GENETIC DOSE LIMIT FOR GENERAL POPULATION, DOSE LIMIT AND DERIVED CONCENTRATION GUIDES FOR MEMBERS OF THE PUBLIC COMPULSIVE ACTION GUIDES FOR EMERGENCY SITUATIONS. A proposal for México, based on data available on Mexican people.

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Using methods recommended by ICRP & UNSCEAR, the mean age of childbearing and genetic dose limit was calculated for mexican population. Data for mexican population when available, complemented with internationally recommended data are used to derive concentration guides for several radionuclides in various environmental media. Derived concentration guides in sea water are calculated applying the specific activity concept. Emergency projected doses demanding action to be taken are proposed. Data lacking is emphasized in order to encourage further studies on habits, critical pathways and transfer factors through food chain for radionuclides in Mexico.

Introduction

Mexico is a developing country with great energetic needs and is now on its way to start using nuclear energy for power production. On this behalf, Uranium ore mining and milling and fuel fabrication is being considered on an industrial scale.

For radiation protection purposes the recommendations of the International Commission on Radiological Protection are now being applied, and regulations are to be issued in a near future, as needed, taking into account habits and characteristics of mexican population.

Genetic Dose Limit

ICRP[1] recommends a genetic dose limit of 5 rems. In the UNSCEAR Report to the General Assembly[2] there is a detailed discussion of the genetically significant dose, and applying the method outlined with data for Mexican population[3,4,5], a mean age of childbearing of 35 years was obtained, this gives an annual genetically significant dose limit of 0.144 man rem per 10^6 inhabitants. Apportionment of this dose, on applying the recommendations of K.Z. Morgan[6] and rounding offnumbers is stated in Table I.

TABLE I

GENETIC DOSE LIMIT FOR GENERAL POPULATION: 5 rems in 35 years
ANNUAL GENETICALLY SIGNIFICANT DOSE: 0.14×10^6 man rem per 10^6 inhabitants
APPORTIONMENT IN MAN REMS PER YEAR 10^6 INHABITANTS

Diagnosis	5×10^3	Other environmental sources	5×10^3
Therapy	10^4	Future Applications and emergency situation	10^5
Nuclear energy production	10^4	Occupational exposure	10^4

It may be noticed that a substantial portion of the genetic dose available is allowed for medical exposure. The genetic dose due to this source tends to increase the benefits being for the present generation whilst the risk will burden future generations, and so it has to be recorded and included in what would be an acceptable genetic risk from all uses of radiation.

Dose Limits and Concentration Guides

Radionuclides, sources and environmental pathways considered as most important for the transfer to man of radionuclides introduced in the environment, were obtained from the general guidelines for the growth of nuclear industry,as set forward by the Nuclear Energy Institute in its development program[7] and on the nuclear power reactor of Laguna Verde, Veracruz to start operating in 5 or 6 years. By now, there is no experience on pathways for radionuclides from source to man in Mexico, and this approach is a purely theoretical one.

Some studies have been made in Mexico on characteristics and habits of mexican population[8,9,10,11,12], this studies were performed for medical or nutritional reasons. They show that a wide difference exists specially on nutritional habits, in different zones of Mexico and even between habits of people living in the same area, but engaged in different economical activities, this does not permit to find the critical pathway for Mexico as a whole, although it is feasible with a well designed survey for a small area, as the one affected by effluents from a nuclear reactor.

Federal Radiation Council[13] has been issuing concentration guides for average population applying a 1/3 safety factor to dose limits set forth by ICRP for individuals in the critical population. Since in Mexico there is also an incomplete knowledge of some data needed, an arbitrary safety factor of 1/4 is used instead. Morphological and physiological parameters obtained from studies on mexican population[8,11] are summarized in Table II.

TABLE II

DATA ON PHYSIOLOGICAL AND MORPHOLOGICAL CHARACTERISTICS FOR AVERAGE MEXICAN POPULATION

PARAMETER	MEN
Body Weight	65 Kg
Daily water intake	1300 ml
Body fluids	39 Kg
Mineral bone	4.6 Kg
Calcium content	975 g
Thyroid	35 g

For other data needed ICRP and other sources were consulted[14,15,16,17,18,19] Data on food consumption were obtained from Zubiran et. al[20], Table III.

