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LIQUID WASTES
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IEA R1 REACTOR

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Ten years of routine waste management at IPEN

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ABSTRACT

A brief overview of routine management of low level radioactive wastes at IPEN during the period of 1983 to 1992 is given Some new experiences are to be gained in the next future with the design of two new waste treatment facilities for radioactive liquid wastes

Dez anos de gerenciamento de rejeitos no IPEN

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RESUMO

É feito um breve resumo do gerenciamento rotineiro de rejeitos radioativos de nível baixo executado no IPEN durante o período de 1983 a 1992 Alguma nova experiência espera-se ganhar em futuro próximo com a construção de duas novas instalações para a imobilização de rejeitos líquidos

Introduction

Production of radioisotopes for medical and industrial purposes, and experiments in reactor physics, nuclear physics, etc , for personnel training were initiated in Brazil in the mid-1950s using the experimental reactor IEA-R1 - 5 MW located in São Paulo

Small amounts of wastes have been produced since then and so far have been kept under radiological control With the beginning of the Brazilian nuclear power programme and an increase in the use of radioisotopes in industry, medicine and other fields, and with growing interest in protecting public health and ensuring public safety, a regulation was established covering all aspects of the use of radioactive materials in nuclear fuel cycle as well as in nuclear activities resulting from the non-nuclear fuel cycle

As a consequence of the small amount of wastes generated until recently in Brazil, the function of waste management at the IPEN was performed mostly by the health physics personnel Since 1983 a department has been in existence with specific functions, that is, to process and treat all kinds of wastes generated by the IPEN and some smaller producers, to develop new processes or implement process for treatment of all kinds of radwaste produced in Brazil and to realize an extensive research, development and demonstration (RD&D) programme in the field of radioactive waste treatment and disposal

Till now a total of 680 m^3 of solid raw wastes were treated at the IPEN installations, including compressible and non compressible wastes, radioactive sources and additionally, there is as accumulated inventory of "historic wastes" which resulted from past practices involving natural radionuclides, primarily radium

This amount of wastes is negligible if comparison is made, for instance, with the currently waste production in Canada which amounts to 13000 m^3/a[1] Even considering the waste arisings from the nuclear industry and from other institutions in the country the total amount of wastes generated till now is lower than 10000 m^3

The purpose of this paper is to outline the present situation and future strategy at IPEN for the management of low and intermediate level radioactive wastes (LLW and ILW)

Conditioning of solid wastes

Compaction is the sole volume reduction process used at IPEN for compressible solid wastes The volume reduction factors obtained using a press strength of 10 t range from 4 to 7 In Figure 1 is shown a detail of the press utilized for this purpose

Solid radioactive wastes are produced mainly during cleaning and decontamination activities and consists of rags, paper, cellulose, plastics, gloves, clothing, overshoes, etc Laboratory materials such as cans, polyethylene bags and glass bottles, as well as bulk exhaust air filters contaminated by the activity adhering to dust particles and aerosols, also contribute to the solid waste inventory

Small parcels of non compressible long lived wastes are also produced and received for treatment They include wood pieces, metal scrap, defective components and tools, and debris from dismantling and decontamination operations These wastes usually are put in 200 L drums and immobilized by pouring cement paste into the voids

Because of the widely divergent nature and quality of solid wastes, they must be graded correctly at the place of origin to facilitate optimum treatment

Figure 1 - Press utilized to reduce volume of wastes

This requires a clear separation and classification of beta/gamma and alpha contaminated solid wastes

The radioactive wastes are collected in 40 L paper bags which are then placed inside polyethylene bags of 0 2 mm thickness The closed bags are transported weekly to the treatment facility for compaction and afterwards to interim storage The non compressible wastes are also collected in polyethylene bags and labelled for special treatment

All radioactive waste bags are identified at the waste sources This is done by the health supervisor, who attaches a properly annotated tag to the transfer bag with the following information (a) dose rate, (b) radioactive isotopes present, (c) estimate of quantity (Bq or Ci), (d) general description of waste, and (e) location of waste producer

