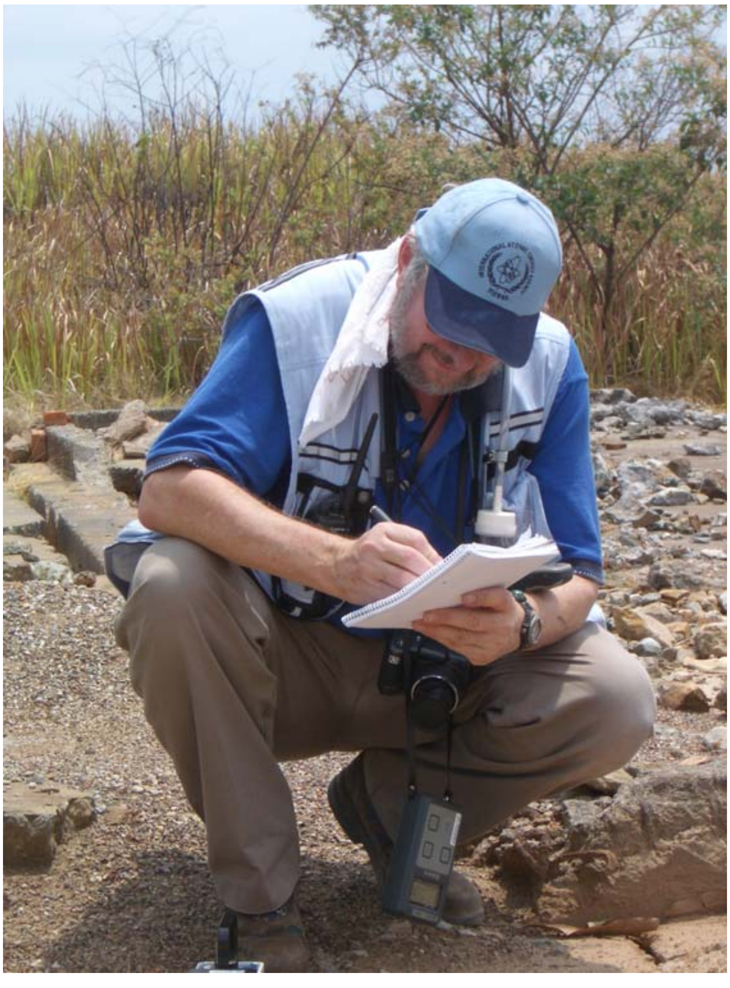
International Atomic Energy Agency

Radiological Report on an Inter-Agency mission to the Shinkolobwe mine site

Democratic Republic of Congo

24 October to 4 November 2004



(Photo: Rene Nijenhuis, Joint UNEP/OCHA Environment Unit)

Prepared by:

Peter Waggitt

16 November 2004, Vienna

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1. History of involvement of IAEA

In July 2004 the Emergency Response Centre of the Division of Radiation, Transport and Waste Safety (NSRW) of the International Atomic Energy Agency (IAEA) received a request for information and assistance from the joint United Nations Environment Programme/Office for Coordination of Humanitarian Affairs (UNEP/OCHA) Environment Unit regarding reports of a collapse at the site of the former uranium mine at Shinkolobwe in Katanga province of the Democratic Republic of Congo. The request was passed to the Decommissioning and Residues Unit of the Waste Safety Section of the NSRW for action.

The main concerns of the UN staff in Lubumbashi, the office closest to the Shinkolobwe mine site, were various but included the possibility of the miners having been exposed to harmful levels of ionising radiation, the possibility of uranium having been mined illegally and the radiation safety risks associated with the transport and storage of potentially radioactive material mined from the site. For these reasons it was agreed that an Agency Waste Safety Specialist would join the multi-skilled mission team being assembled by OCHA/UNEP from Geneva and accompany them on a site inspection to assess the radiation and radioactive waste safety and management issues at the Shinkolobwe site. A complete list of team members is presented in Appendix A.

The Specialist joined up with the team in Kinshasa on the evening of 25 October 2004 and participated in the general program of the mission as set out in the itinerary listed in Appendix B.

2. Radiation issues at Shinkolobwe

Following the mine collapse in July 2004 it was reported that artisanal miners had been exploiting the ore body at the former uranium mine for both uranium and cobalt. Such mining was unregulated in terms of radiation safety and radioactive waste management. In addition there were concerns expressed by various people in the local media that the workers may have been affected by acute exposure to excessive doses of ionising radiation as a consequence of the mine collapse; also that the transport and processing of ore material from the site could be leading to radioactive contamination in areas away from the immediate mine site, specifically processing sites in and around Likasi.

3. Methodology

The major potential pathways for persons to receive a dose of ionising radiation and become radioactively contaminated at the mine site would be:

- Direct exposure to gamma radiation from uranium minerals in the ore body or waste heaps associated with the site
- Inhalation of the radioactive gas Radon and its decay products
- Inhalation of dust containing radioactive particles

- Ingestion of radioactive particles through dust or soil on hands, clothing or foodstuffs etc. or by drinking contaminated water

There were also potential risks of radioactive contamination for the community in and around the mine area and at any location where any form of mineral processing was taking place. Family members, support workers, service industry personnel, etc, may also be at risk from radiological contamination by:

- Direct exposure to gamma radiation from solid material such as ore or processed product being transported or packed by them or brought back to their dwelling by workers;
- Inhalation of contaminated dust arising from the mining activity either at the site or during transport of the ore to areas where it was being processed;
- Risk of inhalation of contaminated fumes from any adjacent processing activity;
- Ingestion of dust or contaminated water; this includes the risk associated with poor management of any process residues e.g. if slag or tailings or similar materials are being simply cast onto open dumps or into local waterways which might result in contamination of potable water supplies;
- Possible ingestion of foodstuffs contaminated by dust or uptake of radioactive material.

The biota of the environment adjacent to all phases of these operations may also be at risk of contamination through the combination of all the pathways mentioned previously:

- By direct radiation;
- Inhalation; and
- Ingestion.

Another pathway is the bio-accumulation of radioactive metals, e.g. radium and uranium, in plants and animals that may be used for food by the local population, e.g. fish, crustacea, molluscs, tubers, roots, leaves, fruits, etc. Such metal accumulation may also affect the organisms as well as making them a source of contamination for humans. These issues might need to be followed up in light of the results of analyses of samples collected by the environmental expert.

The details of the equipment employed on the investigation are given in Appendix C. The primary method of investigation was to use a meter (Eberline FH40 Radiameter) to check ambient gamma dose rates at varied locations around the site and in areas that were highly unlikely to have been contaminated and so would provide an indication of the natural background levels of radiation in the area. Gamma readings were taken at a height of 1 metre above ground level whilst the operator walked across a selected area in a pattern designed to provide a representative measurement of the radiation levels in the area. In addition readings were taken adjacent to stockpiles of ore/mineralised material that had been placed in bags and prepared for shipment but were abandoned by the miners when the site was evacuated. The data collected is presented in Table 1 and are discussed later in this report.

At locations where higher than expected gamma radiation levels were observed the density of readings was increased to ascertain the size of the affected area. Also surface contamination readings were taken to see if further information on the nature of the contamination could be determined.

The visits took note of the situation with respect to drainage lines around the area and especially any obviously leading from the site to establish if there was any major movement of radioactive contamination off-site through surface flow of potentially contaminated water, suspended sediment, etc. The general observation is that the surface drainage was not contributing to any contamination of the surrounding areas.

Gamma dose rate measurements were also undertaken at road site locations along the haulage route from the area of Shinkolobwe to Likasi to establish if any contamination had been spread along this transport corridor and around Likasi, especially within mineral depots and smelting plants. At each stack of ore bags or over bulk samples the same methodology was used where gamma readings were made at 1 metre height above the bag or bulk sample with closer examination at locations where readings were considered to be higher than generally encountered elsewhere.

In addition to the spot sampling, electronic personal dosimeters were worn throughout the period of the fieldwork to establish the levels of exposure to radiation actually experienced at the Shinkolobwe site. The two most potentially exposed team members, based on their assigned tasks, wore the dosimeters. These data are presented in Table 2.

There were also two small personal air samplers used on the site in conjunction with the personal dosimeters to assess the radiation dose due to radon and inhaled dust. Unfortunately there were problems with the rechargeable batteries, which resulted in the machine not working well for much of the time on site. Until the filter papers from the collectors are analysed it is not known if any useful data have been collected. A rough check of the filters with the surface contamination meter failed to give any significant readings.

4. Results

The results of the gamma surveys are presented in Table 1. For the most part the readings are within the range that would be expected on the site of a former uranium mining and milling facility that has not been remediated in any significant manner. Observation of the former mine and mill area revealed the presence of remnant plant items and infrastructure including buildings, concrete foundation slabs and decantation vessels as well as uranium mill tailings which had no erosion covers and were inadequately contained. There are also rehabilitated sedimentation ponds at the site.

The dosimetry results for the mission members indicated that the average exposure over the period spent on site was of the order of 7µSv per day, which equates to approximately 2.5mSv per year. This dose calculation excludes any exposure on the inhalation pathway e.g. due to dust and radon. This is in excess of the permitted public dose rate for a practice of 1mSv/yr. However, the situation at Shinkolobwe is not a practice but an intervention, in radiation protection terms as defined in the International Basic Safety Standard[1]. There is no regulation or control of radiological protection nor is there a responsible party currently operating at the site. Thus the dose rate at which radiological intervention would be introduced may be expected to be higher, depending on the circumstances. The present dose rate, admittedly determined using data from an incomplete inspection of the site, indicates that there may be a radiological safety issue at the site. Consequently a complete characterization of the site should be undertaken to enable a thorough assessment to be made of the radiological and other risks.

However, as the site at Shinkolobwe was never fully remediated it seems preferable that a complete site clean up be undertaken. The site is littered with items that may well be heavily contaminated but could not be adequately inspected on the present mission due to time and resource constraints as well as issues of physical safety (Figure 1). The team was not fully equipped with the personal protective equipment usually required before undertaking investigations inside structures, in underground workings, etc.

A list of the meetings held and the individuals met is included as Appendix B.

5. Conclusions and Recommendations

5.1 ON SITE

There has been no nuclear incident or radiological accident at Shinkolobwe either leading to, or as a result of, the collapse at the mine.

The site is contaminated with naturally occurring radioactive material (NORM) over a considerable area to varying degrees, which is consistent with improperly controlled mining remediation.

The mission found no evidence of widespread elevated radiation levels to indicate there was an acute risk of overdose or exposure to ionizing radiation for the public.

Chronic radiation exposures to miners in the underground workings and at some locations on the surface are likely to have been in excess of the accepted international dose criteria for radiation workers (an average of 20mSv/y) taking into account the dose rates measured at the surface on small dumps and from sacks of ore; in addition there is also the potential for significant dust and radon inhalation in the underground workings. The dose rates adjacent to piles of ore at a depot in Likasi were sufficiently high to cause a worker to exceed the international dose criteria if they were working in the vicinity for 12 hours per day. However, there are presently

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[1] International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources. Safety Series No. 155. 1966. International Atomic Energy Agency, Vienna

no workers on site that would enable this to be verified by observation and measurement of work practices of the artisanal miners.

The annual public dose limit for radiation exposure relating to a practice (1mSv/y) could have been exceeded by visitors to the site who stayed longer than 100 days. However, the site is not considered to be the scene of a practice but an intervention situation. The public does have access to the site and therefore the site should be controlled.

There was no evidence of any regulatory or radiation protection system in place.

The physical safety aspects of the site presented a severe risk and prevented examination of underground workings.

Tailings from the former formal uranium mining operations are exposed and have been “mined” in a few locations (Figure 2); also waste rocks with varying degrees of uranium mineralization may be found all over the site and could represent a radiological safety hazard.

Some waste rock stockpiles have been extensively reworked, presumably for cobalt. However, there was no firm evidence of mining for uranium as a specific separate activity.

The site is clearly contaminated with radioactive material. It is recommended that a full safety characterization of the site be carried out. This in turn would enable a comprehensive risk assessment to be undertaken from which a long-term strategy for the site’s management and possible remediation could be derived.

Aspects of the remediation strategy could include:

collapsing of the workings to prevent further access by artisanal miners,

relocation of tailings and mineralised waste rocks to the former mine pit and the collapsed workings to the greatest extent possible, and

containment of all remaining contaminated residues in accordance with current best practice principles of waste safety and waste management.

5.2 OFF SITE

Transport routes from the site may show some minor levels of radiological contamination; this would be as a consequence of ore dust falling from trucks.

None of the larger dealers/smelters/processors encountered during the mission were prepared to accept any radioactive material from any site due to potential problems with end user customers, especially with the EU and OECD countries. Dealers had systems in place to check dose rates of all incoming materials.

Some dealers/processors advised they use a cut off value of 2 µSv/h; radiological measuring equipment was shown to, and demonstrated for, the mission team.

One smaller depot was found to have a small stockpile of ore (~2t) that gave gamma readings of 5-6 µSv/h. This was reputedly from the area of Kolwezi. However, during discussion it was suggested by the merchant that '….perhaps this was a place where there had earlier been storage of ore from Shinkolobwe……' and later "…….we will take this back to where it came from, to Shinkolobwe…….". The gamma dose rate alone for a worker standing adjacent to this stockpile for 12 hours per day (e.g. a night watchman), would be in excess of the 20mSv/y limit for designated radiation workers.

At another site, samples with higher gamma levels were identified as being from the Kolwezi or Sondra mines rather than from Shinkolobwe.

All dealers interviewed said they were interested only in Cobalt and there was no market in uranium.

The mission found no true artisanal smelting locations; however, there were persistent rumours that such facilities do exist.

The processing sites seen in Likasi were relatively small but appeared professional in their approach. Smaller plants are currently under construction at several locations in and around Likasi. Most seem to be for production of copper although some may be for cobalt. New machinery (a trommel and a vibrating table) was seen awaiting installation at one site where a plant was obviously under construction.

Samples of slag from 2 smelting operations were located and inspected, and found to have low levels of radioactivity, in the range that could be considered to be background.

The mission was advised several times that Shinkolobwe ores were generally exported un-processed to avoid the radioactivity issue and possible contamination of local stocks.

6. Limitations

The mission outcomes are based on data collected from a relatively small number of sample locations visited in a short time span. The resources were not available to undertake a complete and systematic characterisation of the site with respect to physical, chemical and radiological hazards. Nor could all the consequent risks be assessed due to the lack of data.

The underground workings were considered to be too dangerous to enter thus the radiological risk to miners has been estimated on some worst case scenarios based on radiological data collected at the surface and the experiences of team members.

Time constraints precluded an extensive investigation of the claims that artisanal ore processing plants existed around Likasi. However, the sites found by the mission team were all related to copper and although small scale could hardly be considered as artisanal in nature. It is possible that other sites processing cobalt rich materials are around but they could not be located in the time available.

There were no miners present on site, which would have enabled the team to verify work practices and allow better assessment of radiological doses to workers and associated health risks.

The lack of accurate maps of the area made location of sampling sites difficult to place in relation to the overall layout of the site and its position in the landscape. This was important in terms of assessing possible exit pathways for contamination in surface water runoff.

Prepared by:

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16 November 2004

Tables

Table 1 Radiological data

Date	Location Description	Dose rate	Reading type	Surface contamin-ation	Notes
		µSv/h		Bq/cm^2	
27-Oct	Likasi Hotel	0.27	B/G		general area of town and hotel yard
	Plantation	0.22	B/G		freshly planted with beans and maize; alluvial soil,
	Police Station	1.6 - 1.9	B/G	7.0	general background; some spots to 4-6µSv/h
	Old sacks of ore material	6.8	spot	7.0	
	Shop site	30	spot		20m N of police station
	5m from shop site	2.2	area		
	Mill area	15	area	10.0	much debris in the area, old plant items, scrap metal and concrete
	Pathway old workings	45-50	spot		very limited area, generally 5-8 µSv/h in vicinity
	Pathway old workings	2.0 - 2.4	area		

28-Oct	Police Station, shop site	36-42	spot	35.0	discrete area,<4m square. Possible site of sorting to reject uranium; surface contamination suggests high U concentration but area was less than 10 sq m in extent. Hottest spot ;located was very small ; 200 µSv/h very small extent but no obvious source
	Mango Tree #1	1.2	spot	2.0-3.5	area where people likely to have sat around thus of interest as a public exposure site
	Burned houses in vicinity	2	B/G		area background
	Tremies area of mill	25	spot	25.0+	mineralised rock on surface, 20 cm diameter
	Sediment basin side	4.2-4.5	spot	4.5-5.0	fine sediment trapped in depression
	Mill area	1 to 7	area		many small fragments of product and secondary mineralization; some higher readings but very discrete extent; building remains very precarious

Note 1: The surface contamination meter used on the mission was reading in counts per second (CPS). If it is assumed that all the activity is due to uranium then 1 CPS = 0.1Bq/cm^2 which is the basis of the results shown above.
Note 2: B/G=Background reading. Spot =a measurement of a specific location; Area = average of several readings over an extended area of similar activity.
Meters used :
Gamma dose rate measurement: Eberline Model FH40 F2 Radiameter range 0.01µSV/h to 10mSv/h: Serial Numbers 3986 and 7810.
Surface contamination measurement: Mini Instruments “Mini-Con” model 1000C Serial Number 2937.

28 Oct	Tailings dam east	4.76	area	10.0	1 m above ground level; some evidence of digging in tailings; no erosion cover on tailings but some vegetation
	Tailings dam east	8.75	spot	10.0	adjacent to tailings surface
	Base of open cut	10 to 14	area	4.0	windy location
	Sample bags of ore	5 to 7	spot		sacks left in open air by miners
	Artisanal site 1	8.75 - 9.90	area	5.0	9.25 average
	Grey dust sample	3.2	spot	2.0	Environmentalist's sampling site
	10m from artisanal site	50	spot		pathway: high reading over area 5m X 2m
	Screening site	0.6	area	0.5	many small open workings
	Depot Camp	0.4	spot		location in depot centre
	Road side halt	0.5	area		1 m above ground level
29-Oct	Walny Company yard	0.25	area		store house average 0.35
	Bazano Company yard	0.53			sample location in warehouse floor
		0.33	area		warehouse ; max seen 0.6µSv/h
	Tschalukambo Company yard	max 1.8			loading area for trucks, yard at average 0.8µSv/h

		5			possibly ore from Shinko or Kolwezi
	Military depot	0.5	B/G		inside store shed
		0.3	area		outside and at Shinko ore samples
		0.25	B/G		general B/G in yard
	Congo Minerals Company yard	0.5			slag from cobalt smelter
		0.25	B/G		in yard and around area
	Africom Company site	0.5	area		copper smelter - slag
		0.23	spot		copper ingots
		0.19	B/G		average in yard
30-Oct	Countryside area	0.15	B/G		ambient level away from all obvious sources of potential contamination
	Ore washing site	0.3	area		at river's edge; max to 0.33 µSv/h
		0.18	B/G		area background 1m above ground
31-Oct	MONUC yard, Lubumbashi	0.15	B/G		range over 2 days from 0.13 to 0.22 µSv/h

Table 2 Personal Dosimetry readings

Readings from Electronic Personal Dosimeters (EPD)

Instrument type: Siemens model EPD Mk 2

EPD readings

	P Waggitt		µSv
Date	time	location	Cum total
27-Oct	7:00	Lubumbashi	24
	17:30	Likasi	29
28-Oct	7:15	Likasi	30
	10:00	Gombe	30
	11:45	Shinko	30
	21:00	Likasi	40
29-Oct	7:00	Likasi	42
	18:45	Likasi	43
30-Oct	7:10	Likasi	44
	11:10	Likasi	44
02-Nov	7:00	Kinshasa	54

	A. Pasche		µSv
Date	time	location	Cum total
27-Oct	start	Shinko	26
	end	Shinko	28
	evening	Likasi	29
28-Oct	7:15	Likasi	30
	end	Shinko	32
	11:45	Shinko	43
	evening	Likasi	44
29-Oct	morning	Likasi	45

	evening	Likasi	47
30-Oct	morning	Likasi	48
	15:05	Likasi	49

Notes:

The instruments were worn by the two team members whose tasks identified them as the persons with the potential for the highest dose exposure during the mission These were the Waste Safety Specialist (Mr Peter Waggitt) and the Environmental Specialist (Mr Alain Pasche).

Figures

Figure 1: Remnant infrastructure at the former mill area
(photo: Rene Nijenhuis, Joint UNEP/OCHA Environment Unit)

Figure 2: View southwards across western tailings area
(photo: Rene Nijenhuis, Joint UNEP/OCHA Environment Unit)

Appendix A: Assessment Team Members

•Mr Alain Pasche, Independent Environmental Expert, Switzerland

•Mr Bernard Lamouille, Mining Engineer-specialist in small scale and artisanal mining, BRGM (Bureau de recherches géologiques et minières), Orléans, France

•Mr Florent Ekwanzala, Manager of Health Programmes World Health Organisation, Kinshasa, RDC

•Mme Manga Mialaret, Deputy Administrator, associate expert in Humanitarian Affairs, OCHA Genève, Switzerland

•Mr Jean Charles Dupin, Principal Counsellor in Humanitarian Affairs OCHA RDC

•Mr Aliou Kane, Manager of Humanitarian Affairs, MONUC Lubumbashi, RDC

•Mr Peter Waggitt, Waste Safety Expert International Atomic Energy Agency, Vienna, Austria

•Mr Rene Nijenhuis, Team Leader, Environmental Emergencies Section, Joint UNEP/OCHA Group, Genève, Switzerland.

Appendix B: Schedule of Waste Safety Expert during Inter-agency Evaluation Mission to Shinkolobwe

Monday 25 October

- Travel from Vienna to Kinshasa
- Meeting with other mission team members in the evening

Tuesday 26 October

- Travel by air from Kinshasa to Lubumbashi
- Meeting with His Excellence the Gouvern. of Katanga Province
- Meeting with MONUC staff, Lubumbashi Office
- Meeting with OCHA staff, Lubumbashi Office
- Meeting with M. Kongo Nzenga, Administrateur Délégué Général
- Meeting with Mr. M Forrest, Chief Executive Officer, M. Forrest Mining Company
- Meeting with M. le professeur Lory Nda Bar, Department of Geology, University of Lubumbashi

Wednesday 27 October

- Road travel from Lubumbashi to Likasi
- Meeting with the Mayor of Likasi
- Meeting with M. Bombile, Senior Geologist, Gécamines Company
- Meeting with M. Baudouin, Ministry of Environment, Nature Conservation, Waters and Forests, (Likasi section)
- Reconnaissance visit of Mission team to Shinkolobwe

Thursday 28 octobre

- Meeting with the Administrator of the District of Kambove
- Site visit and sample collection at Shinkolobwe site

Friday 29 October

- Visit and sample collection in mineral trading depots and founderies in and around Likasi

Saturday 30 October

- Visit to water pumping station and sampling of waters around Likasi
- Road travel from Likasi to Lubumbashi
- First debriefing meeting for all mission team members

Sunday 31 October

- Working meetings between mission experts; preparation of material for debriefing meetings and initial results

Monday 1 November

- Meeting and presentation of initial results to His Excellency the Governor of Katanga Province
- Travel by air from Lubumbashi to Kinshasa
- Working meetings between mission experts

Tuesday 2 November

- Meeting with and presentation of initial results to MONUC-Kinshasa
- Meeting with and presentation of initial results to OCHA-Kinshasa;
- Meeting with and presentation of initial results to Ambassadors and representatives of potential donor countries (France, UK, Switzerland)
- Meeting with and presentation of initial results to M. Gérard Kamanda wa Kamanda, Minister of Scientific Research, and M. Professor Lumu, Head of the Commission for Atomic Energy

Wednesday 3 November

- Meeting with and presentation of initial results to M. Eugène Diomi Ndongala Nzomambu , Minister of Mines
- Meeting with M. Baudouin Iheta Musombo, Coordonnateur Général de Service d'assistance et d'encadrement du small scale mining (saesscam), at the Ministry of Mines
- Meeting with and presentation of initial results to Mme Nzuzi-wa-Mbombo, Minister of Solidarity and Humanitarian Affairs
- Meeting with and presentation of initial results to M. Léonard Muamba Kanda, Secretary General, et M. Mwanambuyu Kabala, Executive Director

(Environment Division), Ministry of Environment, Nature Conservation, Waters and Forests,

- Meeting with and presentation of initial results to M. William Swing, Special Representative of the Secretary General to the Democratic Republic of Congo

Thursday 4 November

- Working meetings of mission experts and preliminary report discussions
- Departure from Kinshasa by air for Vienna

Appendix C: Details of field equipment used

1. Gamma Dose rate measurements

The meters used were Eberline Radiometers model FH40 F2 model with a measuring range from 0.01 µSv/h to 10 mSv/h.

The equipment is fitted with a ZP 1200 Geiger-Muller counter tube.

These meters are robust and have simple direct read out which facilitates prolonged

field use with great reliability.

The response time varies from between 90 seconds at low levels of gamma radiation (0-1 µSv/h) to less than 35 seconds in the range 0-30 µSv/h, which was the typical range encountered on the survey

2. Personal Air Sampler

The personal air samplers used were Nuclear Associates Model 08-430 portable air pumps using a high flow rate of 5-7 litres per minute and a filter paper to trap any particulates.

There were problems with the rechargeable batteries on two of the pumps and so the results (when available) may be difficult to interpret.

3. Surface Contamination meter

The surface contamination meter used on the mission was a Mini Instruments Model 1000C “mini con”. The instrument uses a Geiger Muller tube and is recommended for locating hot spots emanating alpha and beta radiation. The instrument is not recommended measurements for gamma flux measurement.