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(Project Number: 605173)


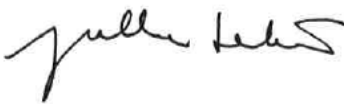

DELIVERABLE D1.5

Updated report on NRC education in European Universities

Lead Beneficiary: UH

Due date: 31/05/2015

Released on: 05/06/2015

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Start date of project: **01/06/2013**

Duration: **36 Months**

Project Coordinator:

Jan John

Project Coordinator Organisation:

CTU in Prague

VERSION: 1.1

Project co-funded by the European Commission under the Euratom Research and Training Programme on Nuclear Energy within the Seventh Framework Programme		
Dissemination Level		
PU	Public	X
RE	Restricted to a group specified by the partners of the CINCH project	
CO	Confidential, only for partners of the CINCH project	

Version control table

Version number	Date of issue	Author(s)	Brief description of changes made
1.0	June 5, 2015	Teija Koivula	1 st draft
1.1	July 31, 2015	Teija Koivula	corrections by received comments

Relevance

This deliverable contributes to the following Work-Packages and Tasks:

ALL

WP 1

Task 1.1 Task 1.2 Task 1.3 Task 1.4

WP 2

Task 2.1 Task 2.2 Task 2.3 Task 2.4

WP 3

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WP 4

Task 4.1 Task 4.2 Task 4.3 Task 4.4

WP 5

Task 5.1 Task 5.2 Task 5.3 Task 5.4

Project information

Project full title:	Cooperation in education and training In Nuclear CHemistry
Acronym:	CINCH-II
Funding scheme:	Coordination Action
ECGA number:	605173
Programme and call	FP7 EURATOM, FP7-Fission-2013-5.1.1
Coordinator:	Jan John
EC Project Officer:	Georges Van Goethem
Start date – End date:	01/06/13 – 31/05/16 i.e. 36 months
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EXECUTIVE SUMMARY

Deliverable 1.5 covers a summary report on the current status of nuclear and radiochemistry education in Europe. It is based on a survey of European universities giving education in nuclear and radiochemistry that was started already during CINCH-I and continued under the CINCH-II project from December, 2013 until May, 2015. The work was carried out mainly by internet survey and sending a questionnaire to the appropriate departments. Personal contacts and contribution from the CINCH-II project partners had also an important role. Detailed information on various curricula in nuclear and radiochemistry was collected and analyzed. Educational programs at BSc and MSc level were compared by their extent, contents and focus on education; evaluation of the postgraduate education was focused on the research topics and number of PhD-projects. In the main text of the report education is first discussed in general level and subsequently described in each listed country. Contact information to the universities/departments included in the survey is attached as an Appendix 1.

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1 INTRODUCTION

The Euratom FP7 project “Cooperation in education **In Nuclear Chemistry**” (CINCH) was started in February, 2010, and continued as CINCH-II – “Cooperation in education and training **In Nuclear Chemistry**” – project from June, 2013. CINCH project aims, as its name indicates, at coordination of the current diverse education and training schemes in nuclear and radiochemistry (abbreviated to NRC). Furthermore, one of the specific objectives of the CINCH-II project is to further develop and implement the plan for the European master’s degree in nuclear chemistry (NRC EuroMaster). To support this work it is important to identify the current and potential level of education in this field and to reach the NRC community in Europe.

Surveying universities and various educational programs in nuclear and radiochemistry was started during the CINCH-I project in the years 2010-2011, mainly by internet survey and sending a questionnaire to the NRC departments throughout Europe. Results were published in a report “Nuclear and radiochemistry curricula in the European universities” (<http://www.cinch-project.eu/>, Documents, Nuclear and Radiochemistry curricula in the European universities). To have an up-to-date view on the current status of NRC education the survey was continued under the CINCH-II project. Universities/departments already included in the first report were contacted and a questionnaire was also uploaded onto the project web page. Moreover, the survey was conducted as an internet survey and by the contribution of CINCH-II project partners during the years 2013-2015.

Results from the overall survey are discussed in this report, covering 72 universities in 22 countries as depicted in Fig. 1.1. In the main text of the report education on nuclear and radiochemistry is first discussed in general level and subsequently described in each listed country (Chapter 6). The detailed analyses of the curricula (Chapters 4-5) are mainly based on the responses to the questionnaires and personal contacts. Contact information to all universities/departments included in the survey is attached as an Appendix 1.

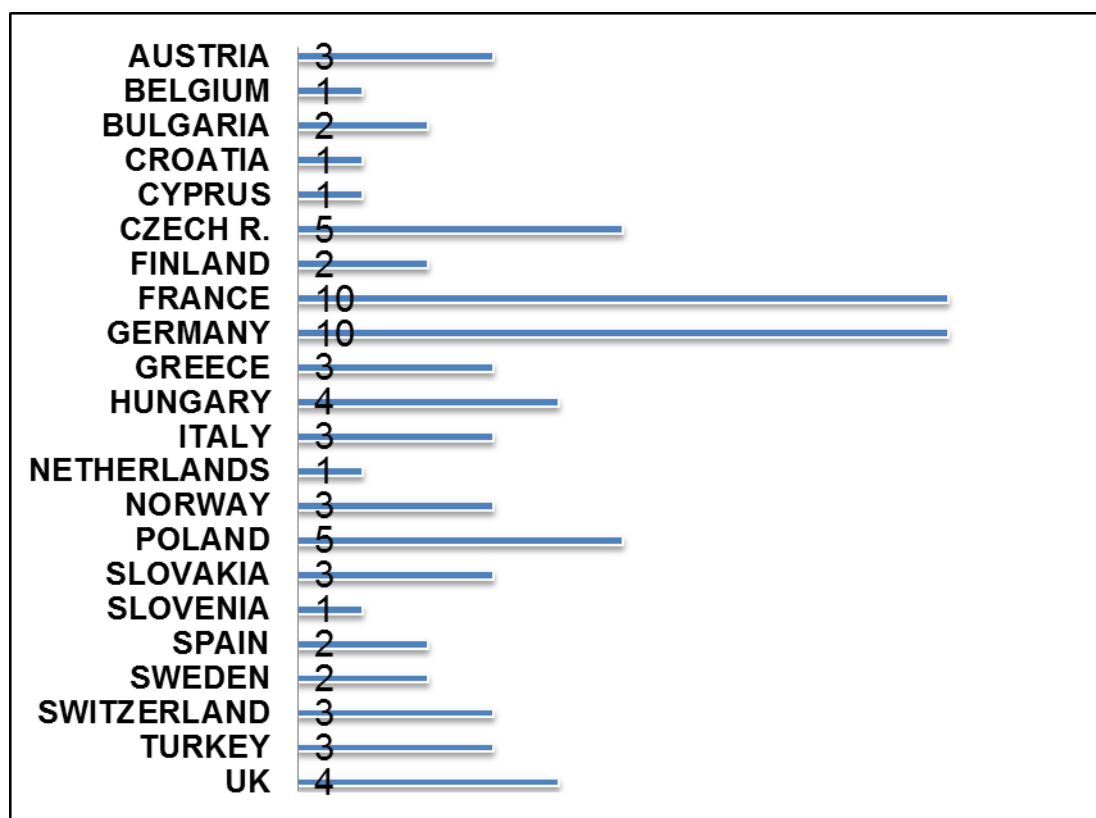


Figure 1.1: Number of universities giving education in NRC in each listed European country.

2 UNIVERSITIES GIVING EDUCATION IN NUCLEAR AND RADIOCHEMISTRY

2.1 Survey and evaluation criteria

The aim of this work was to survey current education in nuclear and/or radiochemistry (abbreviated to NRC) in Europe. Education at BSc, MSc or PhD level was considered. Nuclear engineering or related programs were included only if they contain substantially courses on NRC. Credit values for the programs/courses were defined by the ECTS (European Credit Transfer and Accumulation System) grading system, i.e. 1 ECTS credit (abbreviated to ECTS) corresponds 25-30 hours of work.

The survey was started already early in the CINCH-I project and continued actively during the years 2010-2011, mainly by internet survey and sending a thorough questionnaire to the NRC departments throughout Europe. Eventually 69 universities in 22 countries were included in this first study; having NRC education either as a degree/specialization (43%) or only as individual courses under various educational programs (57%). The total number of degrees/specializations in NRC was 44: 8 at BSc and 36 at MSc level, respectively. The overall percentage of the returned questionnaires was 60%; corresponding value among the 45 universities having a more extensive curriculum in nuclear and radiochemistry was 70%, respectively. Results were published in a report “Nuclear and radiochemistry curricula in the European universities” (<http://www.cinch-project.eu/Documents>).

To have an up-to-date view on the NRC education the survey was continued under the CINCH-II project from December, 2013, until May, 2015. Universities/departments already included in the first report were asked via their contact persons to update relevant information on their unit; especially concerning changes in the curricula and focus of education in NRC. The short questionnaire concerned this time mainly education at BSc and MSc level. Other interested units were welcome to join the survey by sending free-form e-mail or by answering short questions in a more thorough questionnaire on the project web page; work was also presented at the nuclear and radiochemistry conference (RadChem 2014) in Czech Republic, May, 2014. Moreover, the survey was conducted as an internet survey and by the contribution of other CINCH-II project partners. Overall number of responses to this 2nd survey remained quite low, 22 of total 69, however, over 85% of them were from the universities that have more extensive curriculum in NRC.

Altogether 72 universities in 22 countries were included in this updated report. In comparison to the first study there are 6 additional universities and 3 have been left out. Universities were categorized by the extent, level and focus of education. Various curricula in NRC were evaluated by the field of specializations; both by the extent and content of the curriculum, as well as by the number of students participating in the programs. The detailed analyses of the curricula were based on the responses to the questionnaires and personal contacts. If no feedback was received from the university, current status of the NRC education was evaluated by the information on webpages and also with the help of CINCH-II project partners in corresponding country.

2.2 Categorization

Appendix 1 consists of the overall list of universities grouped by the country and form of education. Surveyed universities were first categorized by the extent (and level) of education. Findings can be summarized as follows: **43%** of the universities have a degree program or specialization in NRC and **57%** offer only individual courses under various educational programs, as depicted in Fig. 2.2.1. In this categorization universities that offer NRC as a so-called major subject or as a course module plus a possibility to do a thesis work (> 40 ECTS of NRC in total) were included in the sub-

category specialization. The 2nd category included universities that have only individual courses in NRC. The survey covered only NRC departments and chemistry related programs, therefore, the overall number of European universities in this category is most likely higher. Majority of the surveyed universities, 87%, have education both at MSc and BSc level and 13% only at BSc level.

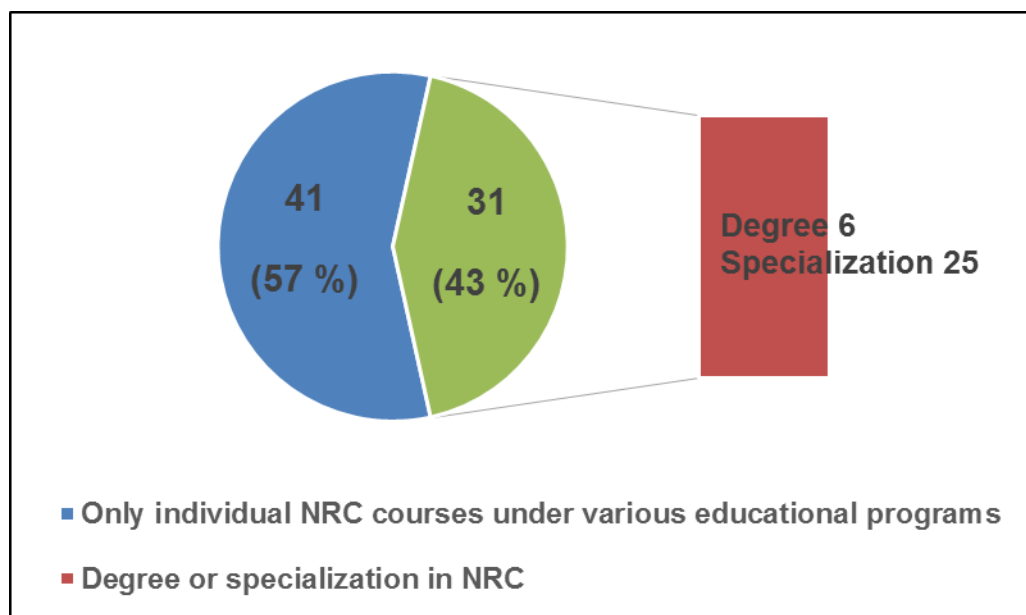


Figure 2.2.1: Categorization of the universities by the extent of education at BSc/MSc level. Slices represent total number of universities under each category. Sub-category specialization include universities that offer NRC as a major subject or as a course module plus a possibility to do a thesis work, > 40 ECTS of NRC in total.

A second classification was based on the area on which the NRC education is focused. Categorization was mainly done based on the degrees/specializations as well as the course offer in NRC. The questionnaire(s) included also one section where special focus of education could be described. However, majority of the respondents did not specify anything in this section, instead, the focus of education was stated as the major research topics of the department. Therefore, in a large number of the universities a single focus of education cannot be defined as both general and several/all applied NRC fields are included in the education. Universities that have education at least in two applied NRC fields (in addition to basic NRC) are listed in Table 2.2.1.; if the unit specified some focus (1-2 topics) despite the versatile curricula it is described separately.

Table 2.2.1: Universities having education both in general and applied NRC*

UNIVERSITY	<i>specified focus</i>
UNIVERSITY OF SOFIA, Bulgaria	
CZECH TECHNICAL UNIVERSITY IN PRAGUE, Czech Republic	
UNIVERSITY OF HELSINKI, Finland	
RUPRECHT-KARL UNIVERSITY OF HEIDELBERG, Germany	<i>chemistry of f-elements and nuclear forensics</i>
DRESDEN UNIVERSITY OF TECHNOLOGY, Germany	<i>f-elements, actinide chemistry</i>
UNIVERSITY OF KÖLN, Germany	
FH AACHEN-UNIVERSITY OF APPLIED SCIENCES, Germany	
KARLSRUHE INSTITUTE OF TECHNOLOGY, Germany	

JOHANNES GUTENBERG UNIVERSITY, Germany DEBRECEN UNIVERSITY, Hungary UNIVERSITY OF MILAN, Italy DELFT UNIVERSITY OF TECHNOLOGY, Netherlands UNIVERSITY OF OSLO, Norway UNIVERSITY OF WARSAW, Poland INSTITUTE OF NUCLEAR CHEMISTRY AND TECHNOLOGY, Poland CHALMERS UNIVERSITY OF TECHNOLOGY, Sweden UNIVERSITY OF BERN, Switzerland EGE UNIVERSITY, Turkey UNIVERSITY OF MANCHESTER, UK	<i>application of experimental design and statistical analysis for sorption studies of radionuclides</i>
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* at least two different topics such as radiopharmaceutical chemistry or radioecology

On the other hand, there are several universities/departments in which NRC education is focused on *Environmental radiochemistry and radioecology*. Other frequent fields are *Radiopharmaceutical chemistry* and *Radioanalytical chemistry*. Universities that have mainly nuclear energy or technology related topics, including nuclear waste and fuel cycle chemistry, were compiled under the category *Nuclear energy and materials*. Overall categorization of the universities under the various topics is depicted in Fig. 2.2.2. Furthermore, universities under the largest specified topics are listed in Table 2.2.2.

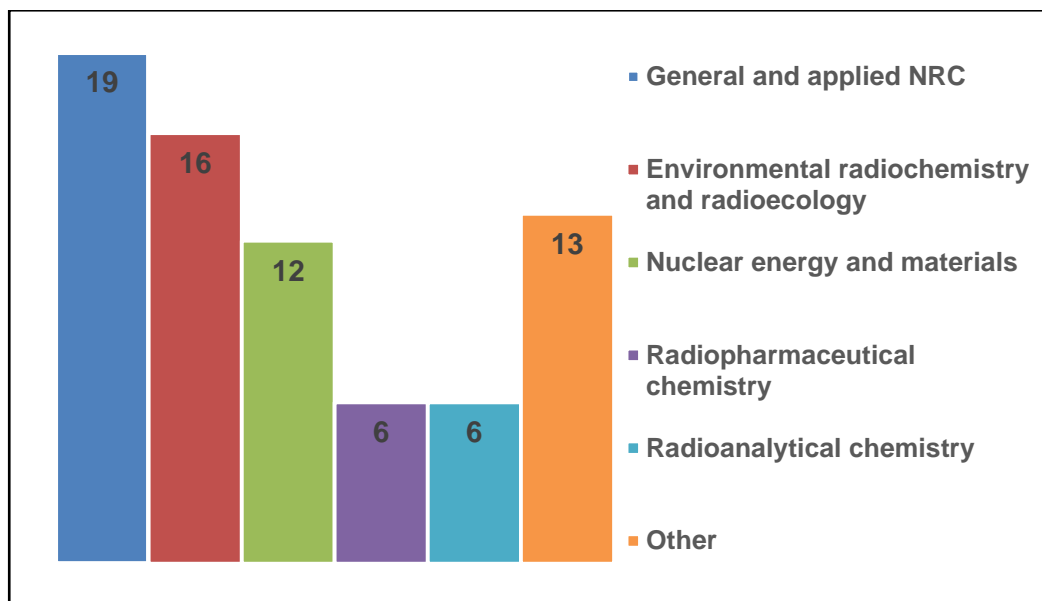


Figure 2.2.2: Categorization of universities by the focus of education in NRC. Fields are determined by the specializations and/or course offer. Category *Other* includes universities that have general NRC courses without any specific focus of education or have some other, minor topic. Bars represent total number of universities under each category.

Table 2.2.2: Universities with a specified focus of education¹ in NRC

FOCUS OF EDUCATION	UNIVERSITY
Environmental radiochemistry and radioecology	UNIVERSITY OF VIENNA, Austria VIENNA UNIVERSITY OF TECHNOLOGY, Austria PLOVDIV UNIVERSITY, Bulgaria UNIVERSITY OF CYPRUS, Cyprus UNIVERSITY OF NICE-SOPHIA ANTIPOLIS, France LEIBNIZ UNIVERSITY OF HANNOVER, Germany UNIVERSITY OF PATRAS, Greece UNIVERSITY OF PANNONIA, Hungary NORWEGIAN UNIVERSITY OF LIFE SCIENCES, Norway UNIVERSITY OF GDANSK, Poland JOŽEF STEFAN INTERNATIONAL POSTGRADUATE SCHOOL, Slovenia COMENIUS UNIVERSITY, Slovakia UNIVERSITY OF SS. CYRIL AND METHODIUS in Trnava, Slovakia TECHNICAL UNIVERSITY OF ZVOLEN, Slovakia UNIVERSITY OF LOUGHBOROUGH, UK UNIVERSITY OF SOUTHAMPTON, UK
Radiopharmaceutical chemistry	UNIVERSITY OF TURKU, Finland MUNCHEN UNIVERSITY OF TECHNOLOGY, Germany FREIE UNIVERSITÄT BERLIN, Germany TECHNICAL UNIVERSITY OF ZURICH, Switzerland UNIVERSITY OF ZURICH, Switzerland KING'S COLLEGE LONDON, UK
Nuclear energy and materials ²	PARIS SUD UNIVERSITY XI, France – <i>actinides chemistry</i> CHIMIE PARISTECH (École nationale supérieure de chimie de Paris), France École des Mines of Nantes (SUBATECH), France UNIVERSITY MONTPELLIER 2, France l'Ecole Nationale Supérieure de Chimie de Montpellier (ENSCM), France GRENOBLE INP Phelma, France University of Aix-Marseille, France University of Limoges, France Lille 1 University, France TU CLAUSTHAL, Germany BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS, Hungary KTH ROYAL INSTITUTE OF TECHNOLOGY, Sweden
Radioanalytical chemistry	UNIVERSITY OF INNSBRUCK, Austria GHENT UNIVERSITY, Belgium UNIVERSITY OF ZAGREB, Croatia UNIVERSITY OF CHEMISTRY AND TECHNOLOGY PRAGUE, Czech Republic EÖTWÖS LORÁND UNIVERSITY, Hungary MARIA CURIE SKŁODOWSKA UNIVERSITY, Poland

¹ A specific focus was stated in the questionnaire and/or education in the specific field is given in addition to basic NRC courses. ² Includes e.g. nuclear waste management and fuel cycle chemistry.

3 NUCLEAR AND RADIOCHEMISTRY EDUCATION IN GENERAL

3.1 Course topics

A significant part of the surveyed universities, 41 of total 72, have NRC education only as individual courses. Typically this means basic NRC courses which students can include in their chemistry (or chemical engineering) studies at BSc level (20%), or both at BSc and MSc level (80%). Additional course offer reflects research interests of the department, that is for example actinide chemistry or radioecology is taught together with basic nuclear and/or radiochemistry. Various NRC courses are categorized by their most popular topics in Fig. 3.1.1. Furthermore, some examples of the various educational programs under which the individual NRC courses are studied are presented in Table 3.1.1. The reason for low proportion of Nuclear energy and materials in comparison to various focus of education (and field of specializations) is that the topic is mostly taught under the degree programs.

