RADIOLOGICAL PROBLEMS IN KAZAKHSTAN

Kadyrzhanov K. K. and Lukashenko S.N
Institute of Nuclear Physics, Kazakhstan National Nuclear Center

Kazakhstan historical development and available mineral resources have pre-determined a scale of radiological problems in the state. Kazakhstan keeps leading positions in the world in explored uranium resources and hydrocarbon raw. More than five hundred nuclear explosions were performed in various regions of Kazakhstan, following various purposes. Due to this, the following sites are to be referred to the lands of enhanced radiological load:

- the former nuclear test sites (the Semipalatinsk Test Site, Azgir) and sites of implementation of peaceful nuclear explosions;
- waste burials of the uranium exploration;
- sites where hydrocarbon raw is explored.

Let's consider every object more carefully.

Former nuclear test sites

Semipalatinsk Test Site

The Semipalatinsk nuclear test site (STS) covers, partially, territories of three provinces in Kazakhstan: the Semipalatinsk, Pavlodar and Karaganda provinces; its net area comprises about 18 500 km^2. Five basic test zones are located at this territory: «Experience Field» «Degelen», «Balapan », «Murzhik» and Telkem». In the Experience Filed atmospheric nuclear tests were conducted including both the ground and air nuclear explosions. In the rest test zones underground nuclear explosions had place, including both the camouflet and excavation ones (i.e., with outburst of ground).

For the last five years, the Kazakhstan Institute of Nuclear Physics undertook a large scope of activities concerning investigation of the nature and scales of contamination in STS.

Up to date, the most hazardous radiation-contaminated areas in STS have been characterised, the main parameters that determine both extent of radiation danger and stability of the current ecological situation have been determined. By a character, scales of contamination and sorts of dominating radionuclides, all contaminated areas at the test site can be divided into three general types:

- the areas of surface contamination occurred as a result of the performed ground and air nuclear explosions;

- the areas contaminated as a result of implementation of the excavation and emergent underground explosions;
- the head well areas with manifestation of water.

In Table 1 a list of the classification parameters and its ranges for every type of selected contaminated areas is presented.

Table 1 - Classification of the contaminated areas at the SNTS

Classification parameters	Tunnels with water (Degelen)	Excavation and emergent explosions	Ground and air explosions
Main Radionuclides	^{90}Sr, ^{137}Cs	Pu, ^{241}Am, $^{152,154}Eu$, ^{60}Co	^{137}Cs, ^{90}Sr, Pu, $^{152,154}Eu$, ^{60}Co
Level of soil contamination up to (Bq/kg):			
^{137}Cs	n*10^{6}	n*10^{3}	n*10^{3}
^{90}Sr	n*10^{5}	n*10^{3}	n*10^{3}
$^{239+240}$Pu	n*10^{3}	n*10^{5}	n*10^{3}
Range of the isotopes ratio:			
$^{137}Cs/^{90}Sr$	$10^{-3} - 10^{2}$	$10^{-1} - 10^{1}$	$10^{-1} - 10^{1}$
$^{239}Pu/^{137}Cs$	n*10^{-4} – n*1	1 - 10^{2}	1 – 10
The average square of contaminated spots (km^2)	< n*10^{-1}	< n*10^{-1} (except Balapan lake)	n*10^{2}
Migration capacities of radionuclides	ion-forms in water, high capacities	strongly bounded	strongly bounded
Potential migration pathway	with water flow, carrying out with plants, wind spreading of plants ash	wind re-suspension	wind re-suspension

Tunnels with manifestation of water in the Degelen mountain

In the mountain range Degelen 209 nuclear tests were performed in the horizontal tunnels. Although the greatest mass of radioactive products is accumulated here, in caverns, radionuclides, still, escape onto the day surface with the water flowing from the tunnels. Although the concentrations of artificial radionuclides (isotopes of plutonium, strontium-90 and cesium-137) in the flowing water are relatively low (less than n*10^{-1} to n*10^{2} Bq/l), at a sufficiently high volume of the flowing water, the soils of the head well areas gradually are