TABLE III

AVERAGE FOOD CONSUMPTION IN URBAN AND RURAL AREAS IN MEXICO

FOOD	GROSS WEIGHT IN GRAMS CONSUMED BY RURAL POPULATION	GROSS WEIGHT IN GRAMS CONSUMED BY URBAN POPULATION
Corn	399	202
Bread and Pasta	25	129
Rice	5	10
Beans	45	45
Meat	47	76
Milk	62	241
Cheese	3	3
Eggs	5	13
Vegetables	81	114
Edible roots	11	20
Fruit	36	72
Sugar	39	77
Fats	13	26
Cacao	3	0
Other	0	12

Table IV shows concentration guides or working limits for average population.

TABLE IV

WORKING LIMITS OR CONCENTRATION GUIDES FOR AVERAGE POPULATION IN MEXICO

RADIONUCLIDE	WORKING LIMIT OR CONCENTRATION GUIDE	IN	
^{226}Ra	3 pCi/l	Drinking water	
U_{nat}	3 μg/m^3	air	
^3H (HTO)	30x10^{-3} μCi/m^3	air	
^{41}A	3x10^{-2} μCi/m^3	air*	
^{85m}Kr	0.1 μCi/m^3	air*	
^{85}Kr	0.2 μCi/m^3	air*	
^{87}Kr	2x10^{-2} μCi/m^3	air*	
$^{88}Kr-^{88}Rb$	10^{-2} μCi/m^3	air*	
^{131m}Xe	0.3 μCi/m^3	air*	
^{133}Xe	0.3 μCi/m^3	air*	
$^{135m}Xe-^{135m}Cs$	8x10^{-2} μCi/m^3	air*	
^{131}I	30 pCi/m^3	air	
^{131}I	110 pCi/day	Total Diet (6 months child)	
^{131}I	1000 pCi/l	cow's milk (Through mother to breast feeded babies).	
^{137}Cs	300 pCi/m^3	air	
	5x10^{3}pCi/day	Total Diet	
	RURAL TYPE DIET	URBAN TYPE DIET	
	1.3x10^4 pCi/Kg	2.6x10^4 pCi/Kg	Corn
	12x10^4 pCi/Kg	12x10^4 pCi/Kg	Beans
	9x10^4 pCi/l	2x10^4 pCi/l	Milk
	11x10^4 pCi/Kg	7x10^4 pCi/Kg	Meat

*Safety factor of 1/4 was not used for calculus.

The main food for children's diet from birth to about 2 years of age is milk, but in Mexico most babies are breast feeded, and weaning starts between 1 and 2 years of age substituting the mother's milk with corn or/and beans, not with cow's milk, the pathway for radioiodine being from milk and food eaten by the mother to breast feeded babies. A survey made at the Instituto de Nutrición by Perez H. et al[21] gives an average of 400 ml milk in the mother's diet and so the derived working level or concentration guide for average individual in general population was calculated,on the basis of Iodine transferred by mother to child,using data from Weaver et al[22] for a mother with a milk production similar to the average mexican mother.

Strontium has a metabolism similar to calcium, but is discriminated against through its pathway from environment to man, the ratio of Sr 90 to calcium in bone needed to obtain a dose of 0.75 rems/year to bone, for individuals in the average population applying the method outlined by UNSCEAR[2]: is 4.5 m rad y^{-1} per pCi $(gCa)^{-1}$, and dose in rems is obtained multiplying by the "relative damage factor" 5, for Sr 90 in bone,giving 23 mrem y^{-1} per pCi $(gCa)^{-1}$ and 33 pCi $(gCa)^{-1}$ for 0.75 rem y^{-1} UNSCEAR[2] gives a transfer factor of 0.12 diet to bone and 275 pCi ^{90}Sr/gCa in diet produces 33 pCi ^{90}Sr/gCa in bone.

A high proportion of calcium is obtained in mexican diet through mineral calcium added to corn (150 mg of Ca/100g corn[23]), in making much of the food based on corn and specially "tortillas" which are used instead of bread by most of mexican population. This calcium has a negligible contribution to ^{90}Sr contamination and in considering a uniform contamination of the biosphere, after UNSCEAR and C. L. Comar[2,24] and calcium content in food items commonly consumed in Mexico, transfer factors are shown in Table V. Doses produced by Sr89 for a long period of time are 25 times lower per pCi/gCa than dose produced by ^{90}Sr, and the average concentration guides or working limits for ^{89}Sr and ^{90}Sr in food regardless of the actual quantity consumed are shown in Table VI.

TABLE V						
RELATIONS BETWEEN *Sr-Ca OF VEGETATION (100 *Sr-100Ca) and *Sr-Ca OF MAN						
	% Ca IN DIET		PLANT	DIET	*Sr PER 100Ca IN BODY	
	RURAL	URBAN	PRODUCT	BODY	RURAL	URBAN
Cereals	5	7	1	0.12	0.6	0.84
Other plants	15	19	1	0.12	1.8	2.28
Dairy products	10	35	0.12	0.12	0.14	0.5
Mineral Ca	67	36	0	0	0	0
Total					2.6	3.7
*Sr RADIOSTRONTIUM						

TABLE VI				
RADIOSTRONTIUM DERIVED WORKING LIMITS OR CONCENTRATION GUIDES FOR AVERAGE POPULATION IN MEXICO				
	URBAN DIET		RURAL DIET	
	^{90}Sr	^{89}Sr	^{90}Sr	^{89}Sr
Corn	100 pCi/Kg	$2x10^3$ pCi/Kg	130 pCi/Kg	$3.5x10^3$ pCi/Kg
Milk	130 pCi/l	$3.3x10^3$ pCi/l	180 pCi/l	$4.5x10^3$ pCi/l
Beans	$2x10^3$ pCi/Kg	$5x10^4$ pCi/Kg	$3x10^3$ pCi/Kg	$7.5x10^4$ pCi/Kg
Vegetables	10^3 pCig Ca	$2.5x10^4$ pCi/gCa	$1.3x10^3$ pCi/gCa	

Concentration Guides in Sea Water. The marine food chain to man is not well known in Mexico's coastal waters and the specific activity approach is likely to be the best under this circumstances. Following Kaye S.V. and Nelson D.J.[25] concentration guides in sea water for some radionuclides of interest are obtained using the following:

$$\text{Concentration Guide in sea water } \mu\text{Ci/l} = \frac{2.8\text{x}10^{-3}\ Y_1\ W}{\Sigma EF\ (RBE)n\ Y_2}\left|1+\frac{T_b}{T_r}\right|\left|\frac{1}{1-e^{-\frac{(0.693t)}{T_e}}}\right|$$

Where: Y_1 = concentration of stable element in sea water (μg/l); Y_2= concentration of stable element in organ of reference (μg/g); W = weekly dose limit (annual dose limit/52); ΣEF(RBE)n = effective energy in MeV per desintegration; T_b = biological half-life in days; T_e = effective half-life in years; t = 70 years.

The dose limit used was not affected by the 1/4 safety factor since there are already safety factors included, in omitting the effective half-life and growth factors for every link in the pathway from sea water to man. Data used for calculation were obtained from literature[1,15,26].

For radioisotopes with GI tract as critical organ, since the exposure is due to the absolute concentration of radionuclide in the tract, instead of using the specific activity approach, the method outlined by Aten[27] is used:

$$\text{Concentration Guide } (\mu\text{Ci/l}) = \frac{M\ PC_w\ \text{x}\ 2200}{\left|(0.13\text{x}F_c\ \text{x}\ K_c)+(0.13\text{x}P_f\ \text{x}\ K_p)\right|4\text{x}10}$$

Where: MPC_w = maximum permissible concentration in drinking water for occupationally exposed personnel (168 h)μCi/ml[15] ; F_c = Concentration factor for shrimps[26]; K_c = Shrimp fraction in marine food intake (1, 0.5, 0); P_f = Concentration factor for fish[26] ; K_p = Fish fraction in marine food intake (1, 0.5, 0); 0.13 = Marine food daily consumption in Kg[12].

A survey made by the Instituto de Nutrición, on food intake, of a fishing community, Alvarado, in the same state where the power reactor site is, although not in the same area, is used for calculus, food consumed were fish and shrimps, but no mention is made on the proportion of each, since both were grouped together for survey purposes. Since concentration factor from sea water to edible product are quite different for shrimps and fish, derived working levels or concentration guides were calculated considering fish 100%, shrimps 100% and 50% consumption of each. A factor of 1/10 for individuals in the critical population and 1/4 safety factor are included.

The concentration guides are presented in Table VII.

TABLE VII

DERIVED WORKING LIMITS OR CONCENTRATION GUIDES FOR SOME RADIONUCLIDES IN SEA WATER

RADIO-NUCLIDE	CRITICAL ORGAN	DERIVED WORKING LIMIT OR CONCENTRATION GUIDE IN SEA WATER: SPECIFIC ACTIVITY METHOD pCi/l	CRITICAL PATHWAY METHOD pCi/l: SHRIMP 100%	FISH 100%	SHRIMP 50% FISH 50%
^{54}Mn	GI Tract		2.2×10^{2}	5.3×10^{3}	4.3×10^{2}
	Liver	6×10^{2}			
^{55}Fe	Spleen	1.7×10^{2}			
^{59}Fe	GI Tract		10^{2}	1.6×10^{2}	1.3×10^{2}
	Spleen	31			
^{58}Co	GI Tract		8.5×10^{2}	4.2×10^{4}	1.7×10^{3}
	Whole body	4.6×10^{2}			
^{60}Co	GI Tract		4.2×10^{2}	2×10^{4}	8.3×10^{2}
	Whole body	1.7×10^{2}			
^{65}Zn	Whole body	1.2×10^{2}			
^{89}Sr	Bone	11×10^{6}			
^{90}Sr	Bone	4.7×10^{4}			
^{91}Y	GI Tract			5×10^{2}	
^{131}I	Thyroid	1.1×10^{3}			
^{134}Cs	Whole body	8.7×10^{3}			
^{137}Cs	Whole body	10^{5}			
^{140}Ba	GI Tract			1.6×10^{4}	
	Bone	3×10^{3}			
^{144}Ce	GI Tract		2×10^{4}	1.4×10^{5}	3.7×10^{4}

Action Levels

In order to set action levels, the social cost together with the expected effectiveness in enforcing the corrective measures has to be balanced against the risk reduced, in this behalf a due study has to be undertaken and each place has to be analyzed in itself, and reviewed as changes happen.

In order for the nuclear industry to include the needed safety measures in design it is considered that people are prepared to move from one state into another and in so doing their risk of accidental death will change, varying from 2.1×10^{-4} in Quintana Roo to 11.1×10^{-4} in Colima [3], so for individuals in the population, an increase in 10% the previous risk due to accidental death is acceptable, and action levels for whole body irradiation, should not produce significant early effects in the individuals exposed, a limit of 25 rems to whole body for men and 10 rems for women in reproductive age, delivered in a short period of time, and for organ irradiation, the enhanced stochastic cancer risks, should not be higher than 10% the actual risk from accidental death in Mexico, about 6×10^{-4} in 1969. Action levels for whole body and different critical organs are displayed in Table VIII, together with data on risk estimates considered.

TABLE VIII PROJECTED ACTION GUIDES

	ACTION GUIDE	ENHANCED STOCHASTIC CANCER RISK OF DEATH PER MILLON PEOPLE EXPOSED.
For whole body		
Women in reproductive age	10 rems	
Men	25 rems	
For Thyroid	35 rems	3×10^{-6} per rem for children [28]
		10^{-6} per rem for adults [28]
		1.7×10^{-6} per rem for average mexican population*
For bone	1.5 rem/year	10^{-5} for 0.3-3 rems/year [29]
For lungs	6 rems	10^{-5} per rem [28]

*Mexican Population includes 33% of children under 9 years[3].

Applying action levels in order to get concentration guides in some of the links of the pathway, should be done after studying the population at risk.

Conclusions

On assesing the dose to average population, the common procedure is to survey the environment, by measuring activity in suitable samples and data obtained must be traduced into dose for people exposed, or compared with data set as based on dose limits, in any case, parameters are needed for dose assesment and the values calculated are as good as the actual numbers used.

On the other hand values for parameters are different among different people and it is important, to dedicate some effort in obtaining these parameters and governmental agencies, beside the Nuclear Energy Institute should be encouraged to do research in this field, in order to find for average mexican population physiological and morphological data, on food consumption habits and transfer factors for common food in Mexico. This studies are of importance, specially in areas where nuclear industry will be developed.

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