ASSESSMENT OF BIOLOGICAL EFFECTS RESULTING FROM LARGE SCALE APPLICATIONS OF COAL POWER PLANT WASTES IN BUILDING TECHNOLOGY IN POLAND

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INTRODUCTION AND RISK ESTIMATES

The aim of this work is to evaluate radiation-induced remote biological effects to the population of Poland /34.2 millions in 1975/ due to the hitherto progressing and the expected development of the building technology. From among the harmful biological effects only severe genetic damage, leukemia and malignant tumors are considered. Serious genetic damage is considered in two groups. One of them comprises the effects which would be expressed over several generations following the irradiation of the parents. The other group consists of effects which would be manifested in the first generation after the exposure, thus being virtually caused by dominant mutations. The value of 10.5 severe genetic defects in the first generation and 300 over all generations of the progeny of irradiated parents per 1 rad per 10 births are accepted as genetic risk factors of chronic irradiation at low dose rates. The risk of induction of harmful somatic effects is evaluated in terms of absolute risk, i.e. as the difference between the risk of the irradiated and non-irradiated population. On the basis of the linear model of the dose-response curve, the absolute risk is expressed as a number of excess cancer inductions or deaths observed in a given population per year and rad or rem. For calculating the absolute risk factors the radiation risk estimates inserted in BEIR-72 and UNSCEAR-72,-77 reports are used. Risk coefficients are determined as average values weighted for products of numbers of irradiated persons times years of observations.

The risk factors for leukemia are estimated in two age groups: in children 0-9 years old /0.96 excess deaths per 10^6 man-rems per year/ and in older people /2.22 excess deaths per 10^6 man-rems per year/. In accordance to the BEIR-72 report the latent period is taken for

2 years and plateau region for 25 years.

Absolute risk of death from cancer /excluding leukemia/ also varies with age at irradiation. Two age groups are distinguished, viz. people younger than 20 and adults, with the respective risk coefficients of 0.73 and 4.20. Latent periods of 15 years and a plateau regions of 30 years are accepted for both groups.

As the concentrations of Rn-222 and its daughters in the indoor air are usually higher than the natural levels it is reasonable to make an evaluation of the lung cancer risk as a specific kind of risk in a population exposed to these excess concentrations. In this case the risk factor of 0.79, a 15-year latent period and a 30-year plateau region are accepted.

The risk of death from cancer, attributable to the prenatal irradiation of an embryo or fetus, is evaluated for the first 10 years of life. A risk factor of 23 deaths per 10^6 pregnant mothers at risk per year rem is used. No latent period and a plateau region of 10 years are assumed.

METHOD OF CALCULATION

The general structure of types of buildings in Poland in each decade since 1950 up to the end of 2010 is determined with the use of statistical data concerning building development and consumption of building materials. Distribution of the population between the particular types of buildings is assumed to be consistent with the presupposed building structure. For four main types of buildings the average additional dose equivalent rates of gamma radiation in air, soft tissue, bone marrow and gonads as well as dose equivalent rates of alpha radiation in bronchial epithelium are estimated and considered as representative for the whole population. The residence time coefficient 0.8, the tissue screening factors for gamma radiation and the equilibrium factor $F = 0.5$ for radon daughters are taken into account. The estimated mean excess dose equivalents in various tissues, weighted for the population distribution among the various types of buildings, are within the range of 12 to 32 mrem/year for gamma radiation and of 276 to 1108 mrem/year for alpha radiation.

The average countrywide dose rate inside buildings varies from one decade to another because of variations in the building structure and the widespreading use of technologies exploiting industrial wastes for the production of building materials. The actual dose cumulated by the population is the sum of individual absorbed doses and its effects depend upon the age distribution of the population and the durations of the latent and the elevated incidence perioda.

Somatic effects are calculated according to Johnson's method /1/ with the use of the above mentioned risk factors. As these values vary with the age of the irradiated persons, fractional and summarized risk factors are introduced for each 10-year periods. The appearence of the somatic effects of the irradiation extents for long periods which do not coincide with the calculation intervals. Therefore for each decade effective values of average annual dose equivalents to bone merrow, soft tissue and bronchial epithelium were calculated with allowance made for irradiation period and the plateau region. Basing on the above mentioned considerations and data the number of somatic effects occuring in a decade is calculated.

RESULTS AND DISCUSSION

Our assessments of risks indicate that the considerably growing use of power plant wastes for the production of building materials, creates an increased risk of death from neoplasms and genetic diseases. In the considered period /1951 - 2010/ the number of leukemias due to that reason are expected to increase more than twice /246 cases in the last decade/, the number of malignant neoplasms nearly three times /1049 cases in the last decade/ and the number of lung cancers nearly five times /8459 cases during 2001-2010/. By the same period only a relatively small increase of about 13 per cent should be observed in the serious genetic defects from the same cause. The malignant neoplasms in children caused by the excess irradiation of pregnant mothers during their stay inside buildings can be neglected as the irradiated population is small and the time of the irradiation reletively short.

According to the present evaluation, the serious somatic effects of the excess indoor irradiation, expressed in absolute numbers, amount in Poland through 1951 to 2010 to more than 31,000 cases. That figure comprised nearly 1000 leukemias and nearly 4000 other malignant neoplasms due to the elevated indoor irradiation, as well as more than 26,300 lung cancers caused by the excess concentrations of Rn-222 and its daughters in the air inside buildings. Deaths caused by the deleterious genetic effects during the same period are reletively small and should not exceed 260 cases in the first generation and 7,500 cases in the whole progeny.

Confrontation of the calculated number of these somatic effects with the death rate of neoplasms from all causes reveals the reletively high contribution of the indoor irradiation in the overall incidence of neoplasms. That contribution in the decade 1971-1980 should equal nearly 3 per cent of the cancers of the respiratory

system and 0.7 per cent of all neoplasms in Poland.

TABLE 1. The expected numbers of leukemias, malignant tumors and severe genetic demages induced by the excess gamma-ray doses and numbers of lung cancers induced by the excess alpha radiation doses to the inhabitants of various types of buildings in Poland.

Biological effect	Decade						Total
	1951 1960	1961 1970	1971 1980	1981 1990	1991 2000	2001 2010	
Leukemias	108	121	138	174	209	246	996
Malignant tumors /excluding leucemias/	383	454	560	703	768	1049	3,917
Lung cancers	1826	2258	2999	4416	6336	8459	26,294
Malignant neoplasms after irradiation of embryo or fetus	2	2	2	3	3	3	15
Genetic effects in the first generation	46	33	41	44	45	51	260
Genetic effects in the whole progeny	1300	951	1159	1254	1289	1469	7,422

REFERENCES

1. Johnson, R.H., Bernhardt, D.E., Nelson, N.S., Calley, H.W. /1973/ : EPA-520/1-73-004, Washington.