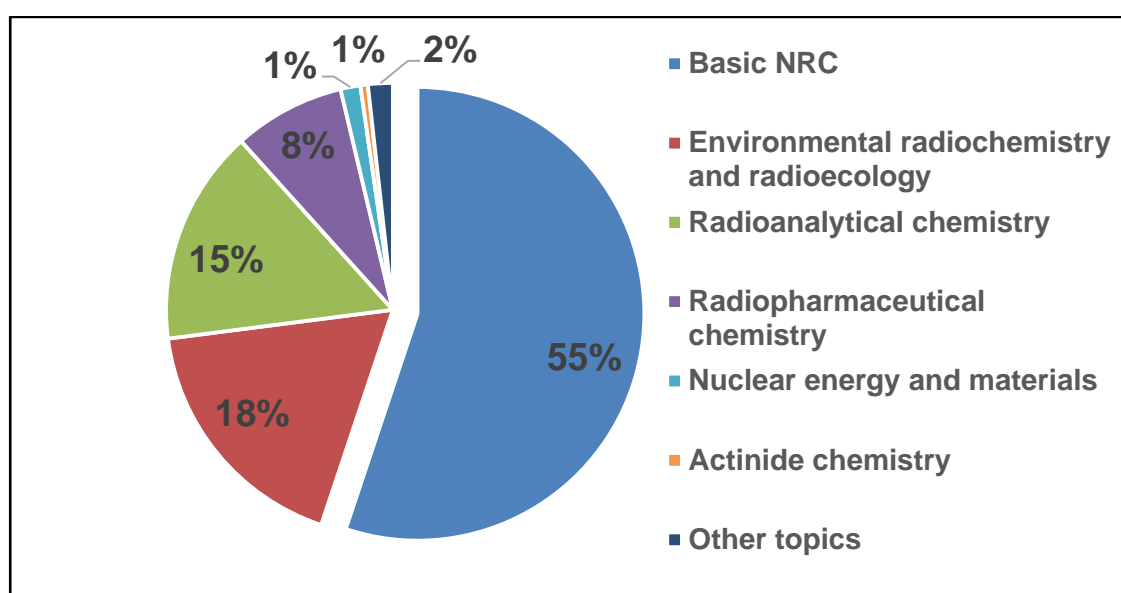


Figure 3.1.1: Major topics of individual NRC courses

Table 3.1.1: Examples of individual NRC courses and educational programs under which they are studied

Course topic	University	Educational program
Basic RC	Ghent University	BSc in chemistry; biochemistry and biotechnology
Basic and environmental RC	University of Cyprus	BSc, MSc in Environmental Chemistry
Basic NC	University of Defence in Brno	BSc in Military chemistry
Basic RC, environmental RC, radiopharmaceutical chemistry	University of Milan	(BSc) MSc in chemistry, physics and geology
Basic NRC, environmental RC, radiopharmaceutical chemistry	University of Bern	BSc in chemistry, biochemistry, pharmacy; MSc in chemistry

3.2 Degree programs/NRC specializations

Only 6 universities in Europe has currently a complete BSc and/or MSc program (degree) in general and applied NRC. However, in 25 additional universities nuclear and/or radiochemistry is included as a specialization in MSc studies of Chemistry or other related programs. Various forms of education are summarized in Table 3.2.1. In comparison to the 1st survey, the overall number of programs has remained at similar level, 39 compared to 44, respectively.

Table 3.2.1: Summary of various forms of education in NRC in European universities

Type of education	Number of programs at 2015	Number of programs at 2010
Program in NRC at BSc level	7	8
* <i>degree in NRC</i>	2	2
* <i>specialization¹ in NRC</i>	5	6
Program in NRC at MSc level	32	36
* <i>degree in NRC</i>	8	8
* <i>specialization¹ in NRC</i>	24	28

¹ A major subject or a course module plus a thesis work under other program such as BSc or MSc in Chemistry

The fields of specializations are in line with the focus of education and thus research interests in the universities, i.e. majority of the specializations are under *General NRC* covering both basic NRC and various applied NRC topics and the largest specified topic is *Environmental radiochemistry and radioecology*, Figure 3.2.1.

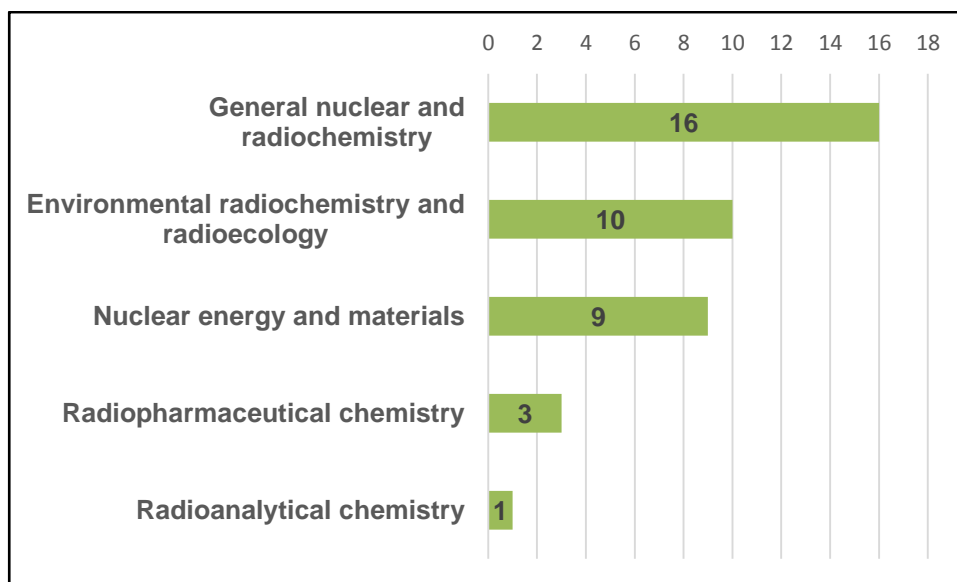


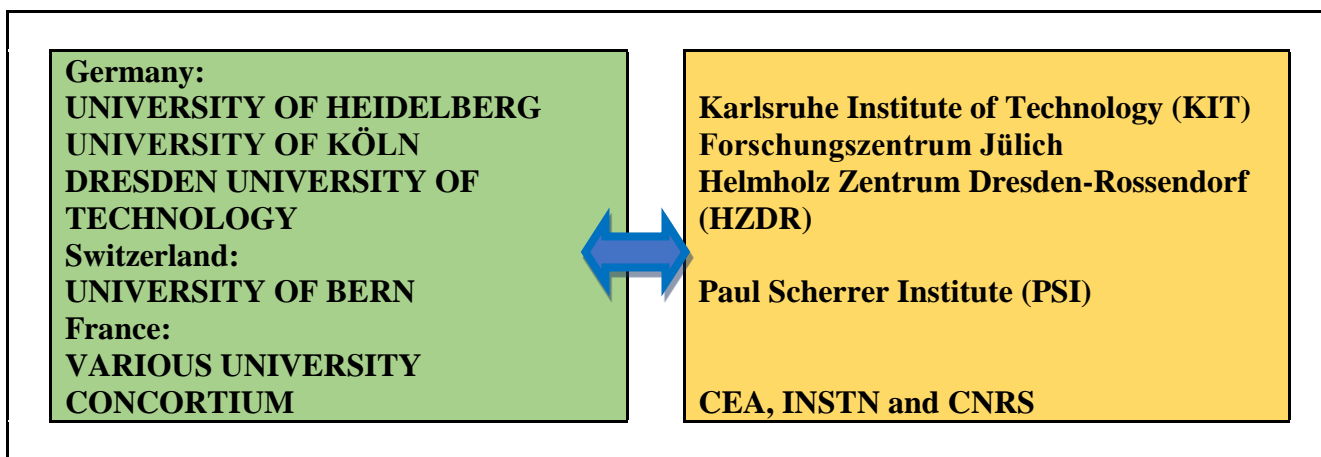
Figure 3.2.1: Current BSc/MSc degrees and specializations categorized in general and applied NRC. Green bars represent number of educational programs under each specified field.

In general, the NRC education can be attained to same extent both under a degree program or specialization. However, the interpretation of specialization varies a lot depending on the educational system; the extent and content of the specialization may also depend on background education, i.e. the graduate program is aimed at students with certain lower level degree in nuclear

and/or radiochemistry.

Implementation of the Bologna system with BSc and MSc degrees (typically with 180 and 120 ECTS, respectively) varies depending on the country and education structure. For example, during the first survey undergraduate NRC education in some German universities was still at diploma level. Currently these educational programs have been updated to BSc or MSc level. In some educational systems the degrees (or part of them) can also be research (*academic*) or professionally (*vocational*) orientated. Especially in Germany universities are focused on education whereas the research is being done at the various research institutes. Collaboration between academia and research institutes or industry has a significant role in the NRC education also in some other countries (or universities), some examples are depicted in Figure 3.2.2. The collaboration brings education and training closer to each other and also complicates comparison of the academic programs.

Figure 3.2.2: Examples of close collaboration in NRC education between academia and research institutes and/or industry



Altogether, there exist MSc programs with 60, 90 or 120 ECTS. Under a complete MSc program (120 ECTS) requirements for studies in NRC varies also significantly, from 47 to 113 credits. Research training and thesis work have typically a significant role in specialization. Thus, course modules (typically in German universities) were also considered as a specialization when there is a possibility to do a thesis work in the same field. Diversity of the NRC educational programs is depicted in Table 3.2.2.; details of the various curricula will be discussed in the following chapters (4-5). Analyses are mainly based on the responses to the questionnaires and personal contacts. Elaborate course syllabi are thus described as in the year 2010 (and/or by the course information on unit's webpage) if no feedback was received from the corresponding university/department. Furthermore, some country specific features of the educational programs are described in more detail in Chapter 6.

Table 3.2.2: Examples of NRC related BSc/MSc degrees and specializations in various universities

Degree ¹ /specialization	University	Contents of specialization ²					ECTS total
		Courses/ seminars	Final exam(s)	Research training/projects	Thesis work		
BSc in Nuclear Chemistry (240 ECTS)	University of Sofia	93	-	4	10		107
BSc in Nuclear Chemistry (180 ECTS)	Czech Technical University in Prague	19-22	-	1	15		35-38
MSc in Nuclear Chemistry (60 ECTS)	University of Sofia	30	(8)	15	15		60
MSc in Radiochemistry and radioecology (90 ECTS)	University of Sofia	50	(10)	20	20		90
MSc in Radiopharmaceutics & PET Radiochemistry (90 ECTS)	King's College London	60		30			90
EurMSc in Radioecology	Norwegian University of Life Sciences	30	(3)	30	60		120
MSc in Nuclear Chemistry	Czech Technical University in Prague	min 42	-	14	30		min 86
MSc in Chemistry: <i>Nuclear Chemistry</i>	University of Oslo	20-40			60		80-100
MSc in Chemistry: <i>Radiochemistry</i>	University of Helsinki	33-34	7	3	40		83-84
MSc in Chemistry: <i>Nuclear chemistry and radioecology</i>	Comenius University	57	-	14	29		100
MSc in Nuclear Science and Technology: <i>Nuclear engineering</i>	Chalmers University of Technology	45	-	-	30		75
MSc in Chemical engineering: <i>Radiochemical technology</i>	University of Pannonia	26	-	-	30		56
MSc in Environmental engineering: <i>Radioecology</i>	University of Pannonia	17	-	-	30		47

¹ 120 ECTS unless stated otherwise² Curriculum in NRC

4 NUCLEAR AND RADIOCHEMISTRY CURRICULA AT BSc AND MSc LEVEL

4.1 NRC curricula at BSc level

There are three universities in Europe that offer a program or specialization in NRC already at BSc level: **University of Sofia** in Bulgaria and **Czech Technical University (CTU)** in Prague, Czech Republic, award BSc degrees in Nuclear Chemistry with 240 and 180 ECTS, respectively; **University of Pannonia** in Hungary has a radioecology specialization under the BSc degree in Environmental engineering (210 ECTS). Details of the curricula are described in Table 4.1.1.

Table 4.1.1: Selected curricula for nuclear and radiochemistry at BSc level

Degree/specialization (University)	Courses	Research training	Thesis work	ECTS NRC(Total)
BSc in Nuclear Chemistry (U Sofia)	93	4	10	107 (240)
BSc in Nuclear Chemistry (CTU)	min 20	-	15	min 35 (180)
BSc in Environmental engineering/specialization radioecology (U Pannonia)	21	8	10	39 (210)

The extensive BSc degree in Nuclear Chemistry at the University of Sofia is a relatively new program; first 10 students were graduated in 2010. At the University of Pannonia average 8 students are awarded annually with a specialization in radioecology and at CTU average 6 students have been graduated annually with the BSc degree in Nuclear Chemical Engineering. Recently, the title of the degree was changed to BSc in Nuclear Chemistry and content of curricula was modified. NRC related course supply for these three programs is described in Table 4.1.2.

At the **University of Köln** and **University of Heidelberg** in Germany a course module (11-15 ECTS, including research training) plus a thesis work (12-14 ECTS) in nuclear or radiochemistry can be taken under the degree BSc in Chemistry (180 ECTS); BSc program in Applied Chemistry (180 ECTS) in the **FH Aachen University of Applied Sciences** includes 10-40 ECTS nuclear and radiochemistry. Number of students attending these BSc courses is in the level of 10-25. Furthermore, radiochemistry (and/or radiation) option can be chosen for undergraduate chemistry studies (BSc, MChem) at the **Loughborough University**, UK.

Table 4.1.2: Course offer under certain BSc degrees/specializations in NRC

Degree	Course title	ECTS	Type ¹
BSc in Nuclear Chemistry (University of Sofia)			
	Atomic and nuclear physics	9	L, E
	Nuclear chemistry and radiochemistry I-II	7	L, P
	Measurement of the ionization radiation	6	L, P
	Radiation protection	4	L, S
	Operation and decommissioning of nuclear power plants	6	L, P
	Radioanalytical chemistry	6	L, P
	Chemistry of the nuclear fuel cycle and of nuclear reactors	8	L, P
	Water treatment and water purification in the nuclear energetic	4	L, P
	Radioecology	4	L, P
	Production of radioactive isotopes and labeled compounds	5	L, P

	Radioactive wastes	5	L, E
	Nuclear safety. Risk analysis and risk informed decision making	3	L, S
	Fundamentals of radiobiology	4	L, P
<i>elective</i>	Hot atom chemistry	4	L, P
	Radioisotope dating	4	L, P
	Radionuclide methods in medicine	4	L, P
	Materials for the nuclear energetic	4	L, E
	Application of radionuclides	4	L, P
<hr/>			
BSc in Nuclear Chemistry (CTU)			
	Nuclear chemistry I	2	L, E
	Nuclear chemistry II	5	L, E
	Detection of ionisation radiation	2	L
	Nuclear Power Plants Design and Operation	3	L, S
	Practical exercises in detection of ionizing radiation	3	P
	Practical exercises in radiochemical techniques	2	P
	Dosimetry and radiation protection	3	L, E
<i>optional</i>	Nuclear physics	6	L, E
	Quantum physics	3	L
	Introduction to Elementary Particle Physics	2	L
	Transport of ionizing radiation and Monte Carlo method	4	L
	Exact methods in research of historic monuments	2	L
<hr/>			
BSc in Environmental engineering, specialization radioecology (University of Pannonia)			
	Basics of Radiation	1	L
	Radioecology	2	L
	Nuclear Energetic	2	L
	Dosimetry and Radiation Protection	2	L
	Nuclear emergency management, radioactive waste management	2	L
	Nuclear Metrology	2	L
	Uses of radioisotopes	2	L
	Lessons from the nuclear and radiation accidents	2	L
	Radiations and radionuclides in the nature	3	L
	Radioecology and Nuclear Metrology	6	P
<i>elective</i>	Nuclear Energetic	2	L
	Natural and artificial radiations	2	L
<hr/>			
BSc in Chemistry, module radiochemistry (University of Heidelberg)			
	Basic Radiochemistry I	6	L, E
	Basic Radiochemistry II	9	L, E, P
<hr/>			
BSc in Chemistry, module nuclear chemistry (University of Köln)			
	Basic Nuclear chemistry	2	L
	Exercises in Basic Nuclear chemistry	2	E
	Lab Course in Nuclear chemistry	5	P
	Seminar in Nuclear chemistry	2	S

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

4.2 Curricula for MSc specialization in General nuclear and radiochemistry

Universities offering general nuclear and/or radiochemistry as an MSc degree or a specialization are listed in Table 4.2.1. In this context general NRC means that the program is not specified under certain field, but the curricula cover both basic and applied NRC. Currently there are 11 MSc level programs in 11 universities that include more than 40 ECTS of (general) NRC.

At the **University of Sofia** MSc in Nuclear Chemistry (60 ECTS) is aimed at students with the BSc degree in nuclear chemistry (240 ECTS). At the **Czech Technical University in Prague** (CTU), students can take the degree MSc in Nuclear chemistry as a 2 year (120 ECTS) program. Furthermore, informal specialization can be chosen from three fields (Applied nuclear chemistry, Environmental radiochemistry, Nuclear chemistry in biology and medicine). Average 5 students are graduated with this degree annually. **FH Aachen University of Applied Sciences** (Germany) offers EurMSc degree in Nuclear Applications (120 ECTS): average 10 students are attending this program annually.

Specialization in general nuclear and radiochemistry is also possible under certain MSc programs in chemistry or related fields. Majority of these programs are 2 year programs with 120 ECTS, however, the proportion of NRC included in the specialization varies to some extent. At the **University of Oslo** (Norway) chemistry students can specialize in nuclear chemistry (80-100 ECTS). The amount of students has improved in recent years, from 1 or 2 to 6 active MSc students. Similar situation is at the **University of Helsinki** (Finland) where the number of MSc students has increased from average 8 to average 12 students. Specialization in radiochemistry (83-84 ECTS) can be taken under the degree MSc in Chemistry. In the **Norwegian University of Life Sciences** (NMBU) average 5 chemistry students are graduated annually with the specialization in general radiochemistry (90 ECTS). In addition, at the **Chalmers University of Technology** (Gothenburg, Sweden) students can nowadays specialize in nuclear engineering under the MSc degree in Nuclear Science and Technology. The program is based on the former MSc degree in Nuclear engineering (specialization nuclear chemistry), content of the curricula is currently under modification. Nuclear chemistry specialization (45 ECTS) under the degree MSc in Chemistry and biosciences does not exist anymore.

In addition to the educational programs described above, there is a number of universities in which nuclear and/or radiochemistry can be taken as a course module and a thesis work can be done under related fields e.g. for MSc in Chemistry. At the **University of Gdansk** (Poland) the specialization in nuclear and radiochemistry includes total 23 ECTS of courses, research training and seminars and 30 ECTS for the thesis work. Recently, also **Debrecen University** in Hungary have started to offer a course module in radiochemistry (total 30 ECTS) for MSc students in Chemistry. Furthermore, course modules in NRC are also offered in two German universities: **University of Heidelberg**, and **University of Köln**. The overall extent of the specializations, course modules and thesis work (30 ECTS), in these universities is average 42 ECTS.

Table 4.2.1.: Universities offering a MSc degree or specialization¹ in general NRC

University	Degree/specialization	ECTS
UNIVERSITY OF SOFIA	MSc in Nuclear Chemistry	60 ²
Czech Technical University in Prague	MSc in Nuclear Chemistry	120
	* NRC	86
FH Aachen University of Applied Sciences	EurMSc in Nuclear Applications	120
	* NRC	30-90
UNIVERSITY OF OSLO	MSc in Chemistry	120
	* nuclear chemistry	80-100

UNIVERSITY OF HELSINKI	MSc in Chemistry	120
	* <i>radiochemistry</i>	83-84
Norwegian University of Life Sciences	MSc in Chemistry	120
	* <i>radiochemistry</i>	90
Chalmers University of Technology	MSc in Nuclear Science and Technology	120
	* <i>nuclear engineering</i>	75
	MSc in Chemistry and biosciences	120
	* <i>nuclear chemistry</i>	45
UNIVERSITY OF GDANSK	MSc in Chemistry	120
	* <i>module nuclear and radiochemistry</i>	53
DEBRECEN UNIVERSITY	MSc in Chemistry	120
	* <i>module radiochemistry</i>	30+thesis
UNIVERSITY OF HEIDELBERG	MSc in Chemistry	120
	* <i>module radiochemistry</i>	40
UNIVERSITY OF KÖLN	MSc in Chemistry	120
	* <i>module radiochemistry</i>	43

¹ ≥ 40 ECTS of NRC included in the curriculum, thesis work may be included

² For students having BSc degree (240 ECTS) in Nuclear Chemistry

Contents of the selected curricula in general nuclear and radiochemistry are described in Tables 4.2.2. and 4.2.3. At the University Sofia the course supply is rather specified as the students have basic NRC already at BSc level. Curriculum at the Chalmers University of Technology included mostly general nuclear chemistry and nuclear technologies until radiopharmaceutical chemistry and radioecology were added into the course supply in 2010. At the University of Helsinki the radiochemistry specialization covers basic radiochemistry, radiation safety and measurement techniques as well as radioanalytical chemistry. In addition, a variety of applied radiochemistry such as environmental radioactivity, radiopharmaceutical and radiation chemistry is taught; 3-4 of these elective courses should be included in the curriculum. The Czech Technical University in Prague (CTU) has an extensive curriculum in NRC and a broad variety of applied NRC courses related to e.g. environmental chemistry, radiopharmaceutical chemistry and nuclear technologies is offered in addition to basic courses. Curriculum was recently updated, course selection was increased and it includes also compulsory internship (4 ECTS). Nuclear chemistry specialization at the University of Oslo (UiO) has highest proportion for the thesis work (60 ECTS); the course portfolio was recently updated. NRC education at the Norwegian University of Life Sciences (NMBU) is mainly focused on environmental radiochemistry, thus, the course supply for the radiochemistry specialization is similar to the curricula described later for Radioecology degree.

