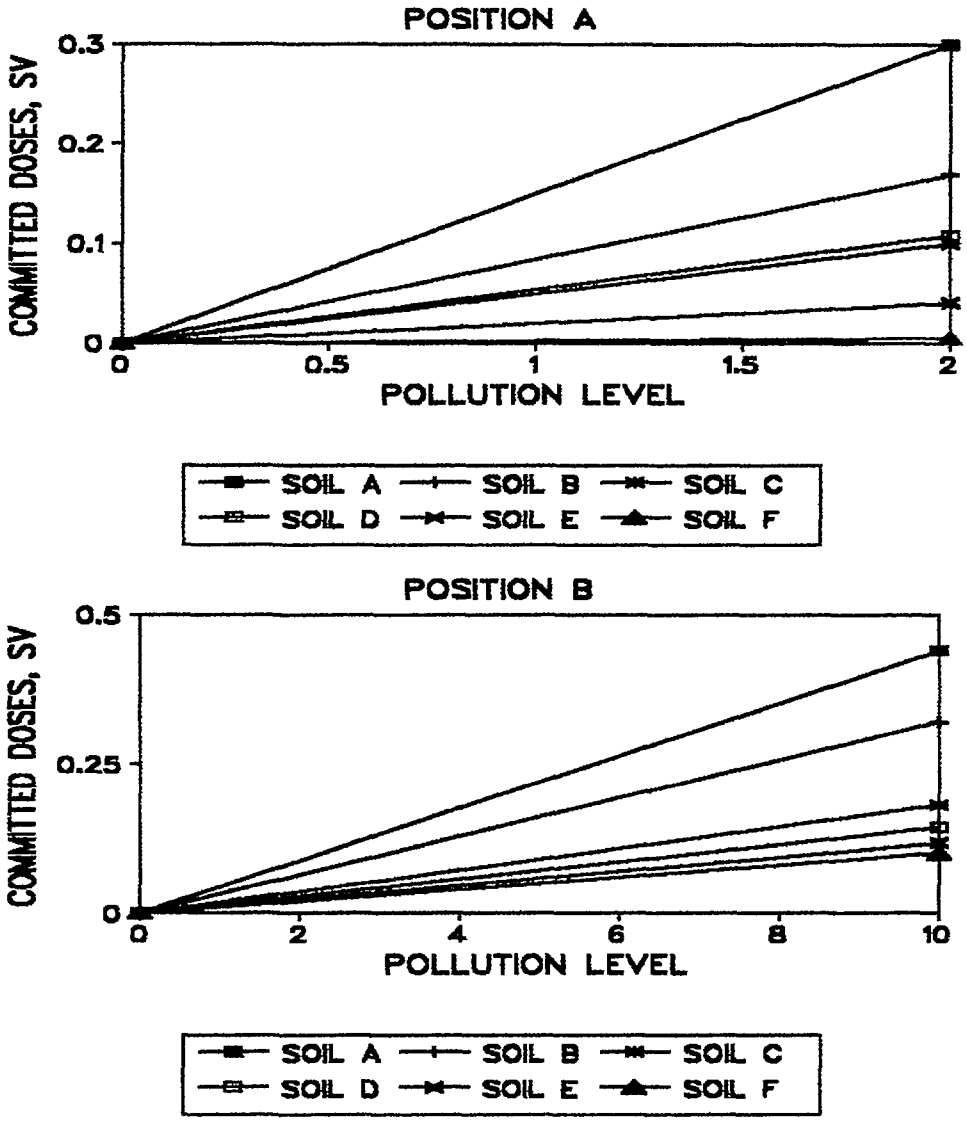

Fig.3. Committed dose from intake radionuclides and different soil type and pollution levels.

Second type of functions demonstrates Fig.3. They are defined as committed dose change as a function of type of soil and level of pollution. Values of level of contamination varied from 0 to 10 Ci/km^2 for caesium and from 0 to 2 Ci/km^2 for strontium. After all this function can be used in solution of opposite problem - estimation of admitted levels of pollution for one or another type of soils.

We want to emphasize that specific for each soil type and plant production transfer factors is not invariant, but it

is very dynamic characteristic change as a function of soluble fractions of radionuclides in soil. Values of soluble fraction change as a function of soil's, climatics and general thermodynamic factors. It is known,Chernobyl pollution is heterogenic in chemical and aggregate states. Solid forms of pollution or hot particles is immense source for the increase of soluble fraction. It is known too, tranfer factor was considerable higher in condition of homogenious soluble form of pollution. Therefore, transfer factors can increase to such definite level. On the other hand, absorbtion by soil minerals and infiltration decreased soluble fraction and reduced transfer factors. Mathematic solutions of this problem will be consideredin second step of our investigation.

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