Exhausted or defective radioactive sources are also received for treatment at IPEN and they mostly arrive from the industry, medicine or research institutions A list of typical sources received for treatment by the IPEN is shown in Table I

Sealed sources are high integrity capsules each containing a small mass of a specific radioisotope in concentrated form The isotope in each case has been chosen for a specific application and the radiation level from the source is usually intense A very high degree of containment of the radioactive material is provided in the design of the capsule This facilitates handling in transport and use

Most of the sealed sources represent a radiological health problem even when the equipment is no longer in use For some of the sealed sources used in Brazil the licensees are required by contract with the supplier to take the source back later when the source becomes waste This is what happens, for instance, with the sources produced and sold by the IPEN A wide variety of sealed radioactive sources are sent to the IPEN for treatment Usually they are immobilized in concrete drums with their original container The advantages of using cement are low cost, easy handling and availability

The number of sealed sources requiring treatment and disposal is considerable, but, because sealed sources are intense concentrations of radionuclides in extremely small masses the total volume of the waste involved is small

TABLE I - SEALED SOURCES USED IN INDUSTRY, RESEARCH AND MEDICINE RECEIVED BY THE IPEN

Source	Source strength (GBq)	Half-life (a)	Principal Applications
^{3}H	1-1000	12 3	Production of neutrons by (D,T) reactions
^{60}Co	$\leq 4 \times 10^{3}$	5 3	Radiotherapy, industrial radiography, level gauge
^{137}Cs	$\leq 4 \times 10^{3}$	30 2	Radiotherapy, industrial radiography, level gauge
^{85}Kr	0 1 - 50	10 7	Paper thickness measurements
^{90}Sr	0 1 - 2	28 6	Paper thickness measurements, beta therapy
^{147}Pm	1 - 10	2 6	Paper thickness measurements
^{226}Ra	0 1 - 50	1600	Level gauge, therapy, industrial radiography
^{204}Tl	1 - 10	3 78	Thickness gauge, therapy
^{241}Am	1 - 10	432	Density gauge, lightning rod
^{241}Am-Be	0 1 50	432	Moisture detector, hygrometer, petroleum detector
^{252}Cf	1000	2 64	Moisture detector
^{226}Ra-Be	0 1 - 50	1600	Research

In consideration of possible final disposal schemes, alpha sources should always be separated from beta/gamma sources as the disposal route will probably be different (shallow land burial vs deep geological repository)

For gaseous or radium sealed sources specially developed packages were designed As in other developing countries, Brazil has made extensive use of radium sources in medicine for treatment of cancer tumors but now are being replaced by ^{137}Cs, ^{3}H, ^{192}Ir and ^{241}Am

Industrial applications have included radium for radiography, certain electronic valves, switches and luminous paints Owing to the long half-life and decay mode, sealed radium sources will never be disposed of as exempt wastes Special care has to be taken in order that in interim storage they do not present a hazard to man

A special package, shown in Figure 2, was developed for interim storage, transportation and final disposal of radium sources which can be used for gaseous sources This special package conforms to the Type A specifications of the IAEA Regulations for the Safe Transport of Radioactive Material As the final disposal site for that kind of material has not yet been defined, the adopted criterion for the package design was that the source should be kept in a form that would not be readily dispersible and that the package could be stored temporarily before transport to the final repository without any hazard to the operating personnel of the interim storage The package was designed in such a way as to accommodate radium sources of up to 20 GBq (~ 0 5 Ci) with a leakage rate lower than 5×10^{-10} kPa L s^{-1} to ensure radiological safety

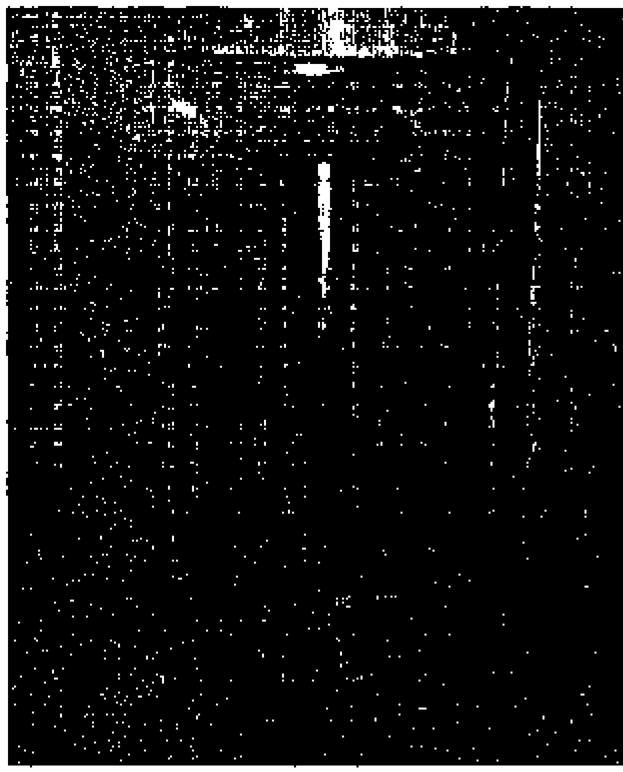

Figure 2 - Special package for radium sources

From the point of view of radioactive waste management it is highly desirable to minimize the number of sources in use or stored pending disposal Therefore, whenever possible a spent source should be recycled or allocated to another user When the source activity is no longer suitable for the original application there may still be sufficient radioactivity to allow the use for another purpose This may especially be the case for the high activity ^{137}Cs and ^{60}Co sources Sources no longer of use for clinical therapy may well be useful in other applications requiring lower levels of activity Transfer of sources to other users within the national boundaries of the country offer economic advantages in both source procurement and final waste management

In order to guarantee a low risk level of accident and a minimal radiation exposure to transport workers and to the general public the IAEA standards restricts the maximum activity content of the package as well the surface radiation level Assurance of these properties for the packaged wastes form as essential component of the quality assurance program adopted at IPEN[2]

A recent experiment [3] with the package designed for the radium sources showed that it can be used also to package neutron Ra-Be sources with activity of up to 3 7 GBq (100 mCi)

Conditioning of liquid wastes

A limited volume of liquid wastes containing small quantities of radionuclides is produced at the IPEN as a result of research or radioisotope production activities This reduced volume results from the optimization of processes to keep the wastes generated to a minimum Moreover, since most of the radioisotopes handled at the IPEN are short lived the delay and decay technique of treatment is still valid

Usually the liquid wastes which are not allowed to be discharged directly to the environment are collected in containers and stored for an appropriated time so that the activity decays to an acceptable level In special circumstances collecting vessels with a maximum capacity of 10 m^3 are constructed in order to permit larger volumes to be managed Before discharging to the environment some chemical adjustment of the effluent is made, this generates small volumes of sludge but reduces the activity even further below the authorized discharge limits When necessary the resulting sludge is immobilized in cement and later on the block is immobilized together with the non compressible wastes

Nowadays with the forecast of an increase in the liquid waste generation two units of treatment of liquid wastes are being designed One of them is specific for the wastes arising from the ^{99}Mo production facility and the other unit will take care of all other liquid waste stream The chosen process was cementation due low cost, easy handling and availability

Interim storage

After the waste has been immobilized, the waste packages are normally placed in an interim storage serving as barrier against unauthorized contact with the waste

The main reason for interim storage is to accumulate a reasonable number of packages before transportation to the final repository or because a repository site is not yet available

At IPEN the interim storage is made on a simple hall on the ground surface with a steel construction and corrugate transit sheets covering the walls and the roof The interim storage as the compaction facility is located in a fenced area measuring 30 by 50 meters The storage area of nearly 200 m^2 has an estimated capacity of about 1500 drums when the drums are stacked 5 units high using simple handling by fork lift truck In Figure 3 is shown a partial view of the stored drums

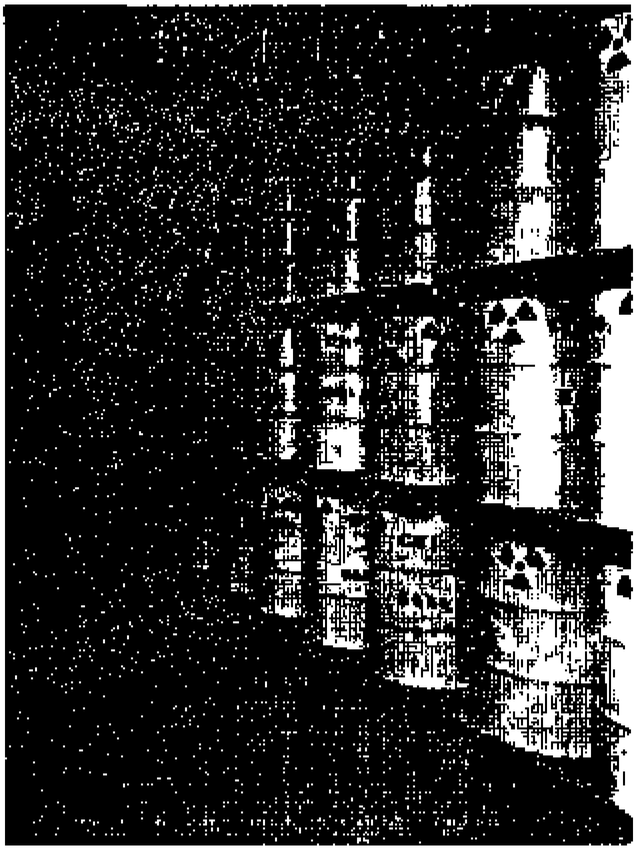

Figure 3 - Interim Storage

In Figure 4 is shown the volume waste production according the year and in Figure 5 is shown the main origin of the wastes The activity distribution of spent sources treated at the IPEN is shown in Figure 6 The total number of drums stored at the interim storage is shown in Figure 7

Concluding remarks

The methodology used at the IPEN to treat solid wastes (compressible and non compressible) as well as spent sources proved to be acceptable, of low cost and conforming the necessary radiological standards

The implementation of the two new units for treatment of liquid wastes in the next future will permit to get a new kind of experience in order to well manage the wastes arisings During the last few years much experience was acquired in characterization of radioactive wastes incorporated in cement matrices which will be useful for the quality assurance of the final waste form

Accumulated treated solid wastes at IPEN

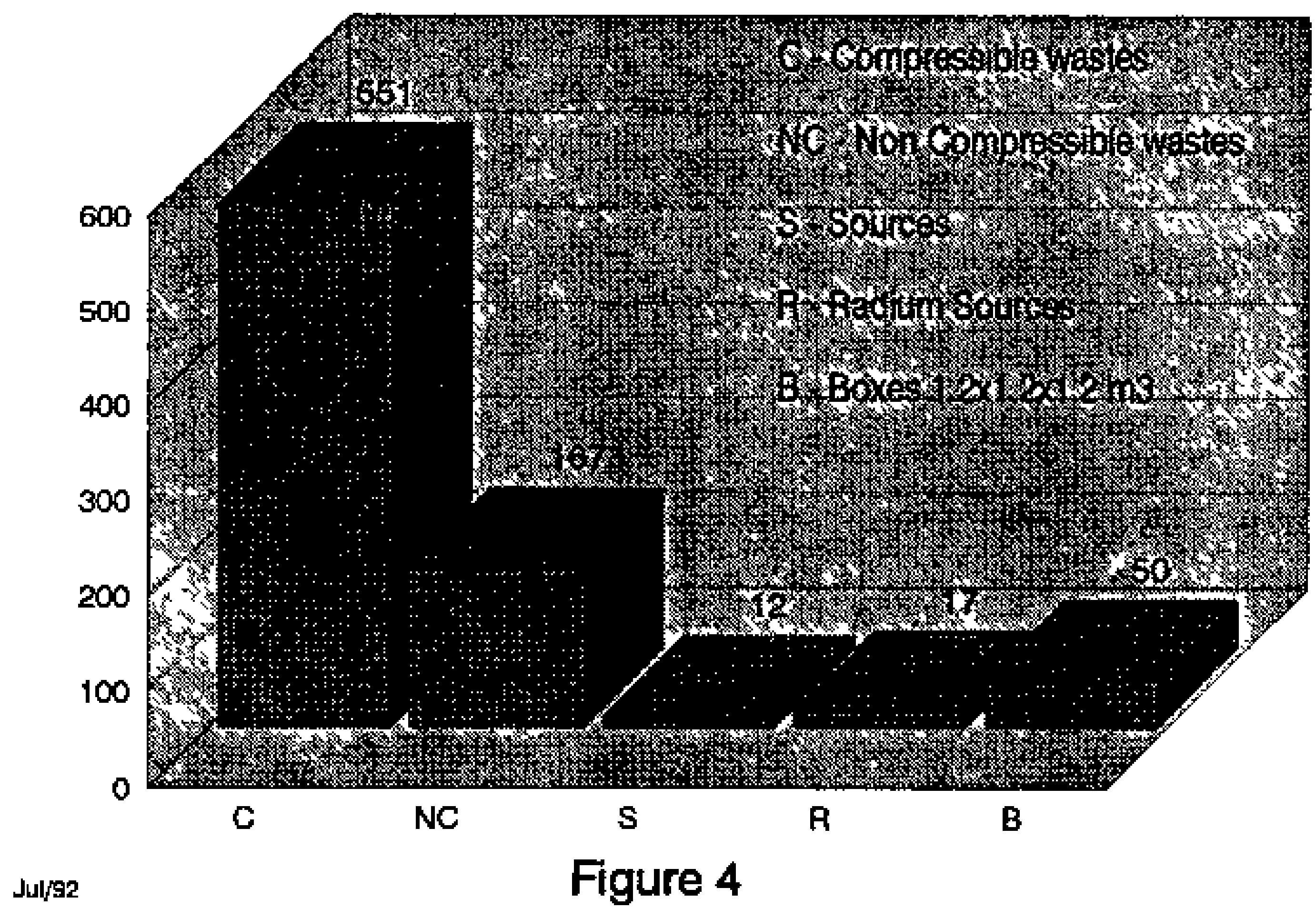

Figure 4

Source of Wastes

(Cubic meters)
Jan/83 to Jul/92

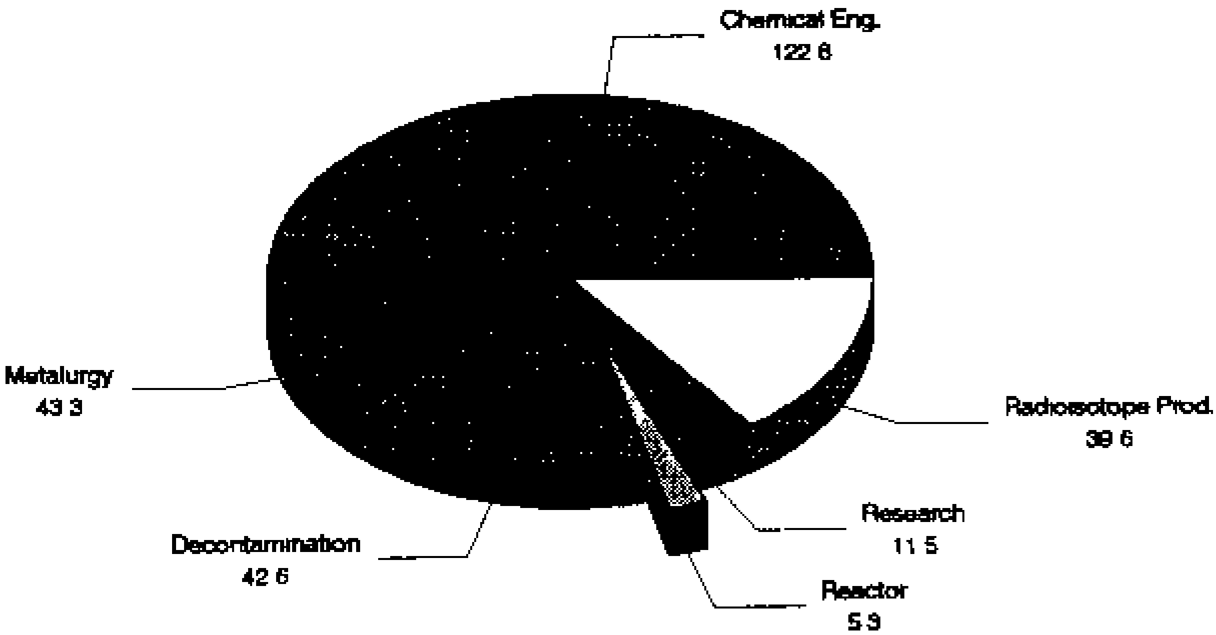

Figure 5

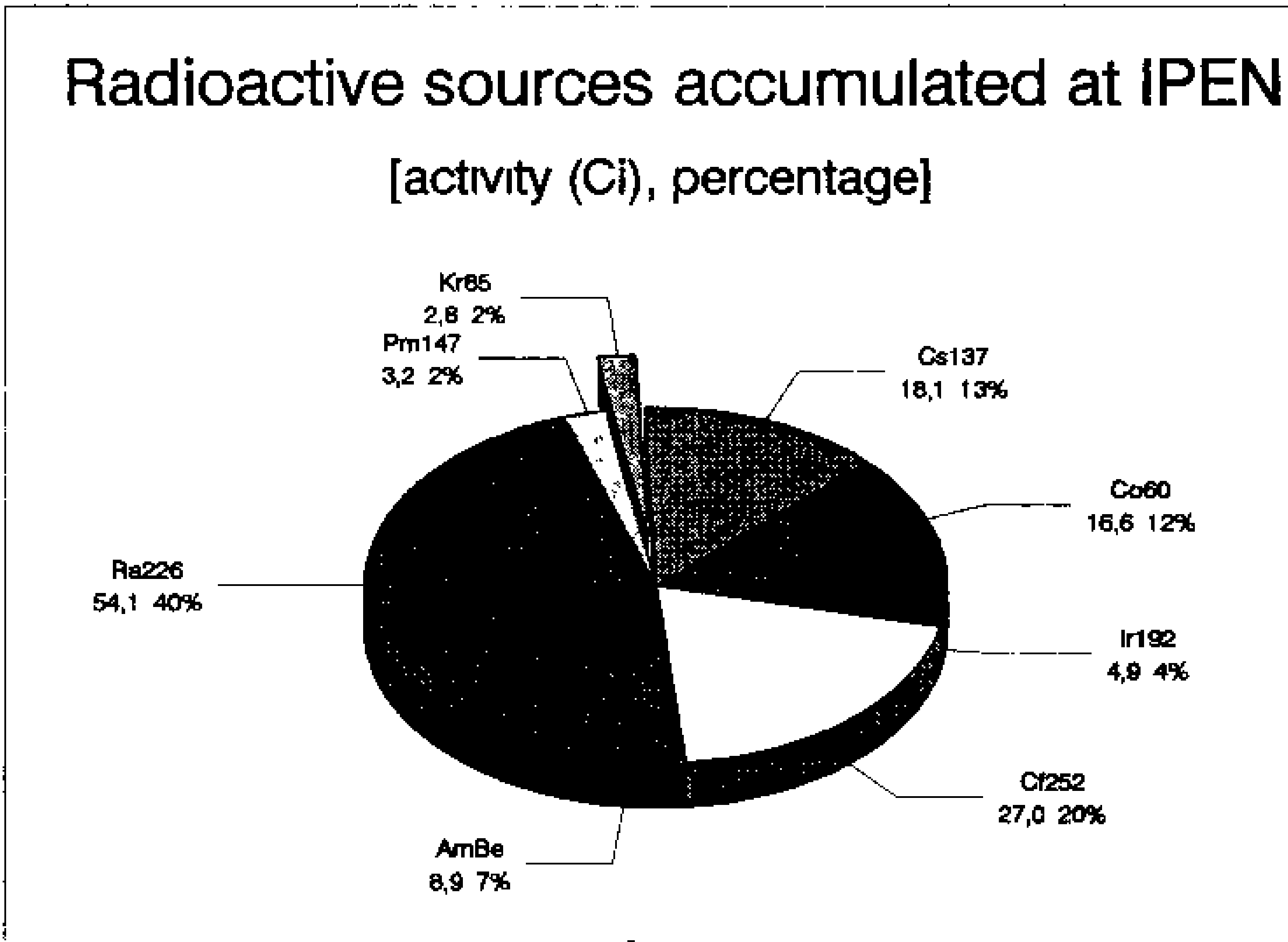
Radioactive sources accumulated at IPEN
[activity (Ci), percentage]
Kr85
2,8 2%
Pm147
3,2 2%
Cs137
18,1 13%
Co60
16,6 12%
Ra226
54,1 40%
Ir192
4,9 4%
Cf252
27,0 20%
AmBe
8,9 7%

Figure 6

Wastes drums accumulated at IPEN

(Jan/83 to Jul/92)

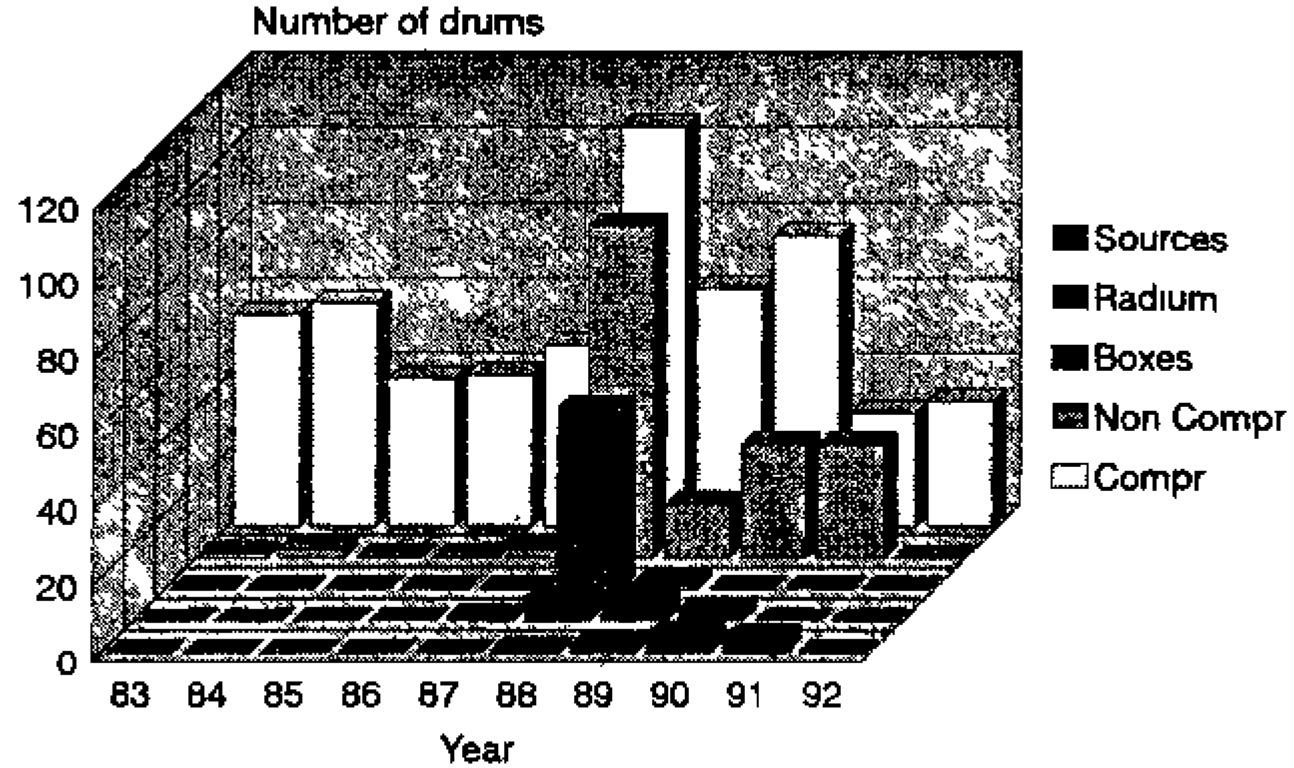

Figure 7

Acknowledgements

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