Table 4.2.2: Selected curricula for general nuclear and radiochemistry at MSc level

Degree/specialization (University)	Courses and exams	Research training ¹	Thesis work ²	ECTS NRC (degree total)
MSc in Nuclear Chemistry (U Sofia)	30	15	15	60 (60)
MSc in Nuclear chemistry (CTU)	min 42	14	30	86 (120)
MSc in Nuclear Science and Technology/ nuclear engineering (TU Chalmers)	45	-	30	75 (120)
MSc in Chemistry/ radiochemistry (U Helsinki)	40-41	3	40	83-84 (120)
MSc in Chemistry/ nuclear chemistry (UiO)	20-40	-	60	80-100 (120)
MSc in Chemistry/ radiochemistry (NMBU)	30	30	30	90 ³ (120)

¹ Other than thesis work

² Literature survey plus experimental work

³ Proportions given for the overall degree, specialization in NRC should include 90 ECTS

Table 4.2.3: Course offer under certain MSc degrees/specializations in general NRC

Degree	Course title	Credits	Type ¹
MSc in Nuclear Chemistry (U Sofia)			
<i>obligatory</i>	Application of radionuclides in chemical investigations	5	L, P
	Chemistry of f- elements and transactinides	3	L, P
	Radioisotope methods in medicine	3	L, P
	Materials for the nuclear energetics	5	L, P
	Liability and resource in nuclear energetics	4	L, P
<i>elective</i>	Metrology of the ionizing radiation	3	L, P
	Programming in UNIX system	4	L, P
	Radiation biophysics	4	L, P
	Experimental physics and Moessbauer spectroscopy	4	L, P
	Fundamentals of the physics of nuclear reactors	3	L, P
MSc in Nuclear Science and Technology, specialization nuclear engineering (TU Chalmers)			
<i>elective</i>	Nuclear Chemistry	7.5	L, P
	Applied Nuclear Chemistry	7.5	L, P
	Chemistry of Lanthanides, Actinides and Super-heavy Elements	7.5	L, P
	Solvent Extraction	7.5	L, P
	Radiopharmaceutical chemistry	7.5	L, P
	Radioecology and Radioanalytical Chemistry	7.5	L, P
MSc in Chemistry, specialization radiochemistry (U Helsinki)			
<i>obligatory</i>	Radiochemistry	4	L
	Basic radiochemistry exercises	4	L, E, P
	Radiation safety	2	L, E, P
	Detection and measurement of radiations	7	L, E, P
<i>elective</i>	Analytical chemistry of radionuclides	7	L, P
	Environmental Radioactivity	3	L, S
	Chemistry of the nuclear fuel cycle	3	L
	Chemistry of final disposal of spent nuclear fuel	3	L
	Radiopharmaceutical chemistry	3	L, P
	Radiation chemistry	3	L, P
	Tracer techniques	3	L, P
	Atmospheric radioactivity	3	L
	Natural radioactive decay series and their use in environmental sciences	3	L, E
Experimental course on radionuclide production*	3	L, E, P	
MSc in Nuclear chemistry, specialization³ applied nuclear chemistry (CTU)			
<i>obligatory</i>	Nuclear chemistry I ⁴	2	L
	Nuclear chemistry II ⁴	5	L, E
	Detection of ionization radiation ⁴	2	L
	Nuclear Power Plants Design and Operation ⁴	3	L, S
	Practical exercises in detection of ionizing radiation ⁴	3	P
	Practical exercises in radiochemical techniques ⁴	2	P
	Dosimetry and radiation protection ⁴	3	L, E
	Separation methods in NC I	3	L
	Trace radiochemistry	3	L
	Radiation chemistry	3	L

<i>elective</i>	Environment Chemistry and radioecology	3	L
	Radioanalytical methods	3	L
	Practical exercises in nuclear chemistry	4	P
	Practical exercises in radiation chemistry	3	P
	Practical exercises in separation methods	3	P
	Radionuclide Production	2	L
	The Technology of the Fuel Cycles of NPS	2	L
	Application of radionuclides I	2	L
	Application of radionuclides II	2	L
	Separation methods in NC II	2	L
	The Chemistry of Operation of NPP	2	L
	Application of radiation methods	2	L
	Radiation methods in biology and medicine	2	L
	Chemistry of radioactive elements	2	L
	Nuclear Materials Technology	2	
	Application of radionuclides 2	2	L
	Practical exercises in radioanalytical methods	4	P
	Instrumental methods 2	2	
	Theoretical foundations of radiation chemistry	2	
	Nuclear physics	6	L, E
Quantum physics	3	L	
Introduction to Elementary Particle Physics	2	L	
Transport of ionizing radiation and Monte Carlo method	4	L	
Exact methods in research of historic monuments	2	L	
MSc in Chemistry, specialization nuclear chemistry (UiO)			
<i>obligatory</i>	Radiochemical methods	10	L, E
	Laboratory exercises in radiochemistry	10	P
<i>elective additional²</i>	Radiopharmaceutical chemistry	10	L, E
	Liquid-liquid extraction	10	L, E
	Radiation and radiation measurement	10	L, E
MSc in Chemistry, specialization radiochemistry (NMBU)			
<i>obligatory</i>	Basic Radiochemistry	10	L, P
	Radioecology	10	L, P, E
<i>elective</i>	Risk assessment	5	L, E
	Ecotoxicology	15	L, S

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Additional courses that are frequently used as support for a MSc in Nuclear Chemistry

³ Informal specialization

⁴ Courses obligatory at NRC BSc level. BSc holders in general chemistry from other universities have to take these courses during their MSc studies at the CTU

4.3 Curricula for MSc specialization in Environmental radiochemistry and radioecology

Environmental radiochemistry and radioecology is the largest topic among specializations in applied nuclear and radiochemistry: there are currently 8 degrees/specializations at MSc level; universities offering the programs are listed in Table 4.3.1.

Table 4.3.1: Universities offering MSc degree or specialization in environmental radiochemistry and radioecology

University	Degree/specialization	ECTS
NORWEGIAN UNIVERSITY OF LIFE SCIENCES	MSc in Radioecology	120
UNIVERSITY OF SOFIA	MSc in Radiochemistry and radioecology	90
PLOVDIV UNIVERSITY	MSc in Radiochemistry and radioecology	74
COMENIUS UNIVERSITY	MSc in Chemistry * <i>nuclear chemistry and radioecology</i>	120 100
UNIVERSITY OF GDANSK	MSc in Environmental protection * <i>radiochemistry</i>	120 73
UNIVERSITY OF PANNONIA	MSc in Environmental engineering * <i>radioecology</i>	120 47
Leibniz University of Hannover	MSc in Analytical chemistry * <i>module related to radioecology</i>	120 14+thesis
Dresden University of Tehcnology	MSc in Chemistry * <i>module related to environmental RC</i>	

Norwegian University of Life Sciences (NMBU) offers a full MSc degree in radioecology (120 ECTS) which is accredited with the European Master status and is taught completely in English. The program is open for students having an environmental related BSc degree, e.g. in chemistry, biology, environmental engineering, and average 10 national and international students are graduated with this degree per year. The Bulgarian Universities, **University of Sofia** and **Plovdiv University** have a program MSc in Radiochemistry and radioecology with 90 and 74 ECTS, respectively. In Sofia the curriculum is designed for students having a BSc degree in chemistry or chemistry-related fields; from 1 to 5 students are graduated annually from the program.

Specialization in environmental radiochemistry and/or radioecology is also possible under certain MSc programs in chemistry or environmental studies. At the **Comenius University** (Bratislava, Slovakia) chemistry students can specialize in nuclear chemistry and radioecology (100 ECTS). Average 5 students are graduated annually with this degree. In Poland, the **University of Gdansk** offers specialization in radiochemistry under the MSc degree in Environmental protection, with average 7 students graduating per year. At the **University of Pannonia** (Veszprem, Hungary) an MSc program in Environmental engineering with a specialization in radioecology started at 2009. Furthermore, at the **Czech Technical University in Prague** (CTU) MSc degree in Nuclear Chemistry includes the possibility of an informal specialization in the Chemistry of the environment and radioecology. The course selection was recently increased significantly. Curriculum and contents of the selected programs are described in Tables 4.3.2. and 3.

In addition, the MSc degree in Analytical chemistry at **Leibniz University of Hannover** in Germany includes mainly courses on radioecology and related radioanalytics. Radiochemistry module in **Dresden University of Technology** is also related to environmental radiochemistry. At the University of SS. Cyril and Methodius in Trnava, Slovakia, the focus of education is specified e.g. as application of radioanalytical methods in the characterization of uptake and translocation of metals or certain radionuclides in plants. Variety of related courses, e.g. in nuclear analytical methods, are offered mainly for BSc and MSc students in Applied Chemistry and Biology.

Table 4.3.2. Curriculum/contents of selected MSc specializations in environmental radiochemistry and radioecology

Degree	Courses and exams	Research training	Thesis work	Other, <i>what</i>	ECTS NRC (total)
EurMSc in Radioecology (NMBU)	30	30	60		120
MSc in Radiochemistry and radioecology (U Sofia)	50	16	20	4 <i>project work</i>	90
MSc in Chemistry: nuclear chemistry and radioecology (Comenius University)	42	14	29	15 <i>seminars</i>	100 (120)
MSc in Environmental engineering: radioecology (U Pannonia)	17	-	30		47 (120)

Table 4.3.3. NRC related courses under certain MSc degrees/specializations in environmental radiochemistry and radioecology

Degree	Course title	ECTS	Type ¹
EurMSc in radioecology (NMBU)			
	Basic Radiochemistry	10	L, P
	Radioecology	10	L, P, E
	Risk assessment	5	L, E
<i>elective</i>	Ecotoxicology	15	L, S
MSc in radiochemistry and radioecology (U Sofia)			
	Radiochemistry	7	L, P
	Radiometry and dosimetry	6	L, P
	Fundamentals of radiobiology	3	L, P
	Radioecology	6	L, P
	Nuclear methods for analysis	6	L, P
<i>elective</i>	Radioactive wastes	4	L, P
	Application of radionuclides	5	L, P
	Chemistry of the f-elements	2	L, P
	Radioisotope dating	3	L, P
MSc in Nuclear chemistry, specialization ² chemistry of the environment and radioecology (CTU)			
<i>obligatory</i>	Nuclear chemistry I ³	2	L
	Nuclear chemistry II ³	5	L, E
	Detection of ionization radiation ³	2	L
	Nuclear Power Plants Design and Operation ³	3	L, S
	Practical exercises in detection of ionizing radiation ³	3	P
	Practical exercises in radiochemical techniques ³	2	P
	Dosimetry and radiation protection ³	3	L, E
	Separation methods in NC I	3	L
	Trace radiochemistry	3	L
	Radiation chemistry	3	L
	Environment Chemistry and radioecology	3	L
	Radioanalytical methods	3	L
	Practical exercises in nuclear chemistry	4	P
	Practical exercises in radiation chemistry	3	P
	Practical exercises in separation methods	3	P
	Radionuclide Production	2	L
<i>elective</i>	Separation methods in NC II	2	L
	Chemistry of radioactive elements	2	L

Determination of radionuclides in the environment	2	L
Protection of environment	2	
Modelling of migration processes in environment	2	
Instrumental methods II	2	
Numerical simulation of complex environmental processes	2	
Nuclear physics	6	L, E
Quantum physics	3	L
Introduction to Elementary Particle Physics	2	L
Transport of ionizing radiation and Monte Carlo method	4	L
Exact methods in research of historic monuments	2	L
MSc in Environmental engineering, specialization radioecology (U Pannonia)		
Decontamination in Nuclear Power Plant	2	L
Environmental radiations, radiation protection	2	L
Nuclear chemistry and application of radioisotopes	2	L
Radioactive waste disposal	2	L
Radioactive tracer methods	2	L
Radiation accident management	2	L
Radiation chemistry and technology	2	L
Radiation measurement	3	P

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Informal specialization

³ Courses obligatory at NRC BSc level. BSc holders in general chemistry from other universities have to take these courses during their MSc studies at the CTU

4.4 Curricula for MSc specialization in radiopharmaceutical chemistry

Radiopharmaceutical chemistry is one of the various fields of specializations in NRC. Typically it is taught under various educational programs of which e.g. nuclear medicine and pharmacy were not included in this survey. However, in recent years radiopharmaceutical topics have been included increasingly in (nuclear) chemistry or technology programs as the utilization of various nuclear imaging techniques and thus radiopharmaceutical chemistry research has increased.

Universities in which NRC education is focused on radiopharmaceutical chemistry are listed in Table 4.4.1. **King's college** (Department of Imaging Chemistry and Biology) in London has a one-year MSc program (90 ECTS) in Radiopharmaceutics & PET Radiochemistry. Czech Technical University in Prague (CTU) offers an informal specialization NC in biology and medicine under the current MSc degree in Nuclear chemistry (86 ECTS/120 ECTS). Radiochemistry specialization that was recently started at Debrecen University in Hungary (together with the Institute of Nuclear Medicine) includes significant part of elective courses in radiopharmaceutical chemistry. At **TU Munich** MSc students in chemistry can choose a course module (17 ECTS) in pharmaceutical radiochemistry. At **Freie Universität Berlin** MSc program in Chemistry include basic radiochemistry courses and a project work (15-30 ECTS); research topics at the department are mainly related to metal and coordination chemistry for applications in nuclear medicine.

Several other universities that has a research group in radiopharmaceutical chemistry offer also some courses and possibility to do a thesis work in the field. This group includes for example Delft University under the MSc program in chemical engineering or applied physics and University of Helsinki under the radiochemistry specialization. Graduate school of natural and applied sciences at Ege University in Turkey offers also radiopharmaceutical chemistry courses, but mainly at PhD level. Charles University in Prague used to have a NC specialization focused on

radiopharmaceutical chemistry, currently similar topics are taught only as individual courses for students in (organic) chemistry.

Table 4.4.1: Examples of universities having focus of education in radiopharmaceutical chemistry*

University	Degree/specialization/course modules
King's College London	MSc in Radiopharmaceutics & PET Radiochemistry
TU Munich	MSc in chemistry/module radiopharmaceutical chemistry
Debrecen University	MSc in Chemistry/ radiochemistry
University of Turku	courses under MSc in Chemistry and other educational programs
Technical University of Zürich	specialized postgraduate courses
University of Zürich	courses under MSc in Chemistry and other educational programs
Freie Universität Berlin	project work under MSc in Chemistry

* Universities included in this survey, may also have other focus of education

In addition, University of Turku has collaboration with Turku PET Centre (and Åbo Akademi) and offer courses especially on PET-radiopharmaceuticals. Swiss universities Technical University of Zürich, University of Zürich and to some extent University of Bern are also involved in radiopharmaceutical chemistry education. It is mostly carried out in collaboration with the Paul Scherrer Institute (PSI). There are also several other programs, organized in collaboration with research institutes or industry, under which related fields can be studied; some of them are described in Table 4.4.2. For example at Uppsala University (Faculty of Medicine, Department of Immunology, Genetics and Pathology, The Rudbeck Laboratory) there is possibility to study MSc in Medical Nuclide Techniques with a 2nd year focus on radiochemistry; the French joint-program International MSc in sustainable Nuclear Engineering: applications and management (SNEAM) includes also a specialization in Nuclear Technologies for Medical Applications.

Table 4.4.2: Examples of specified educational programs in radiopharmacy/nuclear imaging techniques

Degree/specialization	Educational institutions
MSc in Medical Nuclide Techniques: 2 nd year focus on radiochemistry	Uppsala University (in collaboration with Uppsala Imanet AB, GE Healthcare, AstraZeneca AB and Affibody AB) http://www.uu.se/en/admissions/master/selma/program/?pKod=M MN2M&lasar=15/16
The Master's Degree Program in Biomedical Imaging	Jointly administrated by the Department of Biosciences at Åbo Akademi University and the Medical Faculty at the University of Turku https://www.abo.fi/student/en/biomedical_imaging
International MSc in sustainable Nuclear Engineering: applications and management/Nuclear Technologies for Medical Applications	École des Mines de Nantes in collaboration with École nationale supérieure d'ingénieurs de Caen (ENSICAEN), Nantes University and INSTN
Certificate of Advanced Studies (CAS) in Radiopharmaceutical Chemistry/Radiopharmacy ¹	Joint program by the Institute of Pharmaceutical Sciences (ETH Zürich, Switzerland) in cooperation with the Faculty of Pharmacy (University of Ljubljana, Slovenia) and the Institute of Pharmacy (University of Leipzig, Germany) http://www.radiochem.pharma.ethz.ch/
European specialization certificate in radiopharmacy ²	European Association of Nuclear Medicine in collaboration with various institutions http://www.eanm.org/committees/radiopharmacy

^{1,2} consists of modules that can be included in postgraduate studies

4.5 Curricula for Miscellaneous MSc specializations

In addition to radioecology and radiopharmaceutical chemistry, there are some other topics for specialization in applied NRC. Various educational programs containing courses e.g. on fuel cycle chemistry and nuclear waste management were categorized under the field **Nuclear energy and materials**. At **Ege University** in Turkey there is possibility to study Master's Degree in Nuclear Sciences with specialization in Nuclear Technology (or Nuclear Applications). **University of Pannonia** (Hungary) has a chemical engineering program (120 ECTS) with a specialization Radiochemical technology (56 ECTS). Nuclear chemistry is also strongly involved in the engineering programs at **KTH Royal Institute of Technology** in Sweden and at **Technical University of Delft** (Netherlands). At KTH students with chemistry background can include courses in NRC (reactor chemistry, nuclear fuel cycle, photo, radiation and radical chemistry, total 22.5 ECTS) and do a thesis work (30 ECTS) in NRC related fields under the degrees of MSc in Chemical engineering or MSc in Molecular Science and Engineering (120 ECTS). Average 30 students are graduated annually with this specialization. The MSc program (105 ECTS) in chemical engineering (or applied physics) at TU Delft has currently a specialization in Nuclear science and engineering (30-70 ECTS), including courses on nuclear science, chemistry and radiological health physics. Furthermore, majority of the French programs can be included in this category; topics and consortium members are described in Table 4.5.1.

Table 4.5.1: Examples of educational programs in nuclear energy and materials

University or program consortium	Degree/specialization
Ege University, Turkey	MSc in Nuclear Sciences/Nuclear Technology; Nuclear Applications
University of Pannonia, Hungary	MSc in Chemical engineering/Radiochemical technology
Consortium I: ParisTech (Ecole Polytechnique ParisTech – Mines ParisTech – Ecole des Ponts ParisTech – Arts et Métiers ParisTech – ENSTA ParisTech – Chimie ParisTech), Université Paris Sud (XI) , Ecole Centrale Paris (ECP) , Supelec , l'Institut National des Sciences et Techniques Nucléaires de Saclay (INSTN)	1) MSc Nuclear Energy; specialization nuclear fuel cycle
Consortium II: Université Paris Sud (XI) , Université Paris XII , Chimie ParisTech , Mines ParisTech , Polytechnique ParisTech , ECP , INSTN	2) Sciences and technologies Master; chemistry option (<i>Master en science des matériaux, spécialité matériaux pour les structures et l'énergie</i>)
Consortium III: University Montpellier 2 , l'Ecole Nationale Supérieure de Chimie de Montpellier (ENSCM) , INSTN	3) Separative Chemistry, materials and process (<i>M2 Chimie séparative, matériaux et procédés: applications au cycle du combustible nucléaire</i>)
Consortium IV: INSTN in Cadarache in collaboration with Institut Polytechnique Grenoble and Science et Ingénierie des Matériaux et Procédés (SIMAP)	4) International Master of Material Science for Nuclear Energy (MaNuEn)
Consortium V: École des Mines de Nantes in collaboration with École nationale supérieure d'ingénieurs de Caen (ENSICAEN) , Nantes University and INSTN	5) International MSc in sustainable Nuclear Engineering: applications and management (SNEAM): <i>Advanced Nuclear Waste Management (ANWM)</i> , <i>Nuclear Energy Production and Industrial Applications (NEPIA)</i>

Some minor topics of specializations can also be selected based on the contents of the curricula. For example, in **Maria Curie Skłodowska University** (Poland) specialization in radiochemistry is taught under the MSc degree in Analytical chemistry, and the curriculum covers mostly **Radioanalytical chemistry**. This topic may be overlapping with Environmental radiochemistry and radioecology, as quite often radioanalytical chemistry is focused on environmental samples.

5 NUCLEAR AND RADIOCHEMISTRY CURRICULA AT PhD LEVEL

Universities having currently a PhD program in nuclear and/or radiochemistry are listed in Table 5.1. The extent of a PhD-degree is typically 60 ECTS plus a thesis work. Minority of the universities offer NRC related courses at PhD-level, instead, courses are selected from various MSc course supply or from other programs at similar level.

Table 5.1: Universities having a PhD degree in nuclear and/or radiochemistry

University	PhD degree
University of Sofia	PhD in radiochemistry (180 ECTS, thesis included)
Czech Technical University in Prague	PhD in nuclear chemistry (no credit points used)
University of Helsinki	PhD in chemistry, specialization radiochemistry (60 ECTS)
University of Köln	PhD in chemistry, specialization NRC (no credit points used)
University of Pannonia	PhD in chemistry, specialization radiochemistry
Norwegian University of Life Sciences	PhD in chemistry, specialization NRC
University of Oslo	PhD in chemistry, specialization nuclear chemistry (180 ECTS, thesis included)
University of Gdansk	PhD in chemistry, specialization NRC
Comenius University	PhD in chemistry, specialization nuclear chemistry (240 ECTS, thesis included)
Chalmers University of Technology	PhD in chemistry, specialization nuclear chemistry (60 ECTS)
KTH Royal Institute of Technology	PhD in chemistry, specialization nuclear chemistry (60 ECTS)
Ege University	PhD Degree in Nuclear Technology/Nuclear Sciences
King's College London	PhD in radiopharmaceutical chemistry

In addition to the departments with the postgraduate degree in NRC, there is possibility to PhD-work in several other universities and/or institutes. In 2010, 93% of all respondents to questionnaire described PhD-studies and altogether 247 projects were listed. Topics of these PhD-projects are categorized in Fig. 5.1. Based on the results average time allowed for a PhD-work in NRC is 3.9 years; 63% of the universities were using a monograph thesis and in 37% of the universities the thesis was comprised of scientific publications (from 2 to 5) and a summarizing report. Universities with largest group of PhD-students (over 10 at present) and major topics of their work are listed in Table 5.2.

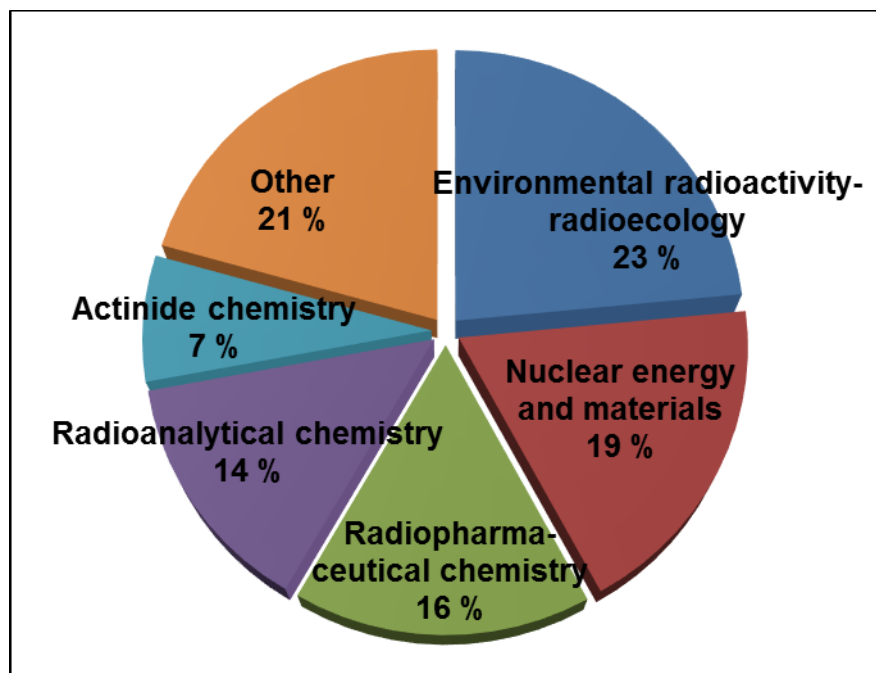


Figure 5.1: Topics of PhD-projects in nuclear and radiochemistry (results by the questionnaire in 2010-2012). The category *Nuclear energy and materials* include research projects related e.g. to fuel cycle chemistry and treatment of radioactive waste. Miscellaneous minor topics such as radionuclide production and radiation (materials) chemistry are included in the category *Other*.

Table 5.2: Universities with large group of PhD-students and major topics related to nuclear and radiochemistry

University	PhD topics
JOHANNES GUTENBERG UNIVERSITY, Mainz, Germany	<ul style="list-style-type: none"> Development of radiopharmaceuticals for nuclear imaging (PET, SPECT) Development of targets for nuclear physics experiments Mass spectrometry of rare isotopes Laser spectroscopy of actinides and other radionuclides Sorption of actinides on mineral surfaces Chemistry of the heaviest elements Boron neutron capture therapy
UNIVERSITY OF BERN, Switzerland	<ul style="list-style-type: none"> Development of radionuclides for therapy Superheavy element chemistry Environmental radionuclides Atmospheric chemistry / Surface chemistry Analytical chemistry/ Paleo-climate research Rad-Waste Analytics
DRESDEN UNIVERSITY OF TECHNOLOGY, Germany	<ul style="list-style-type: none"> Complexation of actinides Sorption and migration studies of actinides and long-lived RN Interaction of actinides and long-lived RN with biological systems (microbes, plants, algae, bio-films)

CZECH TECHNICAL UNIVERSITY IN PRAGUE, Czech Republic

Radioactive Waste Treatment, Separations
Repository sites and migration of contaminants
Radioanalytical Methods
Radiation Chemistry
Radiopharmaceuticals and Labelled Compounds

UNIVERSITY OF HELSINKI, Finland

Development of radiopharmaceuticals for nuclear imaging (PET, SPECT)
Radioecology
Radiation/materials chemistry
Long-term safety of final disposal of spent nuclear fuel
(chemistry, migration and retention of radionuclides in the geosphere)

UNIVERSITY OF MANCHESTER, UK

Coordination chemistry of the radioactive elements
Chemistry of radioactive wastes
Environmental radiochemistry
Synthetic Radiochemistry of the actinides
Chemical Modelling
Geological disposal
Fuel and reactor systems
Environmental Radiochemistry

Nuclear First Training Centre

Synthetic Radiochemistry of the actinides
Chemical Modelling
Geological disposal
Fuel and reactor systems
Environmental Radiochemistry

EGE UNIVERSITY*, Turkey

Preparation of various type of sorbent to remove some important radionuclides
Preparation of uranium and thorium compounds
Development of radiopharmaceuticals for nuclear imaging (PET, SPECT)
Radionuclide Labelled Nanoparticles for Therapy and Imaging
Evaluation effects of plant oriented extracts on the biodistribution of radiopharmaceuticals
Boron Neutron Capture Therapy
The use of environmental radionuclides as tracer in sedimentation investigations and soil erosion
Natural and artificial radioactivity measurements in the environment and radioecological studies

* included in the list after 2010

6 COUNTRY REPORTS

6.1 Austria

In Austria, nuclear and radiochemistry is taught in three universities: Vienna University of Technology, University of Vienna and University of Innsbruck. Neither of these universities has a complete (BSc, MSc) program in nuclear or radiochemistry; instead, NRC is taught as separate courses mainly for students in chemistry or physics.

University of Vienna

Faculty of Chemistry, Institute of Inorganic Chemistry, Radiochemistry group

<http://anorg-chemie.univie.ac.at> ^[1]

The radiochemistry group in the University of Vienna is focused on the development of new methods for the measurement of natural (e.g. Rn-222, Ra-226, Po-210) and anthropogenic radionuclides (Cs-137, Sr-90 etc.) in environmental samples, such as water, aerosol and soil samples, or animal bones. In addition, the group is interested in determining nuclides with very low natural abundance, such as I-129, in the environment. Another important topic is the determination of the long-lived uranium isotope U-236 and its applications in geoscience, nuclear safeguards and environmental protection [1]. Investigations are done in cooperation with VERA, the Vienna Environmental Research Accelerator, Faculty of Physics, University of Vienna.

NRC education in the University of Vienna is also focused on environmental radiochemistry; tables 6.1.1. and 6.1.2. present topics of the courses and PhD-projects. Most of the courses are taught once/year and have 6-10 students attending.

Table 6.1.1: NRC related courses in the University of Vienna

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Radiochemistry I+II	2.5+1.5	German	L	MSc in Chemistry (E)
2	Radiochemistry Lab exercises	6	German	E	MSc in Chemistry (E)
3	Radiopharmaceutical chemistry *	3	German	L	MSc in Chemistry (E)
4	Actinides chemistry	1	German	L	MSc in Chemistry (E)
5	Seminar	3	German	S	MSc in Chemistry (E)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

**medicinal radiochemistry courses in collaboration with Medical University of Vienna*

Table 6.1.2: PhD projects related to NRC in the University of Vienna

Research topic	Number of PhD-students**
U-236 in the environment	1
Sr-90 in soil and deer bones	1
I-129 in aerosol samples	1

** *data from year 2010*

Vienna University of Technology

Atominstytut (ATI)

The Institute of Atomic and Subatomic Physics

Radiation Physics

http://ati.tuwien.ac.at/research_areas/radiation_physics/home/EN/^[2]

The Radiation physics group of ATI has both research and technological development as well as education and training in all aspects of radiation physics and handling of radioactivity [2]. Nuclear chemistry and Radiochemistry are presented as separate sub-groups. The radiochemistry group has research on e.g. various radioanalytical techniques and environmental analysis, these topics are also included in teaching, in addition to the general NRC and radiation protection/dosimetry. Courses and seminars are giving at (undergraduate)/MSc and PhD level, mainly for students in (technical) physics; topics of the courses and PhD-projects are listed in Tables 6.1.13. and Table 6.1.4.

Table 6.1.3: NRC related courses in the Vienna University of Technology

	Title	Credits
1	Radiochemistry	3
2	Radioisotope techniques	3
3	Radioecology	3
4	Assessment of radionuclides in environmental samples	5
5	Radiochemistry laboratory exercises	5
6	Laboratory exercises in nuclear environmental analysis	10
7	Research seminars for master- and doctoral studies on radioecology and environmental radioactivity	2+2+5+5

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

Table 6.1.4: PhD projects related to NRC in the Vienna University of Technology

Research topic	Number of PhD-students*
Migration studies on natural radionuclides	1
Provenancing objects of cultural heritage by NAA	1
Preparation of a silicate in house reference material	1

*data from year 2010

University of Innsbruck

Faculty of chemistry and pharmacy, Institute of Analytical Chemistry and Radiochemistry

<http://www.uibk.ac.at/acrc/>^[3]

Research at the Institute of Analytical Chemistry and Radiochemistry is focused on radioanalytics, especially analysis of environmental samples, as well as on radiation protection [3]. A course in basic radiochemistry/radioanalytics (2.5 ECTS) is offered for BSc students in Chemistry. At higher levels (MSc/PhD) there are seminars in similar topics.

6.2 Belgium

In Belgian educational system studies for BSc degree (180 ECTS) last 3 years and for MSc degree (60-120 ECTS) additional 1-2 years, respectively. From historical point of view the BSc degree can be either *professional* or *academic*. The former is a vocational degree, whereas the latter gives you the right to continue to MSc studies.

NRC related education in Belgium is mostly focused on nuclear energy and materials, for a degree MSc in Nuclear Engineering. Six Belgian universities (Université de Liège, Université Catholique de Louvain, Universiteit Gent, Katholieke Universiteit Leuven, Université Libre de Bruxelles and Vrije Universiteit Brussel) in association with the Belgian nuclear research centre (SCK•CEN) forms a Belgian Nuclear Higher Education Network responsible for this education. Ghent University offers also some courses of Radiochemistry for BSc students of chemistry or other educational programs. XIOS HG Limburg used to have an industrial nuclear engineer program (60 ECTS) with specialization in environmental technology–radiochemistry (or nuclear technology–medical nuclear technology), however, no information was found on the program ever since the school was merged with Provinciale Hogeschool Limburg to Hogeschool PXL.

Ghent University

Faculty of Sciences, Department of Analytical Chemistry

www.analchem.ugent.be

NRC related courses at Ghent University are listed in Table 6.2.1. Average 50 BSc students are attending these courses every year. The group has also NRC related PhD-projects, e.g. on Neutron activation analysis (NAA). One permanent staff member is responsible in teaching radiochemistry in the department.

Table 6.2.1: NRC related courses in Ghent University

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Radiochemistry	3	Dutch	L, E, P	BSc in Chemistry (O)
2	Analytical Biochemistry, partim Radiochemistry	5/3	Dutch	L, P	BSc in Biochemistry and Biotechnology (O)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

6.3 Bulgaria

The higher education system in Bulgaria consists of three steps, BSc, MSc and doctoral degrees. However, the period to study BSc curriculum takes normally 4 years (240 ECTS) following at least one year to complete the MSc degree studies, respectively. All degrees can also be studied either full or part-time; part-time PhD studies last typically 4 years instead of normal 3 years.

Currently there are two universities in Bulgaria which both offer specialized education in nuclear and radiochemistry: Sofia University (St. Kliment Ohridski) and Plovdiv University (Paisii Hilendarski).

Sofia University St. Kliment Ohridski

Faculty of Chemistry, Department of Analytical Chemistry

<http://www.chem.uni-sofia.bg/depart/achem/default.htm>

NRC education in the University of Sofia is highly versatile, although following focuses on the

education are stated:

- Radioecology and radioanalytical chemistry
- Radioactive waste: studies on the influence of different cement additives on the leaching of radionuclides, incorporated in cement matrix.
- Mechanochemistry of 5f-elements
- Application of radionuclides: studies on the influence of radioactive additives on the photocatalytic behaviour of TiO₂.
- Molecular imaging, radiolabeling and chelation complexes of radionuclides for diagnostic and therapeutic radiopharmaceutical.
-

The complete programs in NRC are described in Table 6.3.1. First students in BSc in Nuclear Chemistry were graduated in 2010; MSc in Nuclear Chemistry started in autumn 2010. Average number of students attending in these programs is estimated as 5-12 at BSc level and 1-5 at MSc level. In addition, some courses on NRC are giving to BSc students in chemistry or chemistry-related programs, see Table 6.3.2. There is also possibility to do PhD work in various NRC related fields, e.g. in environmental radioactivity.

Table 6.3.1: NRC related educational programs in the University of Sofia

Degree	Courses	Final exam(s)	Research training	Thesis work	Other, what?	Total
BSc in Nuclear Chemistry	226	40	4	10		240
(I) MSc in Nuclear Chemistry	30	8	15	15		60
(II) MSc in Radiochemistry and radioecology	50	10	16	20	Course project (4)	90
PhD in Radiochemistry	35	4	130		Research seminars (15)	180

Table 6.3.2: NRC related courses in the University of Sofia

Title	Credits	Language	Type ¹	Target group ² (O/E ³)
Atomic and nuclear physics	9	Bulgarian	L, E	BSc (O)
Nuclear chemistry and radiochemistry - I	7	Bulgarian	L, P	BSc (O)
Measurement of the ionization radiation	6	Bulgarian	L, P	BSc (O)
Radiation protection	4	Bulgarian	L, S	BSc (O)
Nuclear chemistry and radiochemistry - II	6	Bulgarian	L, P	BSc (O)
Operation and decommissioning of nuclear power plants	6	Bulgarian	L, P	BSc (O)
Radioanalytical chemistry	6	Bulgarian	L, P	BSc (O)
Radioanalytical chemistry	3	Bulgarian	L, P	<i>BSc (E) for students in "Chemistry" or chemistry-related program</i>
Chemistry of the nuclear fuel cycle and of nuclear reactors	8	Bulgarian	L, P	BSc (O)
Water treatment and water purification in the nuclear energetic	4	Bulgarian	L, P	BSc (O)
Radioecology	4	Bulgarian	L, P	BSc (O)

Radioecology	3	Bulgarian	L, P	BSc (E) for students in "Chemistry" or chemistry-related program
Production of radioactive isotopes and labeled compounds	5	Bulgarian	L, P	BSc (O)
Radioactive wastes	5	Bulgarian	L, E	BSc (O)
Nuclear safety. Risk analysis and risk informed decision making	3	Bulgarian	L, S	BSc (O)
Fundamentals of radiobiology	4	Bulgarian	L, P	BSc (O)
Hot atom chemistry	4	Bulgarian	L, P	BSc (E)
Radioisotope dating	4	Bulgarian	L, P	BSc (E)
Radionuclide methods in medicine	4	Bulgarian	L, P	BSc (E)
Materials for the nuclear energetics	4	Bulgarian	L, E	BSc (E)
Application of radionuclides	4	Bulgarian	L, P	BSc (E)
Application of radionuclides in chemical investigations	5	Bulgarian	L, P	MSc1 (O)
Chemistry of f- elements and transactinides	3	Bulgarian	L, P	MSc1 (O)
Radioisotope methods in medicine	3	Bulgarian	L, P	MSc1 (O)
Materials for the nuclear energetics	5	Bulgarian	L, P	MSc1 (O)
Liability and resource in nuclear energetics	4	Bulgarian	L, P	MSc1 (O)
Metrology of the ionizing radiation	3	Bulgarian	L, P	MSc1 (E)
Programming in UNIX system	4	Bulgarian	L, P	MSc1 (E)
Radiation biophysics	4	Bulgarian	L, P	MSc1 (E)
Experimental physics and Moessbauer spectroscopy	4	Bulgarian	L, P	MSc1 (E)
Fundamentals of the physics of nuclear reactors	3	Bulgarian	L, P	MSc1 (E)
Radiochemistry	7	Bulgarian	L, P	MSc2 (O)
Radiometry and dosimetry	6	Bulgarian	L, P	MSc2 (O)
Fundamentals of radiobiology	3	Bulgarian	L, P	MSc2(O)
Radioecology	6	Bulgarian	L, P	MSc2 (O)
Nuclear methods for analysis	6	Bulgarian	L, P	MSc2(O)
Radioactive wastes	4	Bulgarian	L, P	MSc2(E)
Application of radionuclides	5	Bulgarian	L, P	MSc2(E)
Chemistry of the f-elements	2	Bulgarian	L, P	MSc2(E)
Radioisotope dating	3	Bulgarian	L, P	MSc2(E)
Molecular imaging and Radiopharmaceuticals		Bulgarian	L, P	MSc2(E)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² As in Table 5.3.1.

³ Obligatory = O, Elective = E

Plovdiv University

Faculty of Chemistry

<http://en.argon.uni-plovdiv.bg/>

Plovdiv University has an MSc program in Radiochemistry and radioecology (74 ECTS). The curriculum consists of 59 ECTS of courses and exams and 15 ECTS for the thesis work; overall course offer (data from the university web pages) is listed in Table 6.3.2. Apparently the degree is

aimed at students with certain background education (BSc in Chemistry or Physics) in the Plovdiv University, no detailed information was provided.

Table 6.3.2: NRC related courses at the Plovdiv University*

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Fundamentals of nuclear physics	7	Bulgarian	L, E	MSc I (O)
2	Fundamentals of radiochemistry	4	Bulgarian	L, E	MSc I (O)
3	Radiobiology and dosimetry	4	Bulgarian	L, E	MSc I (O)
4	Radioecology	5	Bulgarian	L, E	MSc I (O)
5	Scientific research practice	4	Bulgarian	E	MSc I (O)
6	Chemistry of the f-elements	4	Bulgarian	E	MSc I (E)
7	Nuclear chemistry	4	Bulgarian	E	MSc I (E)
8	Coordination chemistry	4	Bulgarian	E	MSc I (E)
9	Geochemistry	4	Bulgarian	E	MSc I (E)
10	Nuclear waste and decommissioning of nuclear facility	4	Bulgarian	E	MSc I (E)
11	Nuclear methods for analysis	4	Bulgarian	E	MSc I (O)
12	Application of radionuclides	4	Bulgarian	E	MSc I (O)
13	Technology for fluid purification	4	Bulgarian	E	MSc I (O)
14	Scientific research practice	7	Bulgarian	E	MSc I (O)
15	Nuclear medicine	4	Bulgarian	E	MSc I (E)
16	Biomonitoring and bioindication in radioactive environment	4	Bulgarian	E	MSc I (E)
17	Ecology of plants and animals in radioactive environment	4	Bulgarian	E	MSc I (E)
18	X-ray structure analysis	4	Bulgarian	E	MSc I (E)

* detailed information from year 2010

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

6.4 CROATIA

University of Zagreb (in collaboration with Rudjer Boskovic Institute)

Faculty of Science, Department of Chemistry

www.chem.pmf.hr

At the University of Zagreb radiochemistry course under the title Radioanalytical methods (4 ECTS) is offered for MSc students in Chemistry. The courses include lectures and seminars and have 10-15 students attending annually. The NRC research fields at the Department of Chemistry includes physico-chemical effects of ionizing radiations in materials and modification of polymers. Two permanent staff members and two PhD students are currently participating in teaching NRC in the department.

6.5 CYPRUS

University of Cyprus

Department of Chemistry

<http://www.ucy.ac.cy/chem/en/>

One of the important research areas at the Department of Chemistry of the University of Cyprus is Analytical and environmental chemistry and radiochemistry. Radiochemistry research interests are related e.g. to aqueous nuclear chemistry of actinide ions and environmental alpha radiometry. Nuclear and radiochemistry is also taught at the department, mainly for students in environmental chemistry. At BSc level there are courses in basic and environmental radiochemistry (6 ECTS), MSc students can also choose course in heavy metal chemistry&radiochemistry. In addition, PhD work can be carried out in the field of environmental radioactivity.

6.6 CZECH REPUBLIC

Czech higher education system includes degree programs at Bachelor, Master and doctoral level. Many universities have traditionally offered undergraduate degrees either with 3 or 4 years duration. Moreover, master programs may have been either follow-up programs with 1-3 years, or full programs lasting 4-6 years.

There are several universities/institutions giving nuclear and radiochemistry education in Czech Republic, however, the Czech Technical University in Prague (CTU) is currently the only institution offering complete educational programs in NRC.

Czech Technical University in Prague, CTU

Faculty of Nuclear Sciences and Physical Engineering, Department of Nuclear Chemistry

www.cvut.cz; www.jaderna-chemie.cz; www.fjfi.cvut.cz/kjch

CTU offers NRC related education from BSc to PhD level. No specific areas of education are stated, instead, the curricula cover all fields of NRC. Complete programs in NRC are described in Table 6.6.1. and detailed information on the course offer is listed in Table 6.6.2. MSc students in Nuclear chemistry can choose informal specialization from three fields: Applied nuclear chemistry, Environmental radiochemistry or Nuclear chemistry in biology and medicine. Average 10 students are attending the NRC program at MSc level annually; current number of PhD-students is 15 full-time and 17 part-time, respectively. The key staff in teaching at CTU consists of 17 permanent members. Furthermore, 7 external lecturers and some PhD students are participating in teaching.

Table 6.6.1: NRC related educational programs at CTU

Degree / Specialization	Courses	Research training (other than thesis work)	Thesis work	ECTS Total (degree total)
BSc in Nuclear chemistry	min 20		15	min 35 (180)
MSc in Nuclear chemistry	min 42	6+8	10+20	min 86 (120)
- <i>Applied Nuclear Chemistry</i> ¹				
- <i>Chemistry of the environment and radioecology</i>				
- <i>NC in biology and medicine</i>				
PhD in Nuclear chemistry		no credit points used ²		

¹ informal specializations

² 4-6 obligatory specialized lectures (+1-2 languages) finalized with exams

Table 6.6.2: NRC related courses at CTU

Title	Credits	Language	Type ¹	Target group ² (O/E ³)		
<i>compulsory at BSc level</i>						
Nuclear chemistry I	2	Czech	L, E	BSc (O)		
Nuclear chemistry II	5	Czech, English	L, E	BSc, MSc I-III (O)		
Detection ionization radiation	2	Czech, English	L	BSc, MSc I-III (O)		
Nuclear Power Plants Design and Operation	3	Czech	L, S	BSc (O), MSc I-III (E)		
Practical exercises in detection of ionizing radiation	3		E	BSc (O), MSc I-III (E)		
Practical exercises in radiochemical techniques	2		E	BSc (O), MSc I-III (E)		
Dosimetry and radiation protection	3		L, E	BSc (O), MSc I-III (E)		
<i>optional at BSc (and MSc) level</i>						
Nuclear physics	6	Czech	L, E	BSc, MSc I-III (E)		
Quantum physics	3		L	BSc, MSc I-III (E)		
Introduction to Elementary Particle Physics	2		L	BSc, MSc I-III (E)		
Transport of Ionizing radiation and Monte Carlo method	4		L	BSc, MSc I-III (E)		
Exact methods in research of historic monuments	2		L	BSc, MSc I-III (E)		
<i>compulsory at MSc level</i>						
				MScI	MScII	MScIII
Separation methods in NC 1	3	Czech	L	O	O	O
Trace radiochemistry	3	Czech	L	O	O	O
Radiation chemistry	3	Czech, English	L	O	O	O
Environment chemistry and radioecology	2		L	O	O	O
Radioanalytical methods	3	Czech, English	L	O	O	O?
Practical exercises in nuclear chemistry	4	Czech, English	P	O	O	O
Practical exercises in radiation chemistry	3	Czech, English	P	O	O	O
Practical exercises in separation methods	3		P	O	O	O
Radionuclide production	2	Czech	P	O	O	O
Internship	4					
<i>optional at MSc level (X recommended)</i>						
The Technology of the Fuel Cycles of NPS	2	Czech	L	X		-
Application of radionuclides I	2	Czech	L	X	-	-
Separation methods in nuclear chemistry II	2	Czech	L	X	X	X
The Chemistry of Operation of NPP	2	Czech	L	X		-
Application of radiation methods	2	Czech	L	X	-	
Radiation methods in biology and medicine	2	Czech	L		-	X
Chemistry of radioactive elements	2	Czech, English	L	X	X	X

Nuclear Materials Technology	2			X		
Technology of nuclear materials	2	Czech	L		-	-
Radiobiology	2	Czech	L	-		X
Radiation protection	4	Czech	L	-		X
Determination of radionuclides in the environment	2	Czech	L	-	X	-
Radiopharmaceuticals 1	2	Czech	L	-	-	X
Radiopharmaceuticals 2						X
Application of radionuclides 2	2	Czech	L	X	-	-
Practical exercises in radiation methods in biology and medicine	4					X
Practical exercises in radioanalytical methods	4			X		
Protection of environment	2				X	
Introduction to photochemistry and biology	2					
Modelling of migration processes in environment	2				X	
Instrumental methods 2	2			X	X	X
Numerical simulation of complex environmental processes	2				X	
Theoretical foundations of radiation chemistry	2			X		X
Synthesis of LC	2	Czech	L	PhD		
Biosynthesis of LC	2	Czech	L	PhD		
Instr. RM for pollution monitoring of the environment	2	Czech	L	PhD		
Radionuclides in biological sciences	2	Czech	L	PhD		
Application of large ionizing radiation sources	2	Czech	L	PhD		
Application of radiation chemistry in chemical industry, agriculture and medicine	2	Czech	L	PhD		

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

Table 6.6.3: PhD projects* related to NRC at CTU

Research topic	
Radioactive Waste Treatment, Separations	
Repository sites and migration of contaminants	
Radioanalytical Methods	
Radiation Chemistry	
Radiopharmaceuticals and Labelled Compounds	

* total number of projects currently 32

Charles University

Faculty of Science, Department of Organic Chemistry

<https://www.natur.cuni.cz/chemistry/orgchem>

NRC education in Charles University has changed a lot in recent 5 years. The former department of

organic and nuclear chemistry covers nowadays only organic chemistry and both the MSc and PhD programs in nuclear chemistry were cancelled. There are only optional basic nuclear chemistry courses (lectures and practical exercises) for all the students in the Faculty of Science at BSc level. In addition, some specialized field of NRC, such as synthesis of labelled compounds, radiopharmaceutical chemistry and use of labelled compounds in environmental chemistry, can be studied under the organic chemistry program. Courses with the topics Radionuclides in biological sciences and Labelled compounds are continued at MSc level. Department has currently 2 PhD students under nuclear chemistry related topics.

Masaryk University

Faculty of Science, Department of Chemistry

www.sci.muni.cz

At the Masaryk University e.g. chemistry and biophysics students at all levels (BSc-PhD) can include in their studies courses on general radiochemistry (lectures+practicals 4+4 ECTS) and radioecology (3 ECTS). Currently there are no PhD projects in the field of NRC.

University of Chemistry and Technology Prague (UCT Prague)

(former INSTITUTE OF CHEMICAL TECHNOLOGY PRAGUE, ICTP)

Faculty of Chemical Engineering, Department of Analytical Chemistry

<http://www.vscht.cz/anl/>

The department has a research group on radioanalytical chemistry. There has been PhD projects related e.g. on Migration of radionuclides and bio-toxic components in the environment. Furthermore, courses on radioanalytical methods (4 ECTS) have been given to MSc students in analytical chemistry. Information on current courses is not available via internet.

University of Defence

<http://www.vojenskaskola.cz/school/ud/nbcdi/Pages/default.aspx>

In the University of Defence basic nuclear chemistry is taught, together with e.g. radiation protection and dosimetry, for students in Military chemistry and Economics and management at BSc level. Furthermore, there is possible to do PhD projects in NRC related fields such as under the topic Determination of military significant alpha and beta radionuclides by means of solid state and liquid scintillation spectrometry.

6.7 FINLAND

In Finland, the Laboratory of Radiochemistry of the University of Helsinki is the only academic institute giving a full-scale education in radiochemistry. Technical University in Lappeenranta has a MSc program in Nuclear engineering and it can also be studied as a minor subject in Aalto University in Espoo. These three universities has a joint doctoral programme in Nuclear engineering and radiochemistry called YTERA, funded by the Academy of Finland for 2012-2015. The non-academic partners in the programme are Technical Research Centre of Finland (VTT), Finnish Authority for Radiation and Nuclear Safety (STUK), Ministry of Labour and Economy, Posiva Oy, Teollisuuden Voima Oy, Fortum Oy and Fennovoima Oy.

Co-operation in NRC related education and training is also carried out in two national courses on Nuclear safety (NNS) and Nuclear waste management (NWM). NNS-course is coordinated by the Lappeenranta Technical University. It is organized annually as a 3-week course, having over 70 participants from the academia, industry and authorities. NWM course is organized by a 12-member consortium, which Aalto University coordinates. The course lasts 6 days and has had so far over 100 participants.

In addition, general radiochemistry and specialized courses on radiopharmaceutical chemistry can also be studied at the University of Turku, and as individual courses (BSc studies in biosciences) in some other universities such as University of Oulu and University of Eastern Finland. In Finnish educational system Polytechnics (Universities of Applied Sciences) can also award degrees at BSc, and rarely also MSc level. These educational programs do not currently include nuclear or radiochemistry.

University of Helsinki

Department of Chemistry, Laboratory of Radiochemistry

<http://www.helsinki.fi/kemia/radiokemia/english>

In the Laboratory of Radiochemistry NRC related education is offered from BSc to PhD level. Detailed information on the course offer is described in Table 6.7.1. Basic radiochemistry course (4 ECTS) is offered for students in chemistry already at BSc level. Specialization in radiochemistry (83 ECTS) can be taken under the degree MSc in Chemistry (120 ECTS).

MSc in Chemistry degree in UH consists of 83 ECTS of major subject studies and 37 ECTS of other studies. The major subject studies are divided in 74 ECTS for compulsory studies and 9 ECTS of optional courses, mainly in the field of NRC. The compulsory studies in NRC include 31 ECTS of courses and exams, 3 ECTS of research training (other than thesis work) and 40 ECTS of thesis work.

Average 8 students are attending and 4 graduating from the MSc program annually, in recent years the number of students has been even higher. Furthermore, there are currently 16 PhD projects running in the laboratory; examples of the research topics are listed in Table 6.7.2. Ten permanent staff members, 5 external lecturers as well as all PhD students are participating in teaching NRC.

Table 6.7.1: NRC related courses in the University of Helsinki

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Radiochemistry	4	Finnish	L	BSc (E), MSc I (O)
2	Basic radiochemistry exercises	4	Finnish	L, E, P	MSc I (O)
3	Radiation safety	2	Finnish	L, E, P	MSc I (O)
4	Detection and measurement of radiations	7	Finnish	L, E, P	MSc I (O)
5	Analytical chemistry of radionuclides	7	Finnish/ English	L, P	MSc I (O)
6	Advanced laboratory work in RC	3	Finnish	P	MSc I (O)
7	Environmental Radioactivity	3	Finnish	L, S	MSc I (E)
8	Chemistry of the nuclear fuel cycle	3	Finnish	L	MSc I (E)
9	Chemistry of the final disposal of spent nuclear fuel	3	Finnish	L	MSc I (E)
10	Radiopharmaceutical chemistry	3	Finnish/ English	L, P	MSc I (E)
11	Radiation chemistry	3	Finnish	L, P	MSc I (E)
12	Tracer techniques	3	Finnish/ English	L, P	MSc I (E)
13	Atmospheric radioactivity	3	Finnish	L	MSc I (E)
14	Natural radioactive decay series and their use in environmental sciences	3	Finnish	L, E	MSc I (E)
15	Experimental course on radionuclide production	3	English	L, E, P	MSc I (E), PhD
16	Qualification of a radiation safety officer	1	Finnish/ English	exam	MSc I, PhD

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

2 *Obligatory = O, Elective = E*

Courses 1-3, 7, 9, 11, 13 often also for students in other educational programs.

Courses 7-13 for PhDs if not included in MSc degree.

If course 1 is included in BSc degree, 4 elective courses are required for MSc degree. Sum of major subject studies is then 84 ECTS.

Table 6.7.2: Current PhD projects related to NRC in the University of Helsinki

Research topic	Number of PhD-students
Development of radiopharmaceuticals for nuclear imaging (PET, SPECT)	1
Environmental radiochemistry/Radioecology	4
Long-term safety of final disposal of spent nuclear fuel (chemistry, migration and retention of radionuclides in the geosphere, modelling)	4
Radiation/materials chemistry	7

University of Turku

Faculty of Mathematics and Natural Sciences, Department of Chemistry

<http://www.sci.utu.fi/kemia/en/>

In the University of Turku courses on Basic radiochemistry, Chemistry of PET-radiopharmaceuticals and Radiochemical measuring techniques (total 16 ECTS) are offered for MSc students in chemistry, specialization organic and biological chemistry. In addition, there are several PhD projects related to radiopharmaceutical chemistry under various educational programs in collaboration with Turku PET Centre and Åbo Akademi.

6.8 FRANCE

In French educational system students have to pass their *baccalauréat* before entering the university education. It can already be scientific orientated (with *série scientifique*); *baccalauréat technologique* and *baccalauréat professionnel* combine studies with vocational training. The higher education consists of three possible steps: bachelor (licence and licence professionnelle), master and doctorate. Higher education is divided between public universities and grandes écoles which admit different level degrees. In general, the BSc and MSc degrees consist of *domains* with specific *mentions*, which can be research or professionally oriented; the extent of studies is 3 years and 2 years, respectively.

Collaboration between academia and research institutes (and industry), especially with the Institut National des Sciences et Techniques Nucléaires (INSTN), has a significant role in the education of nuclear and radiochemistry in France. There are universities that offer NRC courses under various educational programs, such as Paris Sud University XI and Chimie Paris Tech. However, majority of the NRC related education is given under joint educational programs, details of the most important programs are described in Table 6.8.1.

Table 6.8.1: Joint educational programs in NRC in collaboration with INSTN

Program consortium	Program
<p>Consortium I: ParisTech (Ecole Polytechnique ParisTech – Mines ParisTech – Ecole des Ponts ParisTech – Arts et Métiers ParisTech – ENSTA ParisTech – Chimie ParisTech) Université Paris Sud (XI), Ecole Centrale Paris (ECP), Supélec, l'Institut National des Sciences et Techniques Nucléaires de Saclay (INSTN), AREVA etc. http://www.master-nuclear-energy.fr/en/index.php</p> <p>Program is divided into 2 parts: The first year consists of basic scientific courses (nuclear physics, material sciences, process engineering...) and some specific courses on chemistry of reactive media, solution chemistry, speciation, radiolysis, separative chemistry and nuclear analytical methods (measurement strategy, use of tracers, trace and ultra-trace analysis, alpha and gamma spectrometry and liquid scintillation, mass spectrometry...). The second year is more focused on risk management, radiation protection, environmental and societal issues and offers specialties in nuclear reactor physics and fuel cycle with a specific focus on radionuclide chemistry and behaviour of radionuclide in the geosphere and biosphere.</p>	<p>1) Master Nuclear Energy (specialization nuclear fuel cycle)</p>
<p>Consortium II: Université Paris Sud (XI), Université Paris XII, Chimie ParisTech, Mines ParisTech, Polytechnique ParisTech, ECP, INSTN etc. http://www.chimie-paristech.fr/en/la_formation/masters/</p> <p>The program includes specific courses on analytical chemistry, molecular chemistry, chemistry and physico-chemistry of materials and chemical engineering.</p>	<p>2) Sciences and technologies Master; chemistry option (<i>Master en science des matériaux, spécialité matériaux pour les structures et l'énergie</i>)</p>
<p>Consortium III: INSTN in Marcoule in collaboration with University Montpellier 2 and l'Ecole Nationale Supérieure de Chimie de Montpellier (ENSCM) http://www.master-chimie.univ-montp2.fr/CSMP ; http://www-instn.cea.fr/formations/diplomes-et-titres/liste-des-diplomes-et-titres/m2-chimie-separative-materiaux-et-procedes-applications-au-cycle-du-combustible-nucleaire,24.html</p> <p>NRC related courses in the program are e.g. coordination chemistry, solution chemistry, analytical chemistry, thermodynamic and kinetic in liquid/liquid extraction, interaction radiation/material, modelling and quantic chemistry simulation.</p>	<p>3) Separative Chemistry, materials and process (CSMP) (<i>M2 Chimie séparative, matériaux et procédés: applications au cycle du combustible nucléaire</i>)</p>
<p>Consortium IV: INSTN in Cadarache in collaboration with Institut Polytechnique Grenoble and Science et Ingénierie des Matériaux et Procédés (SIMAP) http://phelma.grenoble-inp.fr/courses/international-master-manuen-materials-for-nuclear-energy-278507.kjsp?RH=1268753006722</p> <p>The program includes NRC optional courses such as fabrication and characterization of nuclear fuels, design of nuclear fuels and fuel assembly, behavior under irradiation and fuel cycle.</p>	<p>4) International Master of Material Science for Nuclear Energy (MaNuEn)</p>
<p>Consortium V: École des Mines de Nantes in collaboration with École nationale supérieure d'ingénieurs de Caen (ENSICAEN), Nantes University and INSTN http://www.mines-nantes.fr/en/content/view/full/7242</p>	<p>5) International Master of Science in sustainable Nuclear Engineering: applications and management (SNEAM)</p>

The program has focus on backend of the nuclear fuel cycle and environmental impact assessment including nuclear chemistry. It includes 3 specializations: Advanced Nuclear Waste Management (ANWM), Nuclear Energy Production and Industrial Applications (NEPIA) and Nuclear Technologies for Medical Applications (NUTMA)

Consortium VI: INSTN Grenoble in collaboration with Université Joseph Fourier Grenoble **6) European Master of Radioprotection (EMRP)**
<http://www.master-emrp.eu/index.php/en/>

Main courses in the program include topics: Basic knowledge, detection and measurement of radiations, biological effects, applied dosimetry, regulation rules, radioprotection in facilities, risk, public exposure, medical exposure and accidental cases.

INSTN is also involved in other continuing education, especially in Saclay site. This include e.g. the “European (Radio)Pharmacy Course” in collaboration with European Association of Nuclear Medicine (EANM). Other topics are “Nuclear science and energy” with specific courses on Radioactivity (principles and applications, fuel cycle with a specific course on actinide chemistry) and “Detection and measurements” including all nuclear detection techniques for radiation, statistics, survey of facilities and environment devoted to analysis and impact, and all the techniques of characterization of different materials. In addition, INSTN is active in organizing international schools, such as International school in nuclear engineering. In 2014/2015 it was carried out in Cadarache, Marcoule and Saclay. It included doctoral level courses and 1 specific course on Nuclear fuel cycle and reprocessing with a specific item on fundamentals of fuel cycle: Chemistry of actinides and fission products in solution (http://www-instn.cea.fr/IMG/pdf_Leaflet-2014_Nuclear-School_page_BAT.pdf). A second event was XIVth National days on Radiochemistry and Nuclear Chemistry (IPN Orsay, Paris) in September 2014 (<http://indico.in2p3.fr/event/jnr-orsay-2014>) including topics on Molecular modeling, actinide separation processes and speciation of actinides and radioisotopes.

Paris Sud University XI

Radiochemistry Group

http://www.dep-chimie.u-psud.fr/index.php?option=com_wrapper&view=wrapper&Itemid=169

NRC related education at the Paris Sud University XI is focused on actinides radiochemistry. In the program MSc Nuclear Energy, the contribution is in general radiochemistry. Furthermore, there are 6 PhD projects under the field Radiochemistry. The department has 14 permanent staff members participating in teaching.

École nationale supérieure de chimie de Paris (Chimie Paris Tech)

Nuclear Science Division

<http://www.chimie-paristech.fr/spip.php?page=english>

NRC related courses at the Chimie Paris Tech are listed in Table 6.8.2. In the program MSc Nuclear Energy education at the Chimie Paris is profiled on Fuel cycle engineering. The program started at 2009, number of students graduating annually is about 20. Furthermore, there are several PhD projects in NRC related fields, such as solvent extraction and materials chemistry. Ten permanent staff members and 40 external lecturers are participating in teaching NRC in the department.

Table 6.8.2: NRC related courses at Chimie Paris Tech

	Title	Credits	Language	Type ¹	Level
1	Radioactivity	1	French	L, E	BSc
2	The nuclear fuel and the front-end of the nuclear fuel	5	English	L, E	MSc
3	Nuclear spent fuel recycling	5	English	L, E	MSc

4	Waste conditioning	4	English	L, E	MSc
5	Radioactive waste management and repository design	4	English	L, E	MSc
6	Process simulation and process control	4	English	L, P	MSc

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

In addition to the universities participating in the above mentioned programs, at least four other universities/institutes are giving education in NRC to various extents (see the list of contact information). For example at the **Université de Nice-Sophia** NRC education is focused on environmental radioactivity/radioecology. In addition, University of Poitiers (/Institut de Chimie des Milieux et Matériaux IC2MP, in collaboration with CNRS) is strongly involved in research related to final disposal of spent fuel (e.g. hydrogeological studies), although their educational programs do not include directly courses in NRC.

6.9 GERMANY

In Germany vocational training and apprenticeship has traditionally been important part of the educational system, and a popular choice for career after 2nd level education. Students with *Meisterbrief* (master craftsman's diploma) may also apply to university educational programs, in addition to students that have passed their *Abitur* examination or have a *Fachhochschulreife*. Currently both the Universities and Universities of Applied Sciences (Fachhochschulen) can award BSc and MSc degrees; however, the educational programs in Universities of Applied Sciences are more practically orientated. The former lower-level degree, *diploma*, has mostly replaced with BSc (or MSc) degree. Universities of Applied Sciences cannot award doctoral degrees, however, they can have research collaboration with universities and/or industry. Moreover, collaboration between universities and research institutes has a strong role in education in Germany; universities are focused on education whereas research is being done at the various research institutes. This can be seen in NRC education, too. At BSc or MSc level, nuclear and radiochemistry is typically taught as course modules and a thesis work can be done in related fields.

Ruprecht-Karls University of Heidelberg (collaboration with Karlsruhe Institute of Technology)
Faculty of Chemistry and Geoscience, Department of Physical Chemistry, Radiochemistry research group
<http://www.radiochemie-heidelberg.de/>

At the University of Heidelberg chemistry students both at BSc and MSc level can take courses on radiochemistry and do a thesis work in NRC related fields; contents of the curricula and course supply are described in Tables 6.9.1. and 2. Average 25 and 10 students attend these programs annually. Topics of the current PhD projects are listed in Table 6.9.3. In general, education in nuclear and radiochemistry is focused on chemistry of f-elements and nuclear forensics. The department has 3 permanent staff members and 6 PhD students participating in teaching NRC.

Table 6.9.1: NRC related educational programs in the University of Heidelberg

Degree/module	Courses	Final exam(s)	Research training (other than thesis work)	Thesis work	Total
BSc in Chemistry/module RC	12	-	3	12	27
MSc in Chemistry	6	2	2	30	40
I) Chemistry of f-elements					
II) Nuclear forensics					

Table 6.9.2: NRC related courses in the University of Heidelberg

	Title	Credits	Language	Type ¹	Target group ² (O/E ³)
1	Basic Radiochemistry I	6	German	L, E	BSc (E)
2	Basic Radiochemistry II	9	German	L, E, P	BSc (E)
3	Nuclear forensics	3	German	L, P	MSc I (E)
4	Chemistry of f-elements	3	German	L, S	MSc II (E)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² As in Table 6.9.1.

³ Obligatory = O, Elective = E

Table 6.9.3. Current PhD projects related to NRC in the University of Heidelberg

Research topic	Number of PhD-students
Partitioning and Transmutation	3
High temperature fluorescence spectroscopy	2
Coordination of actinides with bioligands	1

University of Köln (collaboration with Forschungszentrum Jülich, Max Planck Institute)
Faculty of Science, Department of Chemistry, Division of Nuclear Chemistry at the Institute of Biochemistry
http://www.uni-koeln.de/math-nat-fak/nukchem/index_e.htm

NRC related education at the University of Köln is focused on following topics:

- Radiopharmacy
- Nuclear data measurement
- Fundamental radiochemistry
- Environmental radiochemistry

NRC related curricula and the overall course supply are listed in Table 6.9.4. and 5. Chemistry students both at BSc and MSc level can include their studies a module in Radiochemistry and do a thesis work in related fields. In addition, MSc and PhD students in geology and physics attend the courses regularly. Furthermore, there is possibility to do PhD work in applied NRC; some topics of the research projects are described in Table 6.9.6. Four permanent staff members (2 employed by the Research Centre Jülich) and 7 PhD students are participating in teaching NRC.

Table 6.9.4: NRC related educational programs in the University of Köln

Degree/module	Courses	Final exam(s)	Research training (other than thesis work)	Thesis work	Total*
BSc in Chemistry/RC	7		4	14	11/25
MSc in Chemistry/RC	6		7	30	13/43

* in both cases (BSc/MSc) the student can choose only the module or both module and thesis work

Table 6.9.5: NRC related courses in the University of Köln

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Basic Nuclear chemistry	2	German	L	BSc (O)
2	Exercises in Basic Nuclear chemistry	2	German	E	BSc (O)
3	Lab Course in Nuclear chemistry	5	German, English possible	P	BSc (O)

4	Seminar in Nuclear chemistry	2	German	S	BSc (O)
5	Lab Course in Nuclear chemistry II	5	German, English possible	P	MSc(O)
6	Radiopharmaceutical Chemistry	1	German	L	MSc(E), PhD (E)
7	Labelling with radioisotopes	1	German	L	MSc(E), PhD (E)
8	Chemistry of Radioelements	1	German	L	MSc(E), PhD (E)
9	Radioanalytics in life sciences	1	German	L	MSc(E), PhD (E)
10	Radioanalytical aspects of research in nuclear data and nuclear energy research	2	German	L	MSc(E), PhD (E)
11	Radioanalytical inorganic chemistry	2	German	L	MSc(E), PhD (E)
12	Seminar Nuclear Chemistry / Nuklearchemisches Seminar	1	English, German	S	All (E)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

Table 6.9.6: Topics of PhD projects* related to NRC in the University of Köln

Research topic	
Development of radiopharmaceuticals for nuclear imaging	
Radiochemical separation procedures and nuclear data measurements	
Environmental behaviour of nuclear waste	

*total number of projects currently 7

Dresden University of Technology (collaboration with Helmholtz zentrum Dresden-Rossendorf, Institute for Resource Ecology IRE))

Faculty of Science, Dept. Chemistry/Food Chemistry, Institute of Analytical chemistry, Professorship in Radiochemistry

<http://www.chm.tu-dresden.de/anc2/>

TU Dresden offers a course module in Radiochemistry, including courses with topics Radiochemistry, Environmental Chemistry and Chemistry of f-elements, for MSc students in chemistry. The professor in radiochemistry is also the head of the IRE at HZDR, thus having close collaboration with this institute. NRC education at TU Dresden is connected with practical exercises in use of radioisotopes in controlled areas, some specific topics are listed as:

- Nuclear fuel cycle
- Production and application of radioisotopes in nuclear medicine
- Synthesis of radioactive labelled compounds
- Interaction of radiation with materials
- Actinide chemistry

The number PhD students at TU Dresden is as high as 25, in the field of radiochemistry, radioecology and also biology. Some topics of the research projects are described in Table 6.9.7.

Table 6.9.7: Topics of PhD projects* related to NRC at the TU Dresden

Research topic
Complexation of actinides
Sorption and migration studies of actinides and long-lived RN
Interaction of actinides and long-lived RN with biological systems (microbes, plants, algae, bio-films)

* total number of projects currently over 25

FH Aachen-University of Applied Sciences (collaboration with FZ Jülich and RWTH Aachen University)

Speciality Chemistry and Biotechnology, Nuclear Chemistry

http://www.fh-aachen.de/nuclear_applications.html

The University of Applied Sciences has two educational programs which include nuclear and radiochemistry: BSc in Applied Chemistry (180 ECTS) and MSc in Nuclear Applications (120 ECTS). Proportion of NRC in these programs varies from 10-40 ECTS at BSc level and 30-90 at MSc level, respectively. The overall course offer is listed in Table 6.9.8. The number of students participating MSc programs has increased up to 40-50 students. The department has 1 permanent staff member and 2 external lecturers in teaching NRC.

Table 6.9.8: NRC related courses at the University of Applied Sciences

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Nuclear Chemistry	7	German	L, E, P	BSc (O)
2	Radioanalytical Methods	3	German	L, E, P	BSC (E)
3	Nuclear Chemistry	10	English	L, E, P	MSc (O)
4	Nuclear Physics and Rad. Detection	10	English	L, E, P	MSc (O)
5	Nuclear Applications	10	English	L	MSc (O)
6	Advanced Radiochem. Methods	10	English	L, E, P	MSc (E)
7	Radioecology	10	English	L, E, P	MSc (E)
8	Biomedical Applications	10	English	L, E, P	MSc (E)
9	Nuclear Fuel Cycle	10	English	L, E, P	MSc (E)
10	Radiation Safety	10	English	L, E, P	MSc (E)
11	Seminar	10	English	S	MSc (O)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

Leibniz University of Hannover

Institute for Radioecology and Radiation Protection (IRS)

www.zsr.uni-hannover.de

At the Leibniz University nuclear and radiochemistry is taught under the MSc program in Analytical chemistry (I), as well as for BSc and MSc students in physics (II). Curriculum of the chemistry degree includes total 14 ECTS of courses e.g. under topics radioanalytics, radioecology and radiation safety, overall course offer in NRC is described in Table 6.9.9. Average 25 students is attending this MSc program annually. There is also possibility to do PhD studies in NRC related fields, current research projects are described in Table 6.9.10. General focus of NRC education in IRS is stated as: Detection and speciation of radionuclides in the environment.

Table 6.9.9: NRC related courses at the Leibniz University of Hannover

	Title	Credits	Type ¹	Main target group ² (O/E ³)
1	Basics of Radiation Protection and Radioecology	2	L, E	BSc (E) MSc I (E) MSc II (O)
2	Analytics of Radionuclides	2	L,	MSc I (E) MSc II (O)
3	Lab Course Radiation Protection	6	P	MSc I (E) MSc II(O) BSc (E)
4	Radioecology	3	S	MSc I (E), MSc II (E)
5	Nuclear Fuel Cycle	2	L	
6	Radiation Protection and Radioecology(II)	2	L	MSc I (E) MSc II(O)
7	Radionuclides in the environment	2	L	MSc I (E) MSc II (E)
8	Nucleosynthesis and Dating	2	L	MSc I (E) MSc II (E)
9	Radiochemistry	6	P	MSc I (E) MSc II(O)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

²Obligatory = O, Elective = E

Table 6.9.10: Current PhD projects related to NRC at the Leibniz University of Hannover

Research topic	Number of PhD-students
Radioecology, detection / speciation of RN at contaminated sites	3
ASGARD (Gen IV fuels)	1
ENTRIA (Nuclear disposal options)	3
TRANSAQUA (I-129 in drinking water)	2
Pu Particle Speciation by SIMS	1
Statistics and metrology of nuclear radiation detection	0
Conditioning of I-129 in inert matrices for final disposal	0

München University of Technology

Faculty of Chemistry, Institute for Radiochemistry “Radiochemie München RCM”

www.rcm.tum.de

At TU Munich, NRC related education is mainly focused on Radiopharmacy. From 2011 it has been carried out by the Radiochemie München RCM, a separate institute under university administration, which also holds a chair in pharmaceutical radiochemistry. MSc students in chemistry has an optional course module in Pharmaceutical radiochemistry, which include courses/exercises also with topics Radioactivity, radioanalytics and production of radiopharmaceuticals as well as Special aspects of radiochemistry. Individual courses in NRC are also offered to students with other educational programs, such as nuclear medicine, either at BSc or MSc level.

Table 6.9.11: NRC related educational programs at TU Munich

Degree/module	Courses	Research training (other than thesis work)	Thesis work	Total [ECTS]
MSc in Chemistry/Pharmaceutical radiochemistry	9	8		17

In addition, there is possibility to do PhD work in various NRC related fields, some topics of the research projects are listed in Table 6.9.12. Six permanent staff members and the PhD students participate in teaching NRC in the department.

Table 6.9.12: PhD projects related to NRC at TU Munich

Research topic	Number of PhD-students*
Nuclear reaction mechanism studies and developments in SHE research	2
Production and separation of the radioisotopes for nuclear medicine	2
Neutron imaging and tomography	1

* data from year 2010

Freie Universität Berlin

Institute of Chemistry and Biochemistry, Inorganic chemistry, Radiochemistry group
<http://www.bcp.fu-berlin.de/chemie/chemie/forschung/InorgChem/agabram/index.html>

At the Frei Universität Berlin basic radiochemistry (5 ECTS) is taught under the degree BSc in Chemistry (or biochemistry). At MSc level, 5 ECTS of courses (radiochemistry, radiation protection) and a project work (15-30 ECTS) in NRC related fields can be included in the MSc program in Chemistry. A possibility to PhD studies in NRC is also offered; research projects are mainly related to metal and coordination chemistry, e.g. Tc-chemistry for applications in nuclear medicine. Four permanent staff members, 2 external lecturers as well as the PhD students (11) are participating in teaching NRC in the department.

Karlsruhe Institute of Technology, KIT

Fakultät für Chemie und Biowissenschaften
Institute for Nuclear Waste Disposal (INE)
<http://www.kit.edu/kit/english/>

Since October 01, 2009, Universität Karlsruhe was merged with the Forschungszentrum Karlsruhe into the Karlsruhe Institute of Technology (KIT). KIT offer education e.g. in nuclear waste management and radioanalytical chemistry, in close collaboration with the University of Heidelberg.

Johannes Gutenberg University, Mainz

Department of Chemistry, Pharmacy and Geosciences, Institute of Nuclear Chemistry
<http://www.kernchemie.uni-mainz.de/>

The Institute of Nuclear Chemistry is involved in a broad field of nuclear and radiochemistry research, such as actinides chemistry and radiopharmaceutical chemistry. These topics are also covered in the NRC education, under the “seminar on Nuclear- and radiochemistry”. Courses are offered for students in chemistry at BSc level. In addition, there is possibility to do PhD work under various research fields in NRC. Topics of some projects are described in Table 6.9.13. Teaching staff in the department consist of over 30 permanent members (4 professors), 2 external lecturers and the PhD students.

Table 6.9.13: PhD projects related to NRC in the Johannes Gutenberg University

Research topic	Number of PhD-students*
Development of radiopharmaceuticals for nuclear imaging (PET, SPECT)	5
Development of targets for nuclear physics experiments	4
Mass spectrometry of rare isotopes	5
Laser spectroscopy of actinides and other radionuclides	5
Sorption of actinides on mineral surfaces	3
Chemistry of the heaviest elements	3
Boron neutron capture therapy	2

* data from year 2010

TU Clausthal

Institute of Disposal Research

<http://www.ielf.tu-clausthal.de/en/ueber-uns/>

Tu Clausthal offers an MSc degree MSc in Radioactive and Hazardous Waste Management which contains a minor part in applied NRC, such as courses related to radioactive waste management and isotopic geochemistry.

Educational programs in chemistry at the University of Applied Sciences at Zittau/Görlitz and the Philipps-University in Marburg include also some course topics in applied NRC.

6.10 GREECE

In Greece, nuclear and radiochemistry is taught in three universities, Aristotle University in Thessaloniki, University of Patras and National Technical University of Athens.

Aristotle University in Thessaloniki

Department of Chemistry, Laboratory of Inorganic Chemistry, Radiochemical laboratory

<http://www.chem.auth.gr>

Basic course on NRC is offered both at BSc and MSc level, for students in Chemistry and in Chemistry and Chemical Education, respectively. A thesis work (11 ECTS) in the field of NRC can also be included in both programs. Average number of students attending annually these programmes is 40 and 6, respectively. Furthermore, there is possibility to do PhD work in radiochemistry and nuclear chemistry; topics of the current projects are listed in Table 6.10.1. The Radiochemical Laboratory has at the moment 2 permanent staff members, and 1 PhD- and 2 MSc-students are assisting in teaching.

Table 6.10.1: Current PhD projects related to NRC at Aristotle University

Research topic	Number of PhD-students
Development and investigation of natural and synthetic sorbents for radionuclides and heavy metals	1
Natural radioactivity studies	1
Application of nuclear techniques to the characterization and study of metallic surfaces	1

University of Patras

Department of Chemistry, Division of Physical, Inorganic and Nuclear-Radiation Chemistry, Radiochemistry group

<http://www.chem.upatras.gr>

The radiochemistry research group in the University of Patras is mainly involved in environmental radioactivity monitoring and determination of trace elements in foods and environmental samples by nuclear (and non-nuclear) analytical techniques. The group consists of 3 assistant professors and has currently 4 PhD students, topics of the project works are described in Table 6.10.2. Lower level education in NRC is given as individual courses mainly for BSc students in Chemistry (total 240 ECTS), e.g. as a course entitled Principles and Applications of Nuclear Chemistry (5 ECTS). A thesis work (20 ECTS) can also be done in the field of NRC.

Table 6.10.2: Current PhD projects related to NRC in the University of Patras

Research topic	Number of PhD-students
Sorption of Radionuclides on low cost sorbents (wastes or agro-industrial by-products)	1
Sorption of Radionuclides on microorganisms	1
Determination of air particulate matter by nuclear techniques.	1
Radioisotopes to study the uptake rate of glucose by free or immobilized cells of microorganisms	1

National Technical University of Athens (NTUA)

School of Chemical Engineering, Laboratory of General Chemistry

<http://www.chemeng.ntua.gr>

NRC education at NTUA is carried out in individual courses for chemical engineering students. At BSc level the topic is general radiochemistry, the MSc level courses are entitled as Nuclear Chemistry–Nuclear Technology and Radiation chemistry-Photochemistry. There is no PhD work in related fields, although the laboratory has research e.g. on Separation and recovery of radioactive elements.

6.11 HUNGARY

In Hungary there are several universities/institutions giving education in nuclear and radiochemistry. University of Pannonia offer educational programs in NRC at various levels and Debrecen University has currently a specialization in radiochemistry; individual courses related to NRC are given in Eötvös Lorand University in Budapest and in Budapest University of Technology and Economics.

University of Pannonia

Institute of Radiochemistry and Radioecology

<http://radio.mk.uni-pannon.hu>

University of Pannonia offers NRC related education from BSc to PhD level. No specific areas of education are stated, however, majority of the education is given under environmental engineering programs. Complete programs in NRC are described in Table 6.11.1. and detailed information on the course supply is listed in Table 6.11.2. In addition, there is possibility to do PhD work under NRC related fields; some topics are described in Table 6.11.3. The department has 5 permanent staff members and PhD students participating in teaching.

Table 6.11.1: NRC related educational programs in the University of Pannonia

Degree/specialization	Courses	Research training (other than thesis work)	Thesis work	ECTS Total (degree total)
BSc in Environmental engineering/ NRC	21	8	10	39 (210)
MSc in Environmental engineering/ NRC	17		30	47 (120)
MSc in Chemical engineering / NRC	26		30	56 (120)
PhD in Chemistry/ NRC	20		?	20 (180)

Table 6.11.2: NRC related course supply in the University of Pannonia

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Basics of Radiation	1	Hungarian	L	BSc (O)
2	Radioecology	2	Hungarian	L	BSc (O)
3	Nuclear Energetic	2	Hungarian	L	BSc (E)
4	Natural and artificial radiations	2	Hungarian	L	BSc (E)
	<i>Radioecology specialization</i>				
5	Nuclear Energetic	2	Hungarian	L	BSc (O)
6	Dosimetry and Radiation Protection	2	Hungarian	L	BSc (O)
7	Nuclear emergency management, radioactive waste management	2	Hungarian	L	BSc (O)
8	Nuclear Metrology	2	Hungarian	L	BSc (O)
9	Uses of radioisotopes	2	Hungarian	L	BSc (O)
10	Lessons from the nuclear and radiation accidents	2	Hungarian	L	BSc (O)
11	Radiations and radionuclides in the nature	3	Hungarian	L	BSc (O)
12	Radioecology and Nuclear Metrology	6	Hungarian	P	BSc (O)
	<i>Radioecology specialization</i>				
13	Decontamination in Nuclear Power Plant	2	Hungarian	L	MSc (O)
14	Environmental radiations, radiation protection	2	Hungarian	L	MSc (O)
15	Nuclear chemistry and application of radioisotopes	2	Hungarian	L	MSc (O)
16	Radioactive waste disposal	2	Hungarian	L	MSc (O)
17	Radioactive tracer methods	2	Hungarian	L	MSc (O)
18	Radiation accident management	2	Hungarian	L	MSc (O)
19	Radiation chemistry and technology	2	Hungarian	L	MSc (O)
20	Radiation measurement	3	Hungarian	P	MSc (O)
	<i>Radiochemistry specialization</i>				
21	Nuclear Measurements	4	Hungarian	L,P	MSc (O)
22	Radiation protection, radioactive waste disposal	6	Hungarian	L	MSc (O)
23	Technologies utilized in NPP	8	Hungarian	L,P	MSc (O)
24	Technologies using radioisotopes	8	Hungarian	L	MSc (O)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S² Obligatory = O, Elective = E

Table 6.11.3: NRC related PhD projects in the University of Pannonia

Research topic	Number of PhD-students*
Comparative study of efficiency, surface chemical and corrosion effects of chemical decontamination technologies	2
Towards multipurpose radiotracer methods for the investigation of contamination and corrosion phenomena on constructional material surfaces	1
Determination of the age of sediments by radiometric methods	1
Radiological study of underground spaces, radiological protection of manganese miners	1
Radon and radon daughters	1

* data from 2010, total number of PhD-students is currently 4

Debrecen University

Department of Colloid and Environmental Chemistry, Isotope and Environmental Chemistry Group
http://dragon.unideb.hu/~kolloid/isotope/main_i.html

NRC related education in Debrecen University is mainly given in the Department of Colloid and Environmental Chemistry. Basic radiochemistry (3 ECTS) course is obligatory for BSc studies in chemistry, environmental science and chemical engineering. Basic radiochemistry (2 ECTS, included in obligatory physical chemistry) and radioanalytical chemistry (3 ECTS) courses are offered for MSc students in chemistry. The number of students attending these courses has increased to about 150 students/semester. Recently Debrecen University has begun to offer a chemist MSc course module with radiochemistry specialization (30 ECTS) together with the Institute of Nuclear Medicine of the university and the Institute of Nuclear Research of Hungarian Academy of Sciences. The content of the course module is described in the following Table 6.11.4.

Table 6.11.4: NRC related course supply for radiochemistry specialization in Debrecen University

	title	credits	target group (O/E ²)
1	Radiochemistry	3	MSc(O)
2	Nuclear environmental protection	3	MSc(O)
3	Medical applications of radioisotopes	3	MSc(O)
4	Nuclear analysis	5	MSc(O)
5	Production of radionuclides	3	MSc(O)
6	Separation of labeled compounds	4	MSc(O)
7	Radiation protection	3	MSc(O)
8	Nuclear analysis in environmental science	4	MSc(E)
9	Radioactive tracers in medical biology	3	MSc(E)
10	Production, quality control and assurance of radiopharmaceuticals	2	MSc(E)
11	Metabolism studies by radiochemical methods	3	MSc(E)
12	Basic radiochemical laboratory	1	MSc(E) (compulsory for those who did not study in BSc)

²Obligatory = O, Elective = E

There is also possibility to do PhD work in NRC related fields; example of a project topic is Storage of radioactive wastes, interactions of isotopes with the geological formations. Additional research projects are carried out in collaboration with the Department of Environmental Physics at the

Institute of Nuclear Research. Four permanent staff members are participating in teaching NRC in the Department of Colloid and Environmental Chemistry.

Eötvös Lorand University in Budapest

Faculty of Science, Department of Analytical Chemistry / Institute of Chemistry

<http://www.chem.elte.hu/en/main>

Based on the web pages of the university, NRC related courses are given at BSc/MSc level, mainly for students in chemistry (module analytical chemistry). Topics of these courses are analytical chemistry: nuclear chemistry (2 ECTS, BSc), radioanalytical chemistry laboratory exercises (4 ECTS), nuclear methods with applications in biology (2 ECTS), nuclear investigation methods (3+2 ECTS), radiation protection (2 ECTS) and radiation chemistry and technology (2 ECTS) at MSc level. Teaching of NRC is the responsibility of the Department of Analytical Chemistry whereas research is carried out in the Laboratory of Nuclear Chemistry (in collaboration with Hungarian Academy of Sciences, HAS).

Budapest University of Technology and Economics (BME)

Faculty of Natural Sciences, Institute of Nuclear Techniques (INT)

<http://www.reak.bme.hu/en/home.html>

Based on the web pages of the institute, it constitutes of two units: Department of Nuclear Techniques and Department of Nuclear Energy. Educational tasks are organized by the former department, whereas the latter operates the Nuclear Training Reactor. The main task of INT is to educate the undergraduate, graduate and PhD students in the field of nuclear techniques both from BME and other Hungarian universities and higher education institutions. They also have an internationally accredited radiochemistry laboratory. NRC related courses, such radioactive waste, nuclear measuring techniques, are given in INT both at BSc and MSc level, mainly for students in physics or engineering physics with nuclear specialization.

6.12 ITALY

In Italy, nuclear and radiochemistry can be studied e.g. in the University of Pavia and University of Milan.

University of Milan

Group of Radiochemistry and Radiation Chemistry

<http://www.lasa.mi.infn.it>

The Group of Radiochemistry and Radiation Chemistry is a part of L.A.S.A. (Laboratorio Acceleratori e Superconduttività Applicata Interdivisional) and has average 8 persons (5 permanent staff members) participating in teaching NRC. NRC related courses, listed in Table 6.12.1., are taught once/year, mainly for students in physics or chemistry. Thesis work (60 ECTS) in NRC is also possible and average 4 chemistry students at MSc level are graduating annually with this specialization. In addition, there is possibility to do PhD-work; some research topics are described in Table 6.12.2.

Table 6.12.1: NRC related courses in the University of Milan

	Title	Credits	Language	Type ¹	Level
1	Basic Radiochemistry	6	Italian, English	L, E, P	BSc
2	Basic Health Physics	12	Italian, English	L, P	MSc
3	Radiopharmaceutical chemistry	2	Italian, English	L, P	MSc
4	Environmental Radioactivity	2	Italian, English	L, S	MSc

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

Table 6.12.2: PhD projects related to NRC in the University of Milan

Research topic	Number of PhD-students*
Development of radiopharmaceuticals for nuclear imaging (PET, SPECT)	1
Development of radiopharmaceuticals for metabolic radiotherapy and imaging	1
Radionuclide production	1

* data from year 2010

University of Pavia

Faculty of Mathematical, Physical and Natural Sciences, Department of Chemistry

www.unipv.eu

In the University of Pavia basic and advanced radiochemistry (total 6 ECTS) is taught for BSc students in chemistry with average 20 students attending the course annually. The department of chemistry has also research on radiochemistry, topics of the PhD-works are related to radiochemical and -analytical methods. Other NRC related course topics in the University of Pavia are e.g. Radioactivity and Radiobiology for students in physical sciences or experimental and applied biology.

6.13 THE NETHERLANDS

Delft University of Technology

Faculty of Applied Sciences, Department of Radiation Science and Technology (RST)

<http://www.tudelft.nl/live/pagina.jsp?id=70f9805f-de88-4790-83dc-b5b04db554a6&lang=en>

The department consists of five research groups: 1) Nuclear Energy and Radiation Applications, 2) Fundamental Aspects of Materials and Energy, 3) Neutron and Positron Methods in Materials 4) Radiation and Isotopes for Health and 5) Radiation Detection & Medical imaging. Close collaboration with the Reactor Institute Delft enables access to the reactor and the irradiation facilities.

Education in the department Radiation Science and Technology is focused on NRC for health or energy. There is a relatively new MSc program in chemical engineering or applied physics with a specialization in Nuclear science and engineering. The program consists of research training (15 ECTS), design project (20 ECTS), thesis work (40 ECTS) and 30 ECTS courses of which nuclear science and nuclear chemistry (total 9 ECTS) are related to NRC and obligatory in the degree. There is also possibility to do PhD work in NRC related fields, e.g. in radiopharmaceutical chemistry. Average 5 external lecturers are participating in teaching with 4 permanent staff members.

6.14 NORWAY

In Norway, two universities offer possibility to specialize in NRC at MSc or PhD level: Norwegian University of Life Sciences in Ås and Oslo University. Some NRC courses is also possible to study in the University of Bergen.

Norwegian University of Life Sciences

(Norges miljø- og biovitenskapelige universitet, NMBU)

Department of Plant and Environmental Sciences, Environmental Chemistry

<http://www.umb.no/ipm-en>

Nuclear and radiochemistry education in the Norwegian University of Life Sciences is focused on radiochemistry, radioecology and radio-ecotoxicology. The university offers a full MSc degree in radioecology which is accredited with European Master status and is taught completely in English. Furthermore, MSc students in chemistry can specialize in radiochemistry; radiochemistry and radioecology courses are also included in the MSc degree in Environment & natural resources as depicted in Tables 6.14.1. and 2. The EurMSc program is open for students having environmental related BSc degree, e.g. in chemistry, biology, environmental engineering, and average 10 national and international students are graduating with this degree annually. In addition, average 5 MSc students in chemistry are graduated annually with the specialization in radiochemistry.

There is also possibility to do PhD work either in direct field of radiochemistry and radioecology or in environmental chemistry and other topics where radiochemistry (tracer techniques) is used, current number of projects is 5+12. The key staff in teaching radiochemistry at NMBU consists of 9 permanent members. Furthermore, 3 external lecturers and the PhD students are participating in teaching.

Table 6.14.1: NRC related educational programs at NMBU

Degree / Specialization	Courses	Final exam(s)	Research training	Thesis work	ECTS Total (degree total)
(I) EurMSc in Radioecology	60	(3)		60	120
(II) MSc in Chemistry / Radiochemistry	60-90	(3)		30-60	90 ¹ (120)
(III) MSc Environment and natural resources	60-90			30-90	10-90 ² (120)
PhD in NRC	20-60				20-60 (60)

¹Proportions given for the overall degree, 90 cu of NRC should be included in the specialization

²Proportions given for the overall degree, minimum proportion of NRC 10 cu of courses

Table 6.14.2: NRC related courses at NMBU

	Title	Credits	Language	Type ¹	Target group ² (O/E ³)
1	Basic Radiochemistry	10	English	L, P	MSc I (O)/ II (O)/III (E)
2	Radioecology	10	English	L, P, E	MSc I (O)/II (O)/III (E)
3	Risk assessment	5	English	L, E	MSc I (O)/II (E)/III (E)
4	Ecotoxicology	15	English	L, S	MSc I (E)/II (E)/III (E)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

²As in Table 5.13.1.

³Obligatory = O, Elective = E

University of Oslo, UiO

Department of Chemistry, Nuclear Chemistry Section

<http://www.kjemi.uio.no/english/>

At the University of Oslo NRC can be included in chemistry studies already at BSc level. Specialization in this field is possible at MSc and PhD level. Programs and course supply are listed in Tables 6.14.3. and 4. Average 2 students graduate annually with the specialization in NRC, current number of students attending the program is 6. Similar increase is expected in the number of PhD students in the near future. Education (and research) at UiO is focused on following topics: Superheavy elements, Radiopharmaceutical chemistry (PET-related) and Industrial use of radioactivity (liquid-liquid extraction, radiotracers, hydrometallurgy), as well as Nuclear Energy Technology (using thorium in the nuclear fuel cycle). Current PhD projects under the related topics are listed in Table 6.14.5. The Nuclear Chemistry Section has 5 staff members and 2-4 students participating in teaching NRC.

Table 6.14.3: NRC related educational programs at UiO

Degree/specialization	Courses	Final exam(s)	Thesis work	ECTS Total (degree total)
MSc in Chemistry/ Nuclear chemistry	20-40	(1)	60	80-100 (120)
PhD in Nuclear chemistry	30-50	-	130-150	180

Table 6.14.4: NRC related course supply offered by UiO

	Title	Credits	Language	Type ¹	Target group ² (O/E ³)
1	Radioactivity and radiochemistry	10	Norwegian	L, E	BSc (E)
2	Radiochemical methods	10	Norwegian or English	L, E	MSc (O)
3	Laboratory exercises in radiochemistry	10	Norwegian or English	P	MSc (O)
4	Radiopharmaceutical chemistry	10	Norwegian or English	L, E	MSc and PhD (E)
<i>In addition, the following courses are frequently used as support for a MSc or PhD in Nuclear Chemistry:</i>					
5	Liquid-liquid extraction	10	Norwegian or English	L, E	MSc (E) or PhD
6	Radiation and radiation measurement	10	Norwegian or English	L, E	MSc (E) or PhD

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

²As in Table 5.14.3.

³Obligatory = O, Elective = E

Table 6.14.5: Current PhD projects related to NRC at UiO

Research topic	Number of PhD-students
Investigation of chemical properties of transactinide elements with automated liquid-liquid scintillation system SISAK	2
Modelling and simulating the use of thoriated fuel in light water reactor cores	1

University of Bergen, UiB

Faculty of Mathematics and Natural Sciences, Department of Chemistry

<http://www.uib.no/en/kj>

At UiB NRC is taught in a course on Radiochemistry and radioactivity (10 ECTS) at MSc level. The course is open for all students at The Faculty of Mathematics and Natural Sciences.

6.15 POLAND

In Poland, there are two universities which have educational programs in nuclear and radiochemistry at BSc/MSc level: Maria Curie Sklodowska University in Lublin and University of Gdansk. In addition, three other universities/institutes, i.e. University of Warsaw, Nicolaus Copernicus University (Torun) and Institute of Nuclear Chemistry and Technology, offer individual courses under various educational programs.

Maria Curie Sklodowska University, UMCS

Faculty of Chemistry, Department of Radiochemistry and Chemistry of Colloids

<http://www.umcs.pl/en/faculty-of-chemistry,2650.htm>

NRC research and education at UMCS is specialized in chemical and radiochemical aspects of environmental protection. Basic radiochemistry is taught at BSc level and students can specialize in radiochemistry under the degree MSc in Analytical chemistry. Contents of this specialization were not provided in detail; however, the overall course supply is listed in Table 6.15.1. In addition, PhD work can be carried out in various NRC related fields; some topics are described in table 6.15.2.

Table 6.15.1: NRC related courses at the Maria Curie Sklodowska University*

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Radiochemistry and radioisotopic techniques	5	Polish	L,P	BSc (O)
2	Radioisotopes' methods of analysis	4	Polish	L,P	MSc (O)
3	Radioisotopic techniques	3,5	Polish	L,P	MSc (E)
4	Trace analysis	4	Polish	L,E	MSc (O)
5	Quantitative analysis in organic matrix	4	English	L,E	MSc (O)
6	Biological and Chemical Effects on radiation on living organisms	1	Polish	L	MSc (O)
7	Radiometry and protection against radiation	5	Polish	L,P	MSc (O)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S² Obligatory = O, Elective = E

* detailed information from year 2010

Table 6.15.2: PhD projects related to NRC at the Maria Curie Sklodowska University

Research topic	Number of PhD-students*
Separation of plutonium from uranium and thorium with a use of liquid scintillator	1
Optimization of measurement parameters of chosen isotopes with a use of scintillators	1

Methods of analyzing strontium -90 in water	1
Study on the plutonium migration rate in soils	1
Measurements on the migration of strontium-90 in soils	1

* data from year 2010

University of Gdansk

Faculty of Chemistry, Analytics and Environmental Radiochemistry Chair

<http://chem.arch.ug.edu.pl/en/>

NRC related education at the University of Gdansk is focused on natural and artificial radiochemistry of marine and land environment. The department offer specialized education both at MSc and PhD level, programs are described in Table 6.15.3 and the overall course offer in Table 6.15.4. Average 7 students are graduated annually with the degree in environmental protection and 2 with general NRC, respectively. Topics of the PhD projects have been e.g. Chemical and radiochemical trace analysis (alpha-spectrometry). Eight permanent staff members and the PhD students are participating in teaching NRC in the department.

Table 6.15.3: NRC related educational programs in the University of Gdansk

Degree/specialization	Courses and seminars	Research training (other than thesis work)	Thesis work	ECTS Total (degree total)
(I) MSc in Environmental protection/ Radiochemistry	20	3	50	73 (120)
(II) MSc in Chemistry/ Nuclear and radiochemistry	20	3	30	53 (120)
PhD in Chemistry / NRC			10	

Table 6.15.4: NRC related courses in the University of Gdansk

Title	Credits	Language	Type ¹	Target group ² (O/E ³)
1 Chemical and radiochemical trace analysis	4	Polish	L, E, P	MSc I (O)
2 Nuclear medicine	1	Polish	L	PhD (E)
3 Nuclear chemistry and radiochemistry	2	Polish	L	MSc II (E)
4 Radioactive contamination of environment	2	Polish	L	MSc (E)
5 Environmental radiochemistry and radiological protection	2	Polish	L	MSc (E)
6 Marine radiochemistry	4	Polish	L, E	MSc I (E)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² As in Table 5.14.3.

³ Obligatory = O, Elective = E

University of Warsaw

Faculty of Chemistry, Division of Physics and Radiochemistry, Laboratory of Radiochemistry

http://www.chem.uw.edu.pl/index_en.php

University of Warsaw has a MSc program Nuclear (Energy) Engineering. NRC courses on general

and applied NRC are also taught for students in chemistry both at BSc and MSc level, see Table 6.15.5. Average 50 students are attending the courses annually at BSc level, at MSc level the number is much lower, average 5, respectively. Furthermore, there is possibility to PhD studies in NRC related fields; examples of research topics are Development of radiopharmaceuticals for nuclear imaging and Isotope effects on phase equilibria. The teaching staffs in NRC consist of 5 permanent members and 4 PhD students.

Table 6.15.5: NRC related courses in the University of Warsaw*

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Nuclear Chemistry I	2	Polish	L	BSc (E)
2	Nuclear Chemistry I	2	Polish	E	BSc (E)
3	Nuclear Chemistry II	8	Polish	E	MSc (E)
4	Nuclear Chemistry	2	Polish	S	MSc (E)
5	Nuclear energy and radioactivity	2	Polish	L	MSc (E)
6	Radiopharmaceutical synthesis and its application in medicine	2	Polish	L	MSc (E)
7	Isotope Effects	2	Polish	L	MSc (E)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

* detailed information from year 2010

Nicolaus Copernicus University (Torun)

Faculty of Chemistry, Department of Nuclear Chemistry

<https://www.umk.pl/en/university/faculties/foch/>

Based on the university web pages chemistry students both at BSc and MSc level can include in their studies course on nuclear chemistry. Up-to-date information in English was not available.

Institute of Nuclear Chemistry and Technology (INCT)

www.ichtj.waw.pl

NRC related education at the Institute of Nuclear Chemistry and Technology is given under two departments: Centre for Radiochemistry and Nuclear Chemistry and Laboratory of Nuclear Analytical Methods. The education is aimed at PhD students and is mainly research based; at MSc level there is one course on Coordination chemistry (radionuclide separation and radiopharm. aspects). Topics of some PhD research projects are described in Table 6.15.6. The key staffs in teaching consist of 5 permanent staff members.

Table 6.15.6: PhD projects related to NRC at the INCT

Research topic	Number of PhD-students*
Development of diagnostic (PET, SPECT) and therapeutic radiopharmaceuticals	6
Elements of nuclear fuel cycle – materials, separation methods/technologies	4
Reprocessing of liquid radioactive waste	2
Environmental radiochemistry and nuclear analytical methods	2

* data from year 2010

6.16 SLOVAKIA

In Slovakia, NRC education is mainly given in Comenius University in Bratislava and in the University of SS. Cyril and Methodius in Trnava. In addition, some related courses, i.e. radioecology and nuclear analytical methods, are offered for environmental engineering students in the Technical University of Zvolen (Faculty of Ecology and Environmental Sciences, Department of Environmental Engineering, <http://www.tuzvo.sk/en>).

Comenius University

Faculty of Natural Sciences, Department of Nuclear Chemistry

<http://www.fns.uniba.sk/index.php?id=2389>

At the Comenius University nuclear and radiochemistry can be studied from BSc to PhD level, NRC related curricula and course supply are described in Tables 6.16.1. and 2. Average 5 students are graduated annually with the MSc degree. PhD projects are e.g. in the research fields of Development of radiopharmaceuticals for nuclear imaging (PET, SPECT) and Determination of radionuclides in environmental and NPP samples. The department has 7 permanent staff members participating in teaching NRC.

Table 6.16.1. NRC related educational programs at the Comenius University

Degree	Courses and seminars	Final exam(s)	Research training (other than thesis work)	Thesis work	ECTS Total (degree total)
MSc in chemistry/ Nuclear Chemistry and Radioecology	57		14	29	100 (120)
PhD in Chemistry/ Nuclear Chemistry	24	45	109	40	218 (240)

Table 6.16.2. NRC related courses at the Comenius University

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Basic Radiochemistry I	5	Slovak	L, S, P	BSc (O)
2	Basic Radiochemistry II	2	Slovak	L,	BSc (E)
3	Radiolabeled chemistry	6	Slovak	L,	MSc (O)
4	Environmental Radioactivity	3	Slovak	L,	MSc (O)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

University of SS. Cyril and Methodius (UCM) in Trnava

Faculty of Natural Sciences, Department of Ecochemistry and Radioecology

<http://fpv.ucm.sk/en/>

NRC related education at UCM is mainly involved in chemistry programs from BSc to PhD level; course offer is listed in Table 6.16.3. Average 10 students are attending the programs both at BSc and MSc level. The department has currently 2 PhD students under the topic Application of radioanalytical methods and approaches (PET, autoradiography, scintillation gamma spectrometry or HPGe gamma spectrometry) in the characterization of the uptake and translocation of metals or typical radionuclides in plants (phytoremediation accent). Research group is also focused on the development of analytical methods and approaches in radiotoxic and chemotoxic analytes determination (especially principles of isotopic exchange and isotope dilution analysis), in evaluation of bioavailability of these analytes in different systems (soil, sediments etc.) and on the study or mathematical modelling of (bio)sorption processes by radioindicator methods as well.

Table 6.16.3. NRC related courses in the University of SS. Cyril and Methodius

	Title	Credits	Type ¹	Main target group ² (O/E ³)
1	Nuclear Chemistry	4	L, S	BSc in Chemistry (O)
2	Radiation Protection	2	L	BSc in Chemistry (E)
3	Radiobiology	3	L	BSc in Applied Biology (O)
4	Nuclear Analytical Chemistry	4	L, S	MSc in Applied Chemistry (O)
5	Nuclear Safety and Radioactive Wastes	4	L, S	MSc in Applied Chemistry (E)
6	Nuclear Analytical Methods and Environmental Analytical Chemistry	8	L, S	PhD in Applied Analytical Chemistry and Bioanalytical Chemistry (O)

6.17 SLOVENIA

Josef Stefan International Postgraduate School, Ljubljana

<http://www.mps.si/splet/index.asp?lang=eng>

Based on the available information in the internet, Josef Stefan International Postgraduate School offers courses on radioecology, radioactive and nuclear methods for the study of processes under MSc and PhD in Ecotechnology. The school has collaboration with J Stefan Institute (Department of Environmental Sciences, Group for Radioecology and Group for Radiochemistry <http://www.ijs.si/ijsw/Environmental%20Sciences%20O2>), University of Nova Gorica, University of Ljubljana and University of Primorska.

6.18 SPAIN

Majority of the Spanish universities, especially technical universities are involved in nuclear engineering and technology programs. Moreover, a lot of NRC related education and research is carried out under nuclear physics departments. Based on internet survey radiochemistry courses are found in MSc studies for chemistry in the University of Barcelona (Faculty of Physics and Chemistry, Department of Analytical Chemistry, http://www.ub.es/dqa/eng/index_eng.html) and University of Granada (Faculty of Science, Department of Inorganic Chemistry, <http://qiserver.ugr.es/asignaturas.html>).

6.19 SWEDEN

Two universities in Sweden are currently offering education in nuclear and radiochemistry: Chalmers University of Technology and KTH Royal Institute of Technology. Furthermore, a biomedical program MSc in Medical Nuclide Techniques including some radiochemistry is given at the Uppsala University (<http://www.uu.se/en/node605?pKod=MMN2M&lasar=10%2F11>).

Chalmers University of Technology

Department of Chemistry and Chemical Engineering / Nuclear Chemistry and Industrial Materials Recycling

<http://www.chalmers.se/chem/EN/divisions/nuclear-chemistry>

Education at the Chalmers University of Technology has been under revision due to changes in university administration/organisation. The MSc program in Chemistry and bioscience with specialization in nuclear chemistry is no longer offered and the former MSc degree in Nuclear Engineering was recently renamed to MSc degree in Nuclear Science and Technology, Table

6.19.1. The degree includes specialization in nuclear engineering, however, content of the overall program is currently under modification. Overall list of courses is depicted in Table 6.19.2. MSc programs at Chalmers are taught in English, students choosing nuclear chemistry specialization have decreased (by 2-3 students) to approximately 17 students in recent years. Furthermore, specialization in Nuclear chemistry, e.g. in actinide chemistry, is possible at PhD level; topics of some research fields are listed in Table 6.19.3. The key staffs in teaching NRC consist of 6 permanent staff members. In addition, all PhD students are participating in teaching.

Table 6.19.1: NRC related educational programs at Chalmers University of Technology

Degree/specialization	Courses	Research training (other than thesis work)	Thesis work	ECTS Total (degree total)
MSc in Nuclear Science and Technology/ nuclear engineering	45		30	75 (120)
PhD in Nuclear Chemistry				60 (60)

Table 6.19.2: NRC related courses at Chalmers University of Technology

	Title	Credits	Language	Type ¹	Level
1	Nuclear Chemistry	7.5	English	L, P	MSc
2	Applied Nuclear Chemistry	7.5	English	L, P	MSc
3	Chemistry of Lanthanides, Actinides and Super-heavy Elements	7.5	English	L, P	MSc
4	Solvent Extraction	7.5	English	L, P	MSc
5	Radiopharmaceutical chemistry	7.5	English	L, P	MSc
6	Radioecology and Radioanalytical Chemistry	7.5	English	L, P	MSc

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

Table 6.19.3: PhD projects related to NRC at Chalmers University of Technology

Research topic	Number of PhD-students*
Separation for transmutation	3
Severe reactor accidents	3
Final storage of radioactive waste	1
Ra/Ba chemistry	1

* data from year 2010

KTH Royal Institute of Technology

The School of Chemical Science and Engineering, Department of Chemistry, Applied Physical chemistry (Nuclear Chemistry)

<https://www.kth.se/en/che/departments/chemistry>

At KTH education is focused on radiation chemistry and chemical problems in connection to deep repositories for spent nuclear fuel (including actinide chemistry) and reactor chemistry. Students with chemistry background can include courses in NRC (reactor chemistry, nuclear fuel cycle, photo-, -radiation and radical chemistry, total 22.5 ECTS) and do a thesis work (30 ECTS) in NRC related fields under the degrees of MSc in Chemical engineering or MSc in Molecular Science and Engineering (120 ECTS). Average 30 students are graduated annually with this “specialization”. Furthermore, there is a possibility to do PhD studies in NRC related fields, topics of some projects

are described in Table 6.19.4. The department has 3 permanent staff members and 2 PhD students participating in teaching NRC.

Table 6.19.4: PhD projects related to NRC at KTH

Research topic	Number of PhD-students*
Interfacial Radiation Chemistry (Nuclear Fuel and Reactor Chemistry)	3
Colloid facilitated radionuclide migration	2
Photocatalytic purification of water	1
Radical polymerization	1

* data from year 2010

6.20 SWITZERLAND

University of Bern, University of Zürich and Technical University of Zürich (ETHZ) offer NRC related education in Switzerland. Furthermore, both the University of Bern and ETHZ has close collaboration with Paul Scherrer Institute (PSI) i.e. joint courses are organized and students can do their thesis work at both institutes.

University of Bern (collaboration with Paul Scherrer Institute, PSI)

Department of Chemistry and Biochemistry, Radiochemistry Group

http://www.dcb.unibe.ch/content/index_eng.html

NRC related courses (and courses containing some NRC) in the University of Bern are listed in Table 6.20.1. At BSc level education is aimed at students in chemistry, biochemistry and pharmacy. Average 15 students are attending each BSc course annually; in the basic course the number of attendants may be as high as 140. A variety of courses is also offered for an MSc degree in Chemistry and biosciences (90 ECTS). The program is research-based containing 45 ECTS of courses and 45 ECTS for the thesis work, during 1.5 years. Average 10 students attend the program annually.

Furthermore, there is possibility to do PhD studies under various fields of NRC; topics of some projects are described in Table 6.20.2. Education is organised in close collaboration with the Department of Biology and Chemistry at PSI. The Laboratory of Radiochemistry and Environmental Chemistry has research on e.g. novel radionuclides for future medical applications, measurement techniques of environmental radionuclides in geoscientific research as well as on target chemistry using of large scale irradiation facilities. Some of the NRC courses are given at the Technical University of Zürich (ETHZ).

Table 6.20.1: NRC related courses in the University of Bern (in collaboration with PSI and ETHZ)

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Allgemeine Chemie (Einführung Radioaktivität); 4 hours NRC	4	German	L/E	BSc (O)
2	Instrumentalanalytik II; 16 hours NRC	3	German	L/E	BSc (O)
3	Physikalische Chemie IV; 16 hours NRC	3.75	German	L/E	BSc (O)
4	Biochemische Methoden I; 9 hours NRC	3	German	L/E	BSc (O)
5	Nuclear- and Radiochemistry	3	German /English	L/E	MSc (E)
6	Atmospheric and Aerosol Chemistry	3	German /English	L/E	MSc (E)
7	Environmental Chemistry	3	German /English	L/E	MSc (E)

8	Environmental radionuclides and nuclear dating	1.5	German /English	L/E	MSc (E)
9	Introduction to radiopharmaceutical chemistry	3	German /English	L/E	MSc (E)
10	Lab Course Nuclear and Radiochemistry	4	German	P	BSc (E)
11	Summer Lab Course (PSI)	4	German	P	MSc (E)
12	Kolloquium Radio- und Umweltchemie		German/English	S	MSc/PhD
13	Course Atmospheric Interface Chemistry (ETHZ)	3	German/English	L/E	MSc

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

PSI= Paul Scherrer Institute, ETHZ=Die Eidgenössische Technische Hochschule Zürich

6.20.2. PhD projects related to NRC in the University of Bern and PSI

Research topic	Number of PhD-students*
Development of radionuclides for therapy	1
Superheavy element chemistry	2
Environmental radionuclides	2
Atmospheric chemistry / Surface chemistry	4
Analytical chemistry/ Paleo-climate research	6
Rad-Waste Analytics	3

* data from year 2010

In addition to previously described collaboration between University of Bern (and PSI), the **Technical University of Zürich** (Die Eidgenössische Technische Hochschule Zürich, ETHZ), namely by the Swiss Federal Institute of Technology, is involved in e.g. radiopharmaceutical chemistry education. The Institute of Pharmaceutical Sciences (http://www.chab.ethz.ch/index_EN) offer course(s) in radiopharmaceutical chemistry. A specialized postgraduate education leading to a degree “Advanced Studies (CAS) in Radiopharmaceutical Chemistry / Radiopharmacy” is organized together with various university collaborators (<http://www.radiochem.pharma.ethz.ch/>). It is also recognized as the theoretical part of the European specialization in Radiopharmacy, by the European Association of Nuclear medicine (EANM). At the **University of Zürich**, Department of Chemistry (<http://www.chem.uzh.ch/index.html/>) radiochemistry course(s) are taught under the degree MSc in Chemistry with specialization inorganic chemistry. The research group in medicinal inorganic chemistry aims at development of new medicinal inorganic compounds and radiopharmaceuticals for diagnostics and therapy. More specific topics include e.g. coordination and organometallic chemistry, labelling of various receptor targeting biomolecules (peptides, amino acids or vitamins) with appropriate metal complexes.

6.21 TURKEY

In Turkish universities higher education at undergraduate level is offered either as two or four years programs; leading to Associate's Degree (120 ECTS; organised by vocational training schools) or BSc degree (240 ECTS), respectively. Graduate programs for MSc degrees (120 ECTS) last minimum two years and typical time for PhD studies (240 ECTS) is four years.

There are several universities, such as Istanbul Technical University and Hacettepe University in Ankara, that offer NRC related education under the nuclear technology and engineering programs,

which are not described here in details. General and extensive applied NRC is mainly taught at Ege University in Izmir.

Ege University

Institute of Nuclear Sciences

<http://nbe.ege.edu.tr>

The Institute of Nuclear Sciences comprises of three main departments: Department of Nuclear Sciences, the Department of Nuclear Technology and the Department of Nuclear Applications. Nuclear and radiochemistry is taught at MSc and PhD level, under the Graduate school of natural and applied sciences. The educational programs are MSc in Nuclear Sciences, specialization Nuclear Technology or Nuclear Applications, and PhD in Nuclear Technology or in Nuclear Sciences (Nuclear Applications). Basic nuclear chemistry can also be included in NRC studies (Nuclear Applications) already at BSc level, details of the overall course offer is described in Table 6.21.1. All other courses except Nuclear Chemistry I-II are optional, 2-5 students are attending these courses annually.

The institute has currently significant amount of PhD students under various field of applied NRC, topics are listed in Table 6.21.2. Special focus of NRC education is summarized as follows: Synthesis and characterization of various nano-size material, application of experimental design and statistical analysis for sorption studies of radionuclides and stability constant calculations using potentiometric method.

Table 6.21.1: NRC related courses at Ege University, Institute of Nuclear Sciences

	Title	Credits	Type ¹	Level
1	Nuclear Chemistry I	8	L, E	BSc, MSc
2	Nuclear Chemistry II (Radiation chemistry)	5	L, E	MSc
3	Chemical Separation Techniques On Nuclear Waste Management I	5	L, E	MSc
4	Chemical Separation Techniques On Nuclear Waste Management I	5	L, E	MSc
5	Radioanalytical Chemistry I	8	L, E	MSc
6	Radioanalytical Chemistry II	8	L, E	MSc
7	Inorganic Ion Exchangers In Nuclear Technology	5	L, E	MSc
8	Chemical Consequences Of Nuclear Transformations	8	L, E	PhD
9	Advanced Radiation Chemistry	8	L, E	PhD
10	Preparation Of Radioelements And Labelled Compounds	5	L, E	PhD
11	Radiopharmaceutical Chemistry	5	L, E	PhD
12	Chemical Properties Of Actinide Elements	5	L, E	PhD
13	Coordination Complexes and Complex Ions in Nuclear Chemistry	5	L, E	PhD
14	Transuranic Elements	5	L, E	PhD
15	Quality Assurance and Quality Control in Nuclear Fuel Fabrication II	8	L, E	PhD
16	Ion Exchange Processes in Nuclear Waste Management II	8	L, E	PhD
17	Optimization of Radiochemistry Process	8	L, E	PhD
18	Enrichment Techniques For Trace Element Analyses In Nuclear Applications I	5	L, E	PhD

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

Table 6.21.2: Current PhD projects related to NRC at Ege University

Research topic	Number of PhD-students
Preparation of various type of sorbent to remove some important radionuclides	3
Preparation of uranium and thorium compounds	1
Investigation of natural radioactivity in the environmental samples	-
Development of radiopharmaceuticals for nuclear imaging (PET, SPECT)	4
Radionuclide Labeled Nanoparticles for Therapy and Imaging	3
Cell Culture and its basic equipment	8
Preclinic animal imaging and biodistribution	7
Evaluation effects of plant oriented extracts on the biodistribution of radiopharmaceuticals	1
Boron Neutron Capture Therapy	2
Preparation of Nanoparticles for Life Sciences	1
The application of nuclear techniques in the environmental studies i.e., the use of environmental radionuclides as tracer in sedimentation investigations and soil erosion	4
Natural and artificial radioactivity measurements in the environment and radioecological studies	4
The measurements of radon in air, soil and water for geophysical and dosimetric purposes	3
Monte Carlo simulations for calculation of radiation dose and detector parameters	3
Application of thermoluminescence dosimetry, thermoluminescence dating and optically stimulated luminescence	3

NRC is also taught at two universities in Ankara, **Middle East Technical University METU** (www.chem.metu.edu.tr) and **Bilkent University** (<http://www.fen.bilkent.edu.tr/~cvchem/>). The current course offer at the chemistry department of METU includes an elective course at BSc level entitled as “Nuclear Analytical Techniques”. In this course, following the introduction of basic concepts related to radioactive decay, its detection and measurements, main nuclear analytical techniques and some of their applications in medicine, geology and archaeology are taught. At Bilkent University graduate students, mainly MSc students in chemistry, can include in their studies courses e.g. on nuclear and radiochemistry (7.5 ECTS) and environmental radiochemistry (7.5 ECTS).

6.22 UK

In UK, students applying for university education need to have certain qualification from the secondary education, typically A-level qualification or the International Baccalaureate (BTEC). Higher education typically includes BSc studies and MSc studies, however, it differs from the traditional Bologna system in that MSc studies can be either *theoretical* or based on *research work MRes/MSc(res)*. BSc studies are typically finished in 3 years, whereas MSc studies can take 1-2 years, respectively. In UK educational system 1 credit point requires about 15 h work (leading to 120 credits per year) which means that 2 UK credits equals 1 ECTS credit.

It is also possible to award so called *undergraduate MSc degree* (in chemistry MChem) as a first degree instead of BSc. Extent of this type of program is typically 4 years. Some universities are also awarding *foundation degrees* as a vocational qualification certificate of the education. Doctoral studies in UK are normally done in 3 years.

A number of universities in UK have Nuclear engineering and technology related programs (see details e.g. from <http://www.nuclearliaison.com/nl-courses>). General or specialized nuclear and radiochemistry education is currently given in few universities.

University of Loughborough

Department of Chemistry, Environmental Radiochemistry Group

<http://www.lboro.ac.uk/departments/cm/>

NRC related education is offered at undergraduate level *i.e.* under the degrees of BSc (3 years) and MChem (4 years) in chemistry. Topics of the courses are listed in Table 6.22.1. Average number of students graduating annually from the BSc and MChem programs is 75 and 40, respectively. PhD projects (12) and Post-Docs (4) are focused on chemistry of nuclear waste disposal and method development for radioanalyses. Three permanent staff members in the department are participating in teaching NRC.

Table 6.22.1: NRC related courses in the University of Loughborough

Title	Credits	Language	Type ¹	Target group
Radiochemistry	10	English	L, E, P, S	BSc and MChem
Radiation Option	10	English	L, E, P, S	BSc and MChem

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

University of Manchester

School of Chemistry / Nuclear First Training Centre

<http://www.chemistry.manchester.ac.uk/>

The University of Manchester has two departments under which education in NRC is given. The School of Chemistry offers general radiochemistry course module (20 credits) for undergraduate students in chemistry (MChem degree). The course consists of parts The Atomic Nucleus, Origin of the Elements and Actinide Chemistry, and approximately 100 students are taking this course in their final year of studies. Furthermore, there are 13 PhD projects under the topics Coordination chemistry of the radioactive elements, Chemistry of radioactive wastes and Environmental radiochemistry. Three permanent staff members are participating in teaching NRC. These staff members are also involved in teaching at the **Nuclear First Training Centre** which offers a broad variety of NRC related courses at PhD level; topics are listed in Table 5.22.2. In addition to the research topics in the School of Chemistry, there are PhD projects under Synthetic Radiochemistry of the actinides, Chemical Modeling, Geological disposal and Fuel and reactor systems.

Table 6.22.2: Course supply at the Nuclear First Training Centre of the Manchester University

	Title	Credits	Language	Type ¹	Target group ² (O/E ³)
1	Basic Nuclear Physics	5	English	E, P	Ph D (O)
2	Basic Radiochemistry	5	English	E, P	Ph D (O)
3	Overview of Nuclear Fuel Cycle	5	English	L, E	Ph D (O)
4	Basic Nuclear Engineering	5	English	L, E	Ph D (O)
5	Environmental Radiochemistry	7.5	English	E, P	Ph D (O)
6	Materials Science in Nuclear Fuel Cycle	5	English	L, P	Ph D (O)
7	Nuclear Fuels	5	English	L, E	Ph D (O)
8	Radiation Chemistry Effects	5	English	L, E	Ph D (O)
9	Radioactive waste	5	English	L, E, P	Ph D (O)
10	Waste immobilisation, Transport and Migration of Pollutants	7.5	English	L, E, P	Ph D (O)
11	Modelling	5	English	E, P	Ph D (O)
12	Short Research project 1	45	English	E, P, S	Ph D (O)
	Short Research project 2	45			

King's College London

Faculty of Life Sciences and Medicine, Division of Imaging Sciences and Biomedical Engineering,
Department of Imaging Chemistry and Biology

// EPSRC CENTRE FOR DOCTORAL TRAINING IN MEDICAL IMAGING

<http://www.kcl.ac.uk/lsm/research/divisions/imaging/departments/imaging/index.aspx>

A one-year (12 months) MSc degree (90 ECTS) in Radiopharmaceutics & PET Radiochemistry is offered. King's also offers PhDs (4 years and 3 years) in radiopharmaceutical sciences. Approximately 4-5 PhD students graduate per year in radiopharmaceutical sciences combining radiochemistry and associated biology. A Doctoral Training Centre in Medical Imaging funded by EPSRC (Engineering and Physical Sciences Research Council) will begin recruiting in 2014 and the numbers of PhD students will increase at this time. The first year of the four year PhD programme comprises an MRes in Medical imaging, which may include modules from the MSc in Radiopharmaceutics and PET Radiochemistry. The Centre will continue to generate at least 5 radiochemistry PhDs per year.

In addition, postgraduate course on e.g. Environmental radioactivity and radiochemistry (7.5 ECTS) is offered by the National Oceanography Centre at the **University of Southampton**. Research interests of the Geosciences Advisory Unit (GAU) are mainly related to extraction and measurement of volatile radioactive isotopes, specifically tritium and carbon-14.

7 CONCLUSIONS

Current university curricula in nuclear and radiochemistry (NRC) at BSc, MSc or PhD level were surveyed: 22 countries and 72 universities were eventually included in the study. A significant part of the nuclear related education in Europe, i.e. nuclear engineering and technology programs, is tailored to the needs of nuclear power industry and has less nuclear and radiochemistry involved. On the other hand, many universities/institutions have high level of nuclear and radiochemistry research and offer possibility to do PhD-work in various related fields but have no education at lower levels, or education for BSc/MSc students is given only at basic level. There are 39 educational programs (degree/specialization) in NRC, 7 at BSc and 32 at MSc level; 57 % of the listed universities have NRC education only as individual courses under various educational programs.

Majority of the universities has adapted the 3-cycle Bologna system with BSc, MSc and PhD levels, however, historical background can still be seen in various emphasis and structure of the curricula. The extent of curriculum varies a lot: there are MSc programs with 60-120 ECTS credits and under the typical 120 ECTS program the extent of NRC specialization can vary from 47-113 ECTS. In general, research training and thesis work has a strong role in specialization and the curriculum reflects research interests of the department. Majority of the specializations are under general nuclear and/or radiochemistry, large specified topic is environmental radiochemistry and/or radioecology. Some notable things in various educational systems are e.g. the close collaboration between universities and research institutes in Germany; NRC education in France is typically carried out by joint programs having partners both from various universities as well as from research institutes and industry. This type of collaboration brings education and training closer to each other and thus also affects development of the academic programs.

In comparison to the first survey, interest on nuclear and radiochemistry education has remained at similar level. There are only few new programs, such as the Radiochemistry specialization at the University of Debrecen; some programs such as the MSc program at Charles University have been ended. In addition, the nuclear chemistry program at the CTU has been recently modified (no formal specializations any more) and the nuclear engineering program at TU Chalmers was renamed to MSc in Nuclear Science and Technology. The number of students has fluctuated a bit, however, the trend seems to indicate increasing number of students in NRC.

As this report is based on the available information on various curricula, mostly relying on the data that was provided with filled questionnaires, it will be open for revision when additional or more detailed information is received.

APPENDIX 1.

LIST OF UNIVERSITIES (/INSTITUTES) GIVING EDUCATION ON NUCLEAR AND RADIOCHEMISTRY IN EUROPE

1.1 AUSTRIA

	FOCUS of EDUCATION- NRC course topics (ECTS credits)	Level
<p>UNIVERSITY OF VIENNA Faculty of Chemistry, Institute of Inorganic Chemistry, Radiochemistry group Head of the Department / Group B.K.Keppler / Gabriele Wallner Web pages http://anorg-chemie.univie.ac.at Tel. +43 1 427752622 Fax. +43 1 42779526 Postal address Währingerstr. 42, A-1090 Vienna, Austria Contact person: Ass. Prof. Gabriele Wallner gabriele.wallner@univie.ac.at</p>	ENVIRONMENTAL RADIOCHEMISTRY- radiochemistry, radiopharmaceutical chemistry, actinides chemistry (17 ECTS)	MSc
<p>VIENNA UNIVERSITY OF TECHNOLOGY Faculty of Physics, The Institute of Atomic and Subatomic Physics, Radiation Physics (Radio and Nuclear Chemistry Groups) Head of the Department / Group Christina Strelj / Radiation Physics Web pages http://www.ati.ac.at/index.php?id=16&L=1 Tel. +43 1 58801 14101 Fax. +43 1 58801 14199 Postal address Stadionallee 2 1020 Vienna Austria Contact person: Prof. Max Bichler bichler@ati.ac.at</p>	ENVIRONMENTAL RADIOCHEMISTRY- radiochemistry, radioecology, assessment of radionuclides in environmental samples, radioisotope techniques (>25 ECTS)	MSc, PhD
<p>UNIVERSITY OF INNSBRUCK Faculty of Chemistry and Pharmacy, Institute of Analytical chemistry and Radiochemistry http://www.uibk.ac.at/acrc/ Contact person: Prof. Günther K. Bonn Guenther.Bonn@uibk.ac.at</p>	RADIOANALYTICAL CHEMISTRY- radiochemistry/radioanalytics (2.5 ECTS)	BSc

1.2 BELGIUM

	FOCUS of EDUCATION- NRC course topics (ECTS credits)	Level
<p>GHENT UNIVERSITY Faculty of Sciences, Department of Analytical Chemistry http://www.analchem.ugent.be Head of the Department / Group Karel Strijckmans Web pages www.analchem.ugent.be Tel. + 32 9 264 48 14 Fax. + 32 9 264 49 60 Postal address Krijgslaan 281 S12 9000 GENT, Belgium Contact person: Prof. Karel Strijckmans Karel.Strijckmans@UGent.be</p>	RADIOANALYTICAL CHEMISTRY- radiochemistry (6 ECTS)	BSc

1.3 BULGARIA

	Dedicated NRC programme (NRC/total ECTS credits)
<p>SOFIA UNIVERSITY ST. KLIMENT OHRIDSKI Faculty of Chemistry and Pharmacy, Department of Analytical Chemistry http://www.chem.uni-sofia.bg/depart/achem/default.htm Head of the Department / Group Prof. Dr. Romyana Djingova – Kostadinova, DSc Web pages www.chem.uni-sofia.bg Tel. ++3592 8161298 Postal address 1, J. Bouchier blvd., 1164 Sofia, Bulgaria Contact person: Prof. Romyana Dzgingova Rdjingova@chem.uni-sofia.bg</p>	<p>1) BSc in nuclear chemistry = 97/240 ECTS 2) MSc in nuclear chemistry = 60/60 ECTS 3) MSc in radiochemistry and radioecology = 90/90 ECTS 4) PhD in radiochemistry = 175/180 ECTS *for other students radioanalytical chemistry and radioecology at BSc level</p>
<p>PLOVDIV UNIVERSITY “Paisii Hilendarski” Faculty of Chemistry http://en.argon.uni-plovdiv.bg/ Head of the Department/Group: Assoc.Prof. Iliyan Ivanov, PhD Web pages www.uni-plovdiv.bg Tel. +35932261403 Postal address 24, ‘Tsar Assen’, Str, 4000 Plovdiv, Bulgaria Contact person: Assoc.Prof. Maria Kostadinova, PhD marianas@uni-plovdiv.bg</p>	<p>1) MSc in radiochemistry and radioecology</p>

1.4 CROATIA

	FOCUS of EDUCATION- NRC course topics (ECTS credits)	Level
<p>UNIVERSITY OF ZAGREB Faculty of Science, Department of Chemistry www.chem.pmf.hr Head of the Department: Professor Predrag Novak Web pages www.chem.pmf.hr Tel. 385 (0)1 4606 010 Fax. 385 (0)1 4606 013 Postal address Horvatovac 102A, 10000 Zagreb, Croatia Contact person: Prof. Davor Kovacevic davor.kovacevic@chem.pmf.hr</p>	<p>RADIOANALYTICAL CHEMISTRY -radioanalytical methods (4 ECTS)</p>	<p>MSc</p>

1.5 CYPRUS

	FOCUS of EDUCATION-NRC course topics (ECTS credits)	Level
<p>UNIVERSITY OF CYPRUS, Nicosia</p> <p>Department of Chemistry Head of the Group Ioannis Pashalidis Web pages http://www.ucy.ac.cy/chem/en/ Tel. +357 22 892785 Fax. +357 22 892801 Postal address. 75 Kalipoleos Av., 1678 Nicosia, Cyprus Contact person: Assoc. Prof. Ioannis Pashalidis pspasch@ucy.ac.cy</p>	<p>ENVIRONMENTAL RADIOCHEMISTRY- basic radiochemistry, environmental radioactivity (7 ECTS)</p>	<p>BSc, MSc</p>

1.6 CZECH REPUBLIC

	Dedicated NRC programme (NRC/total ECTS credits)	
<p>CZECH TECHNICAL UNIVERSITY IN PRAGUE (CTU) Faculty of Nuclear Sciences and Physical Engineering Department of Nuclear Chemistry Head of the Department prof. Jan John Web pages http://www.jaderna-chemie.cz, www.fjfi.cvut.cz/kjch, www.cvut.cz Tel. +420 224 358 228 Fax. +420 222 317 626 Postal address Břehová 7, 115 19 Prague 1, Czech Republic Contact person: Prof. Jan John jan.john@fjfi.cvut.cz</p>	<p>1) BSc in nuclear chemistry= 36/180 ECTS 2) MSc in nuclear chemistry, informal specializations: ➤ applied nuclear chemistry ➤ chemistry of the environment and radioecology ➤ nuclear chemistry in biology and medicine = 110/120 ECTS (2 years) 3) PhD in nuclear chemistry</p>	
	FOCUS of EDUCATION-NRC course topics (ECTS credits)	Level
<p>CHARLES UNIVERSITY, Prague Faculty of Science, Department of Organic Chemistry https://www.natur.cuni.cz/chemistry/orgchem Head of the Department Prof. Jana Roithová, Ph.D. Web pages www.natur.cuni.cz Tel. +420-221951339 (L.L.) Fax. +420-221951326 (secretary) Postal address Hlavova 8, 12840 Praha 2 Contact person: doc. Ing. Stanislav Smrček, CSc stanislav.smrcek@natur.cuni.cz</p>	<p>nuclear chemistry, radionuclides in biological sciences, labelled compounds</p>	<p>BSc, MSc</p>

MASARYK UNIVERSITY, Brno

Faculty of Science, Department of Chemistry
<http://www.sci.muni.cz/en/UCH/>
Head of the Department / Group Dr. Ctibor Mazal
Web pages www.sci.muni.cz
Tel. +420549495801
Fax. -420549492443
Postal address Kotlářská 2, 61137 Brno
Czech Republic
Contact person: Prof.RNDr. Jiří Příhoda jiriprihoda@seznam.cz

basic nuclear and
radiochemistry, radioecology
(11 ECTS) BSc,
MSc,
PhD

University of Chemistry and Technology Prague (UCT Prague) (former INSTITUTE OF CHEMICAL TECHNOLOGY PRAGUE, