

Radiation and Radiological Protection. Guidelines for Primary And Secondary Schools

Muñoz Pelayo Paula, Rueda Guerrero M^a Dolores, Tamayo Tamayo Belén, Rodríguez Martí, Manuel. CSN, Pedro Justo Dorado Dellmans 11, 28040 Madrid, Spain

Abstract:

One of the tasks assigned to the Spanish Regulatory Body in radiation protection (Nuclear Safety Council, CSN) is to inform to the citizens in relation with topics in the area of its responsibility.

One way to inform to the society about the uses of ionizing radiation, the risks and the measures of protection to apply is through the education system. The CSN has signed an agreement with the Education and Science Ministry (MEC), related to the knowledge transfer concerning the field of ionizing radiation. In the framework of that agreement, it has been carried out an updated of a document published by the Directorate General XI (environment, Nuclear safety and radiation protection) of the European Commission, entitled "radiation and radiation protection: course for primary and secondary schools".

A general objective for the teaching guide for primary schools is to stimulate student's interest in the physical phenomena that reveal the existence of radiation in daily life, as well as to introduce the different types of radiation (ionizing and non ionizing) from both natural and man-made sources. These issues are explained in a very intuitive and general way, due to the fact that pupils of this age have not yet studied the internal composition of matter.

The teaching guide for secondary schools is more ambitious, its general objectives are wider, and try to explain the origin, the types of radiations, their characteristics, instruments for detecting and measuring them, biological effects of radiation on the human body, measures for radiation protection, and its implementation in medicine, industry, research and security.

The objective is to contribute to the knowledge and to help the teachers to transmit it in the classrooms. Only from this position we will form a responsible citizenship, capable of facing a critical attitude the scientific advances in general and the world of the radiations especially

Keywords: Guideline, radiological protection, primary school, secondary school, teachers

1.- Introduction

The aim of these didactic guidelines is to offer a document to primary and secondary education teachers to introduce the students in the uses and applications of ionizing radiation.

The knowledge is a key factor in our lives and this knowledge is absolutely necessary to manage the ionizing radiations.

Then, information and communication is necessary. We want to be a support to people entrusted to transmit it in the classrooms, so teachers must have an adequate knowledge in radiological protection.

Only from this position we will form a responsible citizenship, capable of facing a critical attitude in front of the scientific progress in general and especially, the radiations.

The CSN has established an agreement with the Education and Science Ministry (MEC), related to the knowledge transfer concerning the field of ionizing radiation. In the framework of that agreement, it has been carried out an update of a document published by the Directorate General XI (environment, Nuclear safety and radiation protection) of the European Commission, entitled "Radiation and radiation protection: course for primary and secondary schools".

Due to the time elapsed since the edition of the above-mentioned document and, to update it to the current educational system in Spain, it was necessary to develop two new documents. A teaching guide for primary schools was issued (aimed at students between 6 and 12 years old) and a teaching guide for secondary schools (high school and vocational training), for students aged 12 to 18 years old.

Ionizing and non ionizing radiation are quite complex and abstract topics, and specially to explain them to younger students, so it is a question of cross-cutting matter to teach if the teachers consider it adequate.

2.- Guidelines structures:

Contents including in both guides are divided by levels according the ages to the pupils:

- Three levels in primary guideline
- Two levels in secondary guideline

Both of them have a “spiral program”, that means that different topics reappear in every level increasing in difficult. Both guides are independent though complementary.

The aim is to provide teachers the tutorial material needed to explain radiological protection to students and to include it in the curricular syllabus, if it is appropriate or adequate, as in our education system, this item is not included within the mandatory education.

The ultimate goal of these guidelines is to inform the society of different applications of ionizing radiation in different fields taking into account issues and concerns, like: medicine, agriculture, industry, research, security, electric power generation through the use of nuclear energy and the protection against the hazards of ionizing radiation

These guides have developed de following topics:

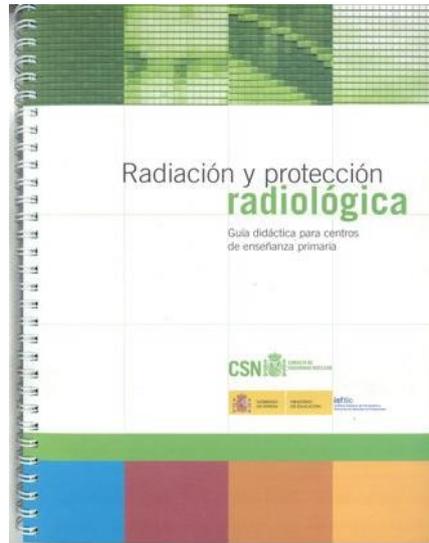
- Physical subjects underlying the applications, such as: radiation, ionizing radiation, the types of ionizing radiation or the phenomena of interaction of radiation with matter.
- Topics related to radiological protection: The fundamental principles on which an appropriate radiological protection can be based (justification, optimization, and the application of dose limits) and health effects of ionizing radiation.
- Topics related to the different International organizations and national authorities responsible for radiological protection, their publications and recommendations.

The working group involves in this task was composed by:

- CSN technical staff (from the Technical Direction in Radiation Protection).
- Teachers from secondary education proposed by the Ministry of Education, to make the pedagogical adaptation of texts.
- CSN Staff from the publications and information department as a support for the issues presentation, and for the coordination of all activities related to the edition of these guidelines.

Once published the guidelines, they were sent to several primary and secondary schools for diffusion and knowledge, and one technical conference was prepared in the CSN site for their presentation.

3.- Guidelines for primary school



The content included in this guide is divided into three levels, depending on the age:

- Level I: students between 6 and 8 years old.
- Level II: students between 8 and 10 years old.
- Level III students between 10 and 12 years old.

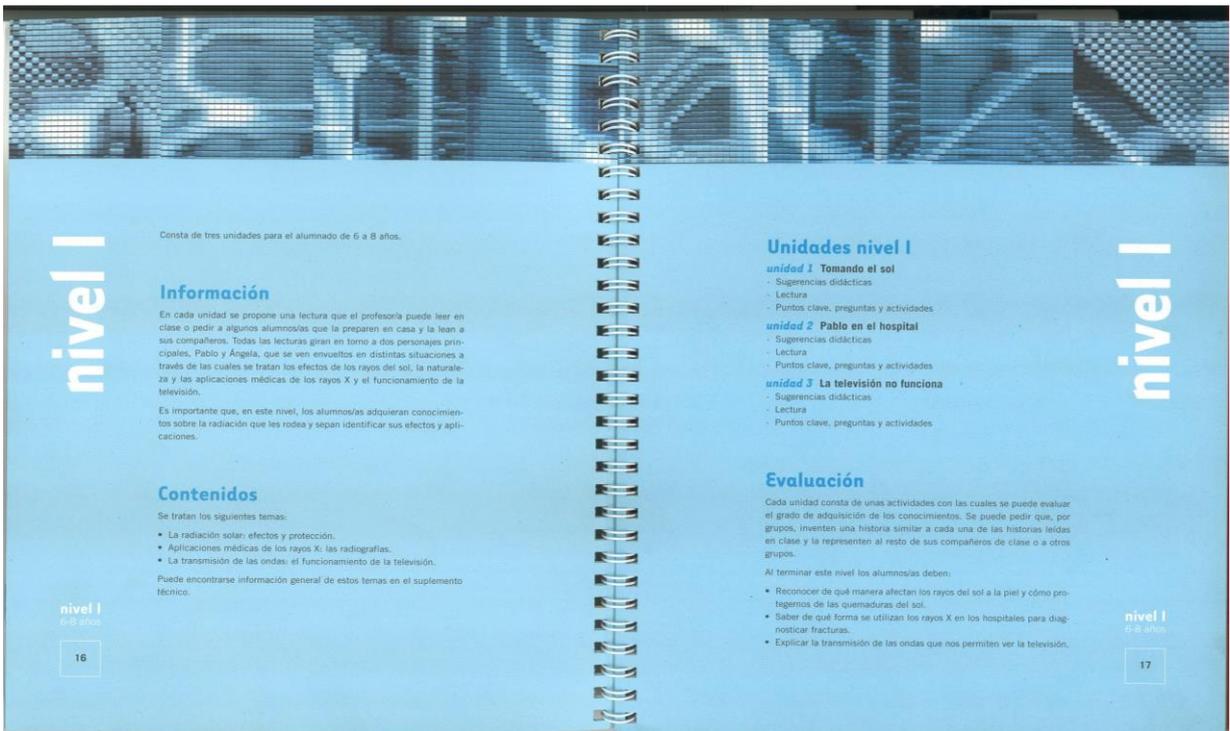
To improve and streamline the presentation, each level is identified by a different color. Each one comprises 3 or 4 units.

The texts contain all the tools for the teachers to provide the three levels and also a technical supplement is included.

The beginning of each level includes:

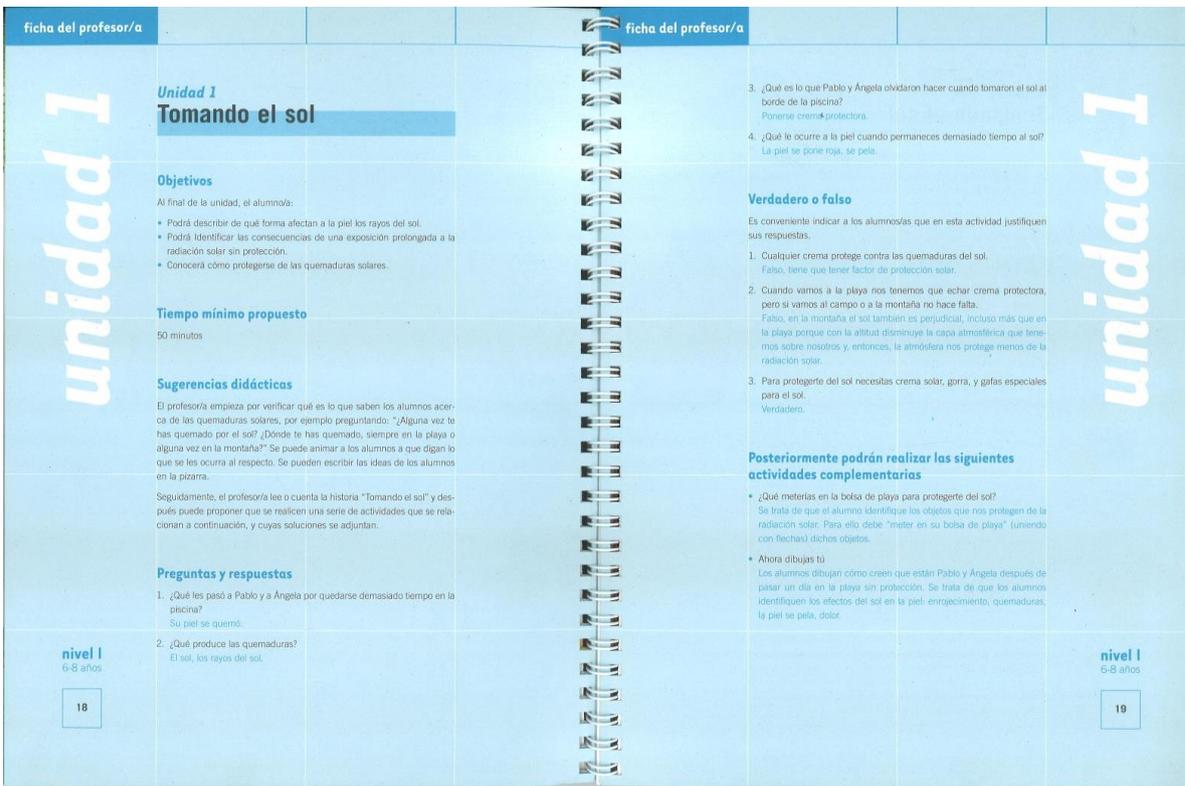
- General information about the topic concerned.
- A relationship of units including in this level.
- Criteria to assess what students have learnt.

4	Prólogo
6	Enfoque general
8	Objetivos
10	Estructura
12	Contenido
14	Nivel I (alumnado de 6 a 8 años)
18	Unidad 1 Tomando el sol
24	Unidad 2 Pablo en el hospital
30	Unidad 3 La televisión no funciona
36	Nivel II (alumnado de 8 a 10 años)
40	Unidad 1 Radiación solar
46	Unidad 2 Al hospital o al dentista
54	Unidad 3 El walkie-talkie
60	Nivel III (alumnado de 10 a 12 años)
64	Unidad 1 Luz, calor y sonido
70	Unidad 2 ¿Becquerel?, ¿quién es?
78	Unidad 3 Aplicaciones hospitalarias
84	Unidad 4 ¿Podemos vivir sin radiación ionizante?
92	Suplemento técnico
94	1. Tipos de radiaciones: radiaciones no ionizantes y radiaciones ionizantes
100	2. Desintegración radiactiva. Medida de la radiación ionizante
103	3. Efectos biológicos de las radiaciones ionizantes. Protección radiológica
105	4. Aplicaciones de las radiaciones ionizantes
110	Glosario
116	Bibliografía



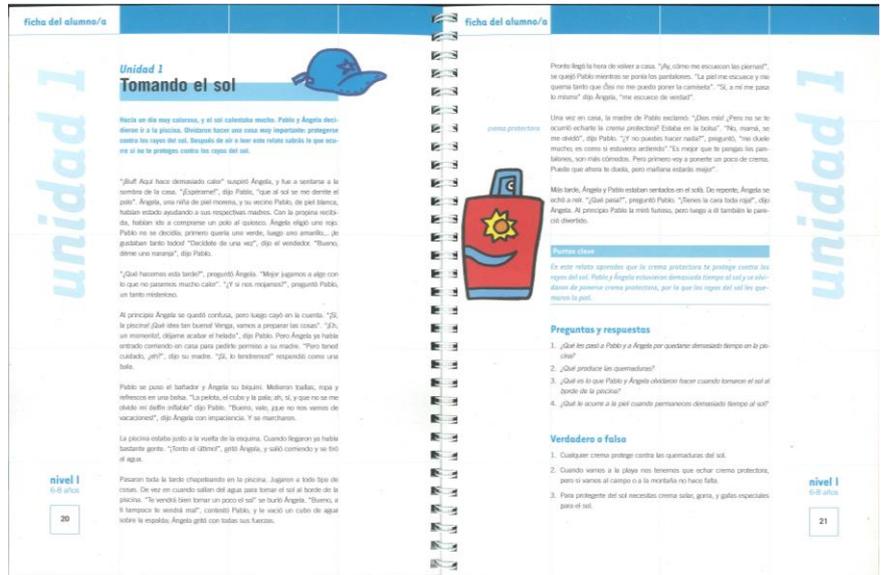
At the beginning of each unit it's included the teacher sheet, which contains:

- Objectives.
- Minimum period of time proposed for development (schedule program)
- Methodology.
- A range of activities for students (with answers when it's necessary).



The **student sheet** includes an introduction followed by a story, mainly of fictional cases, or an explanation with illustrations and figures, and finishes with the "key points". These key points are the key concepts that should be learned by the students.

Those words considered key words, are highlighted out of the story. Also, there are some activities and questions without the answers.



This is only an example to illustrate several subjects of radiation and radiological protection. Each teacher can use them or adapt them if it is necessary, in an adequate and appropriate way.

The **technical supplement** includes more comprehensive information on the different items that are dealt with in the different units.

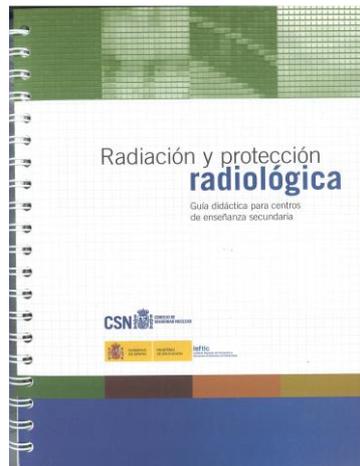
This information is aimed to teachers and tries to be as clear and **objective** as possible. The supplement is followed by a glossary, a bibliography and a list of useful addresses.

The information contained in the technical supplement is the following:

- Types of radiation.
- Radioactive decay.
- Measurement of ionizing radiation.
- Health effects of ionizing radiation. Radiological Protection
- Applications.



4.-Guideline for secondary schools



The topics of this guideline are:

- Understanding the radiation is everywhere.
- Make known the radiation: origin, types, and characteristics.
- Become familiar with the radiation uses.
- Health effects of ionizing radiation.
- Measures Units
- Instruments for radiation measurement.
- Protection against radiation.

The content of this guideline is divided in two levels, according to the age:

- Level I: students between 12 and 16 years old (Mandatory Secondary Education)
- Level II: students between 16 and 18 years old (High school and vocational training)

As the primary guideline, to improve and streamline the presentation, each level is identified by a different color. Each level consists of 7 units.

Each point provides in-depth coverage of a specific subject area. The texts contain all the necessary to teach both levels and include:

- A Technical supplement
- A Glossary
- A Bibliography
- Web site.

4	Prólogo
6	Enfoque general
8	Objetivos
10	Estructura
12	Contenido
14	Nivel I (alumnado de 12 a 16 años)
18	Unidad 1. La radiación está en todas partes
26	Unidad 2. ¿Qué es la radiación ionizante?
32	Unidad 3. ¿Cómo detectar la radiación ionizante?
38	Unidad 4. ¿Cómo afecta a nuestro cuerpo la radiación ionizante?
44	Unidad 5. Aplicaciones médicas de las radiaciones ionizantes
50	Unidad 6. Aplicaciones de las radiaciones ionizantes en industria e investigación
56	Unidad 7. Obtención de energía de origen nuclear
64	Nivel II (alumnado de 16 a 18 años)
68	Unidad 1. Radiación ionizante en la vida diaria
78	Unidad 2. La radiación ionizante y sus efectos biológicos
84	Unidad 3. Protección contra la radiación ionizante
92	Unidad 4. Aplicaciones médicas de las radiaciones ionizantes
102	Unidad 5. Otras aplicaciones de las radiaciones ionizantes
110	Unidad 6. Obtención de energía de origen nuclear
122	Unidad 7. Los residuos radiactivos
130	Suplemento técnico
132	1. Antecedentes históricos
137	2. La estructura del átomo
140	3. Espectro de ondas electromagnéticas: radiación ionizante y no ionizante
144	4. Radioactividad y radiaciones ionizantes
149	5. Efectos biológicos de la radiación: aspectos legales
153	6. Ciclo del combustible nuclear y funcionamiento de las centrales nucleares
158	7. Otras aplicaciones de las radiaciones ionizantes
167	8. Residuos radiactivos: origen y gestión
174	9. El Consejo de Seguridad Nuclear
180	Glosario
188	Bibliografía

In this guideline, the stories included in the primary guidelines have been replaced by science based texts, adapted to student knowledge including the physical concepts necessary to approach the subject.

Like the other, this guideline only represents an approach for developing a framework to teach different items about the radiation and the radiological protection.

Each level can be teaches as a complete unit, although the teachers are free to use information of others units. Each teacher will be able to use or to adapt them in a more suitable way, making attention in different features.

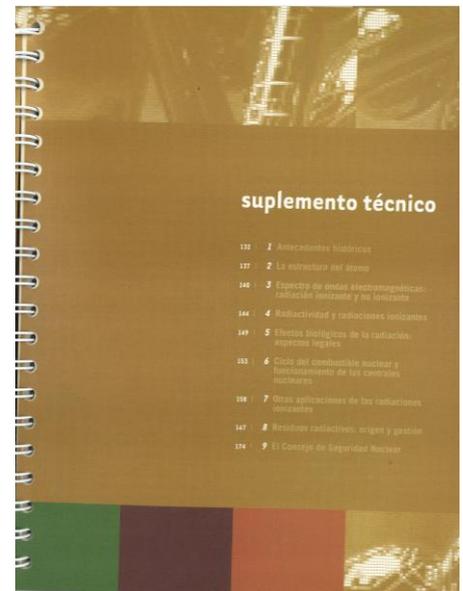
The **technical supplement** contains additional information about different aspects of ionizing and non ionizing radiation and radiological protection based on the latest available scientific information of the biology and physics of radiation exposure.

This information is aimed to the teaching staff, or the students who wish improve their knowledge, and its exposed as cleared and objective as possible.

The information included in the technical supplement is grouped in 9 units, and contains issues related to apply of ionizing radiation, physical concepts, health effects, radiological protection system and relevant national and international authorities in radiological protection.

The issues are:

- Background
- Atomic structure.
- Electromagnetic waves: ionizing and non ionizing radiation (natural and artificial).
- Radioactivity and ionizing radiations. Includes concepts relate to radiation, types of radiations, dose measurement and interaction of the ionizing radiation with the matter.
- Health effects of ionizing radiations.
- International organizations and national authorities responsible for radiological protection, their publications and recommendations.
- Legal aspects relative to the different Organisms with competition in radiological safety and its publications.
- Cycle of the nuclear fuel and nuclear power stations.
- ITER. Scientific project that tries to demonstrate the possibility to produce a commercial way of electrical energy coming from the nuclear fusion. International organizations and national authorities responsible for radiological protection, their publications and recommendations.
- Other applications of ionizing radiations:
 - In the interaction of matter on radiations: x-ray and industrial gammagraphy, process control (measured of density, thicknesses, grammage...).
 - In the action of radiation on the matter: treatment by irradiation: sterilization, food storage, polymer production.
 - Ionizing action: smoke detectors, lightning rods.
 - Radioactive isotope used for study the material behavior.
 - Radioactive waste.



- The Nuclear Security Council. Mission.
- INES scale, like competent Organism in the matter of nuclear security and radiological safety in Spain. It includes its missions, the means whereupon it counts

5. Conclusion

In conclusion, the guidelines objective is to contribute to the knowledge about ionizing radiation, and to help the teachers to transmit it in the classrooms. Only from this position we will form a responsible citizenship, capable of facing a critical attitude the scientific advances in general and the world of the radiations especially

Guideline for primary school objective is to show to younger students that the radiation is in the background of his life: we receive sun radiation; also the doctor uses radiation when he makes a radiography to see a broken bone or it's possible to watch TV or use walked talkies because of radiation exists.

Guideline for secondary school objective is more ambitious. It shows to students the science bases about current issues, such of them are discussion topics, as power plants uses and the radioactive wastes involved, or technology advances involving the uses of ionizing radiations in the fields of medical exposures of patients or food industry or access control systems. The knowledge about the operation conditions, involved risks, environmental control and radiological protection actions will provide citizen the adequate tools to assess the different uses of ionizing radiation