getting considerably contaminated. The main contaminators are strontium-90 and cesium-137; its levels of concentrations reach several million of Becquerels per kg. The isotope ratio in soils of the head well areas noticeably varies versus the distance of the tunnel mouth head, and strontium-90, propagating over large distances, plays a stronger part as the distance increases. Contamination is accumulated along the riverbed. The range of radionuclide propagation depends on the migration capability of a nuclide, the tunnel "age", the volume of flowing water and the physical and chemical properties of underlying soil, comprising, in maximum, 2.5 km (the tunnel 609). In the direction perpendicular to the riverbed, contamination propagates not larger than several dozens of meters, considerably depending on a local relief. Radionuclides in water are, mainly, in ion forms, resulting in the high radionuclide concentration revealed in plants growing in the tunnel head areas, Bq/kg: $^{239+240}$Pu – n*10^3, ^{90}Sr – n*10^4, ^{137}Cs –n*10^5. The detected abnormally high coefficients of radionuclide transition in a system "soils-plants" create favourable background for radionuclide ingress to organisms of animals and people.

Thus, radiological situation is unstable and has a tendency for getting worse. At present the activities on tunnels conservation have been completed. These actions, to a definite extent, have removed threat of further contamination of the surface; however, probability of further water manifestation and accompanying contamination is rather high.

Excavation and Emergent Explosions

The main feature of radiological situations in the areas were the excavation and emergent explosions were performed is high concentrations of transuranium elements (***$^{239+240}$Pu, ^{241}Am***) and the activation products (***^{60}Co, ^{152}Eu, ^{154}Eu***). The contamination is of local character: the dominant amount of radioactive radionuclides is, mainly, in a formed funnel or near it. As a rule, the main part of radionuclides is in big soil fractions, being strongly bound to the substance of the soil matrix. So the current radiological situation is stable.

Ground and Air Explosions

The air and ground tests have led to contamination of large areas. However, the average level of contamination isn't high and over the main area it doesn't exceed first thousand of Becquerels per kg. There is no any dominant type of contaminator; both the decay products (strontium-90 and cesium-137) and radionuclides of fissile substances (plutonium isotopes) are present in equal concentrations.

The AZGIR test site

In total, for period from 1966 to 1979 seventeen explosions of various powers were performed in 10 technological areas in wells in the depths from 165 to 1500 m. Nine caverns of the primary net volume comprising about 1.2 million cu. m were created. In the well denoted as A2 seven nuclear explosions were performed. In nineties, in the firing well head areas the remediation actions were undertaken. At present, residual contamination by radionuclides in the form of small local spots is observed. Its total area doesn't exceed n*10^3 m^2. By results of the

works performed in 1999-2000, a conclusion was made that the radiological situation in the inhabited localities situated at the lands adjacent to the test site is stable, normal and is characterised by the parameters typical for a local region in question.

Sites of performed nuclear explosions

From 1997 to 2000, the Institute of Nuclear Physics carried out radiological studies in the sites of performed peaceful nuclear explosions: facilities «LIRA», «Batolit-2», «Region-3», «Mangyshlak», as well as in the Kaztal, Zhanibek and Urdinsk regions of the Western Kazakhstan province and the sites situated within the range of potential impact of the test sites «Kapustin Yar», «Azgir», «Region-3». In the investigated sites the radiation situation is, as a rule, normal. Sometimes local spots of contamination are available of the areas not greater than several hundreds of sq. km. Also it should be noted that, due to special attention paid by government, publicity and world scientific community to radiological problems in the former nuclear test sites, these lands are controlled, being in focus of special interest.

Burial sites of the uranium exploration

The tail waste repository Koshkar Ata

Radiology of the regions where uranium is explored is paid much less attention. A scale of the problem can be exemplified by the tail waste repository Koshkar Ata. The repository *Koshkar Ata* represents drain-free lake used for settling industrial, toxic, chemical and radioactive waste, ordinary drains and is situated 5 km to the north of Aktau town (the Mangistau province) located, in turn, in the shore of the Caspian Sea. In the tail waste repository, beginning with 1965 and up to now, industrial waste and solid non-purified ordinary drains, including the waste of the chemical mining metallurgic plant, waste of uranium exploration, are stored. The total area of the repository comprises 56 km^2. For the last years, due to economical troubles in some enterprises, earlier added liquid waste to the repository, the inflow of liquid to it is stopped. Balance between the liquid volumes entering and evaporating from the lake is broken. As a result, this lake is getting shallower, bottom sediments, represented by the waste of the phosphate and uranium raw, are naked. The net area of the naked part of the lake comprises about 11 km^2.

The outcomes of the activities undertaken by the Institute of Nuclear Physics in 1999 showed that the exposure dose rate (EDR) throughout the shallow part of the repository comprises 80 to 150 μR/hour. The areas where EDR reaches 1500 μR/hour were revealed. Concentrations of such toxic natural radionuclides as ^{226}Ra and ^{210}Pb reach the values 10000 and 2700 Bq/kg respectively.

Sites of hydrocarbon raw exploration

The sites of hydrocarbon raw exploration refer to the third type of radiation hazard. Accumulation of natural radionuclides, mainly, radium on the inner surfaces of the technological equipment of the oil exploration industry leads to an increase in the exposure dose

rates, reaching 10000 μR/hour. However, the level of radiation control at these enterprises is minimal. With the increasing volume of explored hydrocarbon raw taken into account, one can deduce that solution of radiological problems in these areas will be first-priority task in Kazakhstan.

In 1992 to 1996 the team of Kazakhstan scientists carried out the large-scale studies of radiological situation in a number of sites of the Western Kazakhstan. The objects of investigation were the areas of single deposits of oil and gas or a group of deposits throughout the territories of the three biggest oil-exploring companies: JSC «Mangistaumunaigas», «Embamunaigas» and «Tengizmunaigas», with application of the techniques of the field/air gamma survey. The net area of the examined lands comprises about 3000 km^2.

317 radioactive abnormalities were revealed throughout the territories of the company activities. 267 of them were classified as the sites of man-caused radioactive contamination (SRC). The overwhelming majority of SRC, by the gamma emission ERD levels, refer to the 1-st category low-activity waste (EDR from 100 to 30000 μR/hour). As for a character of contamination, the determined objects can be divided into four types, Table 2.

Table 2. Characteristics of the radioactive contaminated spots

Type of contaminated spot	Quantity	Average square of one spot (m^2)	Maximum of the EDR, (μR/h)
Fields of oil-associated water "evaporation"	179	$n*10^2$	1000-3000
Scales, oil-sludge accumulations	31	$n*10^1$	5000-6000
Technological metal wastes	42		10000
Acting technological equipment			17000

Comparative analysis of radiation-hazardous sites

On a base of comparison between existing sources of radiological danger, with such "unphysical" parameters as a population density in a place of radiation-danger object location and its accessibility taken into account, the following conclusions can be made:

- radiological problems on places of nuclear explosions aren't too; however, unfortunately, too much attention is paid to them;

- the focus of attention is to be re-oriented to examination of radiological problems of the sites where release and re-distribution of natural radionuclides occur as a result of industrial activities. Special attention should be paid to the oil exploration sites, especially taking account increasing volumes of exploration and the nearness of these site to the inhabitants localities.

CONCLUSION

There is necessity to carry out remediation actions at the former test sites of Kazakhstan, especially at the Semipalatinsk test-site (STS). But because of the high cost of such actions it should be expedient to carry out them only in case of emergency and inclusion of the former test sites lands to the national economic activity, as in general, under conditions of competent policy of inhabitants, STS doesn't represent a hazard. At the same time, we ought not to lose an invaluable scientific material of test-sites. It is necessary to keep some areas of Semipalatinsk test-site as a rarities, reflected the important stages of the human evolution. Test-sites should be considered as world laboratory for studies of artificial radionuclides behaviour in natural medium.

Illustrations of radiation-hazardous objects, of used technologies and procedures, under the Kazakhstan Republic instance, show that main power industries lead to the common increase of radioactivity materials in human environment. Mankind certainly will become aware of fact that industrial activities, under the current level of science and technologies development, will lead to the common increase of radioactivity materials in human environment.

Solving of radioecological problems is possible only when people review their approach to a radioactivity, as a whole. Not only specialists involved in this field, but also all local population have to know rules of radiation safety and how reasonable manage with radioactive materials.