

# **Exposure of animals and their products to radiation.**

## **Surveillance, monitoring and control of national and international trade**

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*Summary: The major sources of radiation are identified and an indication of their effective dose equivalent is given. The different routes of exposure to ionising radiation are discussed together with the molecular, biological and clinical effects of radiation on livestock.*

*The requirements, aims and strategies of surveillance schemes are considered together with those of monitoring programmes designed to support them. Particular reference is made to the role played by surveillance schemes and monitoring programmes in assessing the nature and distribution of radionuclide deposition in different countries from the plume of radioactivity released during the accident at Chernobyl.*

*Protective measures taken by countries to control the entry of radionuclides into the human food chain after the accident at Chernobyl are discussed and their effects on national and international trade are reported.*

**KEYWORDS:** Animal products - Contamination - Domestic animals - Environment - Public health - Radiation - Radioisotopes.

### **INTRODUCTION**

Recent events at Chernobyl have focussed attention on the effects of radiation on animals and animal products. In 1959 the OIE considered the implications of nuclear energy for Veterinary Services. At that time atmospheric testing of nuclear weapons was in progress, and deposition of radioactive nuclides from these tests was occurring in most, if not all, parts of the world. The accident at the nuclear reactor in Windscale, UK, had only recently occurred. Accidents at nuclear installations such as Three Mile Island in the USA and Chernobyl in the USSR were yet to come. Public awareness of the destructive power of nuclear energy was high at that time but peaceful uses were probably not so widely known. The use of nuclear power to generate electricity was still at an early stage. Data on the biological effects of radiation were sparse, and the public had little idea of long-term effects of small doses of radiation.

At the time of the 1959 meeting, the maximum permitted annual levels of radiation to man were 50 millisieverts (mSv), which represented a steady decline from 728 mSv

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per annum in 1931 (Table I). Today an annual dose of 5 mSv is accepted in some countries, and the International Commission on Radiological Protection (ICRP) has now recommended that the permitted doses from all sources over a lifetime (excluding natural background and medical radiation) should not exceed an average of 1 mSv for each year of life.

**TABLE I**  
*International System of Units*

Measurement	Unit & Symbol	Other SI Units	Old Unit	Conversion Factor
Activity	Becquerel (Bq)	$S^{-1}$	Curie (Ci)	$1 \text{ Bq} = 2.7 \times 10^{-11} \text{ Ci}$
Absorbed dose	Gray (Gy)	$J \text{ kg}^{-1}$	Rad	$1 \text{ Gy} = 100 \text{ rad}$
Dose equivalent*	Sievert (Sv)	$J \text{ kg}^{-1}$	Rem	$1 \text{ Sv} = 100 \text{ rem}$

\* Dose equivalent = Absorbed dose  $\times$  quality factor for the type of radiation

Quality factor = 1 for beta particles, gamma and X-rays

Quality factor = 20 for alpha particles.

Veterinary Services have a major role to play in protecting the public as far as is reasonably possible from exposure to radioactive contamination from animals and their products.

This presentation considers:

1. Effects of radiation on animals
2. Surveillance schemes
3. Monitoring procedures
4. Effects of protective measures on national and international trade.

## THE EFFECTS OF RADIATION ON ANIMALS

### Background radiation

A continuous, life-long exposure to natural background radiation occurs from four main sources: cosmic radiation, external gamma-radiation from the earth's crust, internal irradiation from natural radionuclides in the tissue, and inhaled radon and its decay products (Table II). Cosmic radiation is relatively constant for any one location, although there may be occasional variations from solar flares. There are more marked variations with latitude and altitude. External radiation from radionuclides in rocks and soil varies considerably depending on the radioactive content of materials and the local geology. Small quantities of natural radionuclides are present in food and water and these irradiate the body internally. Radon and its decay products are produced principally from radium-226 compounds in the ground and construction materials.

TABLE II

*Average annual effective dose equivalents in the UK  
from radiation of natural origin (22)*

Source	mSv
Cosmic	0.31
Terrestrial gamma-rays	0.38
Radon decay products	0.80
Other internal radiation	0.37
Total	1.86 mSv

Radiation doses from different sources are additive. Besides background radiation, animals may be exposed to radioactivity from:

1. human activities (nuclear power plants, hospitals, etc.)
2. medical exposure (radiography for fractures, etc.)
3. accidental exposure (accidents at nuclear power plants).

Table III gives a list of the annual average doses received by the population in the United Kingdom. The figures were produced in 1981 by the National Radiological Protection Board (NRPB). The NRPB is an authoritative reference centre set up by the UK Parliament in 1970.

TABLE III

*Average annual dose to the population of the UK*

Source	mSv
Natural	1.860
Medical	0.500
Occupational	0.009
Discharges	0.003
Fallout	0.010
Miscellaneous	0.008
Total	2.390 mSv

Exposure from natural radiation (1.86 mSv) dominates all other types, with medical procedures (0.5 mSv) being the major artificial source of exposure for the population as a whole. All the other sources contribute very little.

Under normal farming conditions the accumulative dose is well within the internationally agreed safety limits for man. In peacetime, accidental exposure would be the only source of radiation likely to endanger animal health or the safety of animal products.

### Subcellular effects of radiation

Radiation damage is caused by the transmission of energy to the target cell by alpha- and beta-particles or gamma-rays emitted from the nuclei of radioactive atoms as they disintegrate. Molecules within the target cells absorb this energy and undergo ionisation and/or excitation (10). Ionisation can lead to the production of free radicals which are chemically highly reactive. These ionisation events are thought to be the principal cause of radiation effects in living tissues. However, the role of excitation in the induction of biological damage is not clearly understood.

The direct and indirect effects of radiation upon molecules result in the wide range of biological alterations seen in irradiated living organisms. At the molecular level, ionisation can damage macromolecules such as enzymes, RNA and DNA and interfere with metabolic pathways. This in turn can damage cell membranes surrounding the nucleus, mitochondria and liposomes for example. At the cellular level this can lead to inhibition of cell division, cell death and transformation to a malignant state. Disruption of systems such as the central nervous system, the bone marrow and intestinal tract may lead to the death of the animal.

The quantity and quality of the biological damage depend upon the chemistry of the radionuclides involved, the dose of radiation, the rate at which it is given, and the distribution of the dose in the tissues. The size, physiological state, and age of the animal as well as environmental conditions are all important factors which can affect the degree of radiation damage (1, 6, 10).

### External exposure

The irradiation of animals may occur from external or internal sources or both. The major external source is gamma-radiation from the deposition of radionuclides. Animals in the open may also receive localised beta- or even alpha-radiation to the skin from fallout particles landing on and adhering to hair, fur or skin.

The dose required to kill 50% of an exposed group of animals within 60 days is referred to as the LD<sub>50/60</sub> dose (2, 3, 9, 31). In most studies the relevant dose is delivered within the first 4 days of irradiation (1, 4, 9, 19). Table IV summarises the relative susceptibility of livestock to irradiation. Poultry are more resistant than sheep or cattle (4).

TABLE IV

*Mean lethal dose (LD<sub>50</sub>) 60 days after exposure of farm animals to gamma-radiation alone (external) and in combination with beta-radiation (external + internal)*

	Total gamma exposure (Sv)	
	Whole body	Whole body + skin + gastro-intestinal
Cattle	5.0	1.8
Sheep	4.0	2.4
Pigs	6.4	5.5*
Horses	6.7	3.5*
Poultry	9.0	8.0*

Data from Bell, Sasser & West (4)

\* Estimates based on anatomy, grazing habits and physiology of species.

Early symptoms include a severe drop in blood platelets so that blood may be lost into intracellular spaces and from the respiratory and gastro-intestinal tracts as a result of blood clotting failure (2, 11). Increased capillary permeability also contributes to loss of blood cells, plasma and electrolytes. Low white cell counts sometimes accompanied by pyrexia and bacterial invasion also occur (4, 11, 23). If the amount of radiation is below the lethal dose, most animals have the capacity to recover. More severe exposure is accompanied by gastro-intestinal syndrome (diarrhoea due to loss of mucosal cells) (32). A cerebral syndrome due to damage of the nerve tissue (1, 24) may also occur in some animals. Few, if any, animals experiencing these symptoms would be expected to survive. As far as the general health of large animals is concerned, the consequence of gamma-irradiation will generally be of more significance than the effects of beta-irradiation from radionuclides deposited in the environment (2, 3). Nevertheless, it is possible that the beta-dose from fallout deposited on pastures may be sufficient to damage the sensitive areas of the animal such as mucosae of the udder, eyes, nose and mouth (7). Injury to the skin due to fallout irradiation was observed in cattle exposed at Alamogordo (USA) in 1945 (8). The injury appeared in the form of thermal burns. In some animals, squamous cell carcinoma of the skin on irradiation-damaged areas occurred 15 years after the exposure (8).

### **Internal exposure**

Internal sources of radiation are the result of animals grazing contaminated pastures and inhaling radionuclides. Inhaled beta- and alpha-emitters irradiate the lung mucosa, while gamma-emitters irradiate the whole body.

The ingestion of contaminated herbage results in the exposure of the digestive tract. Relatively few of the radionuclides are absorbed during digestion; most of the radioactivity therefore passes through the gastro-intestinal tract without entering the bloodstream (15, 16, 17, 28). During transit, local irradiation of the gut wall by beta-particles may occur and gamma-rays may irradiate the whole body (4, 26, 32). Damage to the gastro-intestinal tract depends on the radiosensitivity of the particular tissue exposed, the concentrations of the activity at various points in the gut, and the transit time (5). The rumen and abomasum are critical organs. In the experimental cases where damage was localised in these organs and found to be acute, no gross damage was observed in the large intestine (4).

The small number of radionuclides that enter the bloodstream can be distributed throughout the body or localised in specific tissues depending upon their chemical properties and metabolism (15, 25, 27, 28). Investigations on the metabolism of caesium-137 in dairy cows (25) have shown that it is widely distributed throughout the body and behaves like potassium. The nuclides of caesium will therefore effectively administer a dose of whole-body irradiation, and their effects will be similar to those of a dose of whole-body irradiation administered from an external source. Iodine-131 behaves like stable iodine and is concentrated in the thyroid. Consequently, this tissue will receive much larger doses of radiation than any other in the body and is more likely to be damaged when sheep or cows ingest iodine-131. The acute toxicity of iodine-131 has been studied in sheep and in cattle (18, 21). The findings are summarised in Table V. The thyroid gland of the sheep is more sensitive than that of the cow but doses of many tens of Sv, delivered at a dose rate of 10 Sv per day, are required to cause any moderate damage. Moderate damage to the thyroid glands of sheep or cattle results in only slight and temporary impairments to their general

health. Cattle receiving doses sufficient to destroy their thyroid glands nevertheless survived and remained fertile, but their lactations decreased by more than 50% (18).

**TABLE V**  
*Effects of irradiations of the thyroid gland of cattle  
by iodine-131*

Dose (Sv)	Dose rate per day	Effect
300	15	None observed
700	30	Follicles slightly hyperplastic
2,000-3,000	100-150	Extensive necrosis of thyroid myxoedema but no haematological changes. Reduced milk yield. No impairment of fertility.

Data from Garner, Sansom, Jones & West (18).

Animals are much more susceptible when irradiated from a combination of sources (e.g. from an external source, from deposition on their skin and from ingested radionuclides) than when they are irradiated from a single source (e.g. whole-body irradiation from an external source) (Table IV).

### Effects on reproduction

The reproductive performance of cattle exposed to the first atomic bomb at Alamogordo (USA) was not affected. Beef heifers exposed to 2-4 Sv of radiation demonstrated no long-term loss of reproductive performance for survivors 8 years post-irradiation (8). Over twice the lethal dose level administered directly to the ovaries would be required to sterilise females (12, 13). Studies of the effects of total-body irradiation (4-8 Sv) on sperm production in bulls, boars, rabbits and rodents have shown no evidence of inducing permanent sterility (1). Several long-term investigations have been performed in mice to investigate the long-term effects of small doses (28, 29). In one investigation each of 55 generations of male mouse progenitors received an acute dose of 2 Sv (28). When the fertile life and weaned litter sizes were compared with a non-irradiated control group there were no significant differences. During gestation the embryo is very sensitive to radiation at the periods when the limb buds are forming. In cattle this corresponds to gestation days 32-34 and in sheep to gestation days 22-24 (14, 20). In pregnant females irradiated with 1 Sv or more during this period of gestation, there is a high percentage of bone deformities in the offspring (14, 20).

The doses of radioactivity necessary to endanger animal health would be expected to occur only in the immediate vicinity of a major accident involving a nuclear reactor or in the event of an uncontrolled detonation of a nuclear device. The radiation doses from the exposure of farm animals to controlled emissions from nuclear power stations, and the dose in non-Eastern bloc countries from the deposition of radionuclides released during the accident at Chernobyl, are many orders of magnitude lower than those that would be considered a hazard to animal health.

## SURVEILLANCE SCHEMES

In addition to maintaining the health and welfare of livestock, the veterinarian must also consider radioactivity entering the food chain in the form of animal products contaminated with radionuclides. Absorption of certain radionuclides from the gastrointestinal tract and their transfer to edible tissues and milk occurs in ruminants grazing contaminated pastures (15). Radionuclides of caesium, for example, are distributed throughout the animal and could enter the food chain if contaminated tissues are consumed. Experiments with mixed fission products collected from trials of nuclear weapons have demonstrated that the radionuclides that are transferred to any significant extent from the cow's diet to its milk are iodine-131, tellurium-132, strontium-90, barium-140, and caesium-137 (16, 30). Of these radionuclides iodine-131, caesium-137 and strontium-90 are the most biologically significant. Milk is still a major constituent of the human diet in many countries and young children are most at risk from consuming contaminated milk.

It is desirable to carry out surveillance on the levels of radionuclides entering the human food chain and, if any increase is detected, to implement more intensive monitoring programmes in order to ensure that public health is not endangered.

Surveillance schemes and strategic planning depend upon each country's perception of the problems posed by the release of radionuclides, along with political constraints, trade considerations and available resources.

In countries where surveillance schemes are in operation, government agencies monitor air, dust, soil, water and agricultural produce for the presence of radionuclides. In coastal countries, marine life and sediment may also be examined. This is usually organised on a network basis and may include the services of the Air Force for altitude sampling. When necessary, other bodies including universities, commercial laboratories and nuclear power stations are included.

The role played by different Veterinary Services in their national surveillance schemes varies considerably. In England and Wales, for example, the State Veterinary Service is responsible for the analysis of dairy and agricultural produce on a regular basis; in Canada routine examination of animals does not occur, but animal produce is included in a sampling programme undertaken by the Health Protection Branch; in the Philippines exposure of animals to radiation is monitored indirectly by monitoring the animals' environment.

The aim of surveillance schemes is to obtain data on the levels of radionuclides entering the human food chain. Information is required for different commodities from representative areas, and a central system of collation and evaluation is necessary. Since any incident involving the release of radioactivity is likely to be unique, the surveillance programme needs to be flexible to allow sufficient data on relevant commodities to be obtained rapidly. In order to respond to an incident, it is necessary to identify which radionuclides were released, where deposition occurred and in what quantity. This information enables an assessment to be made of the nature and location of contaminated produce, the likely consequences of this contamination and the identification of critically exposed groups within the community.

In England and Wales, for example, a surveillance programme is in operation which involves the collection and analysis of samples from the vicinity of each of the 17 licensed nuclear sites. These include nuclear power stations, research

establishments, laboratories involved in the commercial production of radionuclides and the Sellafield plant involved in the full-scale reprocessing of radioactive waste. The programme aims to quantify the emissions from the sites and to assess exposure from ingested foodstuffs to the local population. The first phase of this programme covers licensed sites which have gaseous emissions. Once the scheme is fully operational, monitoring will be extended to dockyards, industrial and other miscellaneous operators. A similar programme operates to assess emissions into coastal waters.

The principal samples collected are those in the ingestion pathway to man. Milk comprises the majority of samples, with some 6,200 collected annually. Crop and vegetable samples are collected as available, animal tissues and a small number of soil and faeces samples are also taken. All samples are sent to the Central Veterinary Laboratory (CVL) and analysed for those radionuclides likely to be present in the vicinity of each particular site. A central unit in London collates and assesses data produced at CVL together with that produced at the laboratory responsible for monitoring the aquatic environment.

The surveillance programme was expanded to monitor produce on a national basis when radionuclides released from Chernobyl were deposited in the UK. Early surveillance data together with information on wind conditions and rainfall were used to identify areas where deposition occurred and to plan a sampling strategy. With the data obtained from the sampling, a map of radioactive deposition in the UK was produced. Fallout varied to a considerable extent within the UK as it did within other countries as well. Norway, Sweden and Switzerland also produced maps of radioactive deposition using data from their network of monitoring stations.

## MONITORING

Appropriate analytical procedures should be available to ensure that surveillance programmes can adapt to any situation. Facilities should exist for the determination of alpha-, beta- and gamma-emitting radionuclides. The specifications of the monitoring procedures will depend upon the objectives of the surveillance programmes. Procedures can range from gross techniques where many radionuclides can be measured at any one time, to analytical schemes involving separation and measurement of individual radionuclides. Gamma-ray spectrometry can be used to measure gamma-emitters. The technique requires only a minimum of sample preparation; by using an interactive computer programme, a spectrum can be compared against reference spectra in the data base. Iodine-131, caesium-134 and caesium-137 can be measured in this way. Radiochemical analyses are required for the determination of low energy beta-emitters such as tritium, carbon-14 and sulphur-35. The measurement of alpha-emitting radionuclides, such as plutonium, americium and uranium can be achieved by alpha-spectrometry but, in contrast to gamma-spectrometry, chemical separation and preparation are required before the sample can be examined. In general, if low levels of detection are required, then long counting times are necessary. This must be balanced against the number of samples to be examined and the resources of the analytical laboratory.

The major radionuclides deposited from the plume of radioactivity from Chernobyl were iodine-131, caesium-134 and caesium-137. Deposition of smaller amounts of other radionuclides including ruthenium-103 and strontium-90 were also reported by

some countries. The detection of iodine-131 in samples of air and pastures indicated that intensive monitoring of milk would be necessary. Since iodine-131 can be detected in milk within hours of ingestion, analyses of milk formed a major part of monitoring programmes immediately after this radionuclide was identified. Iodine-131 enters the food chain very rapidly and concentrates in the thyroid of consumers. Milk from sheep and goats tended to contain higher levels of iodine-131 than cow's milk (15). Dairy produce and milk products were also examined mainly for iodine-131 but subsequently for caesium-134 and caesium-137.

As patterns of contamination emerged in different countries and as the radiobiological significance of iodine-131 subsided, the emphasis of the monitoring programmes began to change. The increasing levels of caesium-134 and caesium-137 in the muscle of grazing animals alerted scientists to a second potential problem area, and there was a general intensification in monitoring meat from cattle and sheep. In addition some countries included fish, game, goats and reindeer in their monitoring programmes. Other foods included crops (as they came into season), fresh fruit, honey, leafy vegetables and root-crops. In many cases gamma-spectrometry was used to monitor these commodities since it enabled adequate detection levels to be achieved with maximum sample-throughput. Whole-body monitoring of live animals has also been used.

## **EFFECTS OF PROTECTIVE MEASURES ON NATIONAL AND INTERNATIONAL TRADE**

Once a problem has been identified, actions may need to be taken to ensure that radioactivity entering the human food chain is at an acceptable level. When determining what levels are acceptable it is necessary to consider the most vulnerable sector of a community in order to ensure that individuals are not exposed to levels of radiation likely to cause them harm. The advice of organisations such as the International Commission on Radiological Protection is often taken when drawing up tolerance levels for exposure through the human food chain. Such levels will take into account the dose of radioactivity to which individuals may already have been exposed and their anticipated future exposure levels. Data on national diet including the amount and frequency of consumption of different foods are important in assessing exposure and in setting safety limits for radionuclides in different commodities. Local differences will arise as traditional patterns of food consumption vary. Safety limits may vary considerably from country to country, reflecting national diets and different social values.

Trade controls can lower the exposure of a community by containing the problem. This can be achieved on the national level by controlling the movement of animals and/or products from contaminated areas. The strategy at the international level is reversed: the aim of each country is to control the entry into the home market of contaminated animals and their products. How and when such measures are applied often depends not only upon the circumstances of the environmental contamination but also upon their cost-effectiveness.

### **National trade**

In response to contamination from Chernobyl, several countries recommended that farmers should defer the slaughter of sheep and goats. Countries such as Norway

and the UK took protective actions to reduce caesium-134 and caesium-137 entering into the human food chain from meat. Norway controlled sheep, goats, cattle and reindeer. The UK controlled sheep. In both cases the key element was the designation of zones within the country based upon monitoring data. In Norway there were Free Zones (no restriction on slaughter) and Ban Zones (animals slaughtered but not approved for human consumption). The UK imposed restrictions on the movement and slaughter of sheep in certain Designated Areas. All other parts of the UK were free from restrictions. The policy aimed to prevent animals in Designated Areas from entering the human food chain until it was safe for them to do so.

A special low radioactivity feeding regime was established in Norway when animals were moved from mountain pastures to Special Measures Zones. The UK faced a problem in early August when lambs from Restricted Areas were ready for store sales and movement off to other pastures for fattening. Farmers within Designated Areas did not have fodder available to keep them without jeopardising their winter supplies. This led to the introduction of the Mark and Release Scheme in which sheep were clearly marked and released for market. Sheep from restricted areas could be identified and were banned from slaughter until the restrictions in the Designated Areas from which they came were lifted. In some areas it was likely that restrictions would be lifted quickly, while in others it was anticipated that it would take longer for radioactivity to reach acceptable levels. Designated Areas were therefore subdivided into Low Deposition Areas (where restrictions were expected to be lifted quickly) and High Deposition Areas (where restrictions were expected to be imposed for a longer period). Both Sweden and the UK undertook to compensate producers for losses caused by radioactivity.

The strategy of controlling the flow of animal products from a contaminated area had previously been adopted in the UK in 1957 following the Windscale accident. Iodine-131 was the principal radionuclide released, and milk from cattle in the vicinity of the accident was withheld. After the accident at Chernobyl, Switzerland recommended that children under 2 years old, pregnant women and nursing mothers should change from fresh milk to milk products prepared before the accident. Local action was taken in parts of Italy to prohibit the consumption of fresh milk and dairy products, and Cyprus banned sheep milk from immediate consumption.

### **International trade**

Regarding international controls, it is important that the importing country prescribe tolerance levels of radionuclides for each of the food items it imports. These levels should be communicated to the countries with which it trades; where appropriate, the procedures used to measure them should also be stated. These levels are likely to vary from country to country, as previously mentioned, but it would be reasonable to expect that the limits used to control imported food should be no higher than those used to control the home food supply.

The control system used will depend upon the requirements and resources of the importing country, but it should:

- a) be capable of rapid implementation
- b) allow for rapid clearance at ports
- c) provide quantitative data on the levels of radionuclides in specific food items
- d) be acceptable to trading countries
- e) be effective.

The exposure of countries to the plume of radioactivity released from the reactor at Chernobyl was, and still is, difficult to assess. Public concern in Greece and parts of Italy was such that immediate local action was taken. Some of these actions may be difficult to substantiate scientifically but they were necessary politically because of widespread uncertainty and fear of the unknown hazard. Lack of information and poor communication triggered restrictions and counter-restrictions on international trade. Germany banned Italian vegetables, Italy banned German milk, members of the EEC took national measures regarding imports from the Eastern Bloc. The EEC Commission tried to mediate by proposing community standards. The variation in degrees of exposure, the desire of countries to be seen as taking protective action, and the lack of information on the levels of contamination in different countries, particularly in the Eastern Bloc, led to the inevitable compromise. The proposed levels for iodine-131 were conservative and have been criticised scientifically, but the levels for caesium-134 and caesium-137 which were introduced later were considered more realistic at 600 Bq/kg for general foodstuffs and 370 Bq/l for milk. The Euratom scientists advised the EEC Commission that a level of 1,000 Bq/kg of caesium-134 and caesium-137 was a generally appropriate level for the major elements of diet.

In the meantime, Jordan banned imports from all countries thought to be contaminated, Italy banned imports from Austria, the Eastern Bloc, Scandinavia and Switzerland, Cyprus rejected some exports from the USSR and Bulgaria, Sri Lanka destroyed individual consignments from Europe, and trade representatives from Austria, Belgium, Denmark, France, Holland, Sweden and Switzerland gave a joint press conference in Taiwan to assure local consumers of the wholesomeness of the products imported from these countries. At the time of writing, certain countries are testing imports on arrival, others accept a certificate to guarantee that exported animals and their products are within the safety limits specified by the importing country and some are relying on the goodwill and the sense of responsibility of the exporting country.

In conclusion, the events associated with the accident at Chernobyl have clearly demonstrated the need for:

1. regular monitoring to establish base-line radiation levels that can be used in assessing the magnitude of an emergency;
2. establishing action levels for radionuclides in major food commodities;
3. rapid international exchange of information on nuclear accidents and their consequences;
4. comprehensive contingency arrangements which can be implemented at short notice;
5. responsible and informed press coverage to avoid unnecessary public concern;
6. improving the general level of understanding of radioactivity.

Let us ensure that these lessons of Chernobyl are put to good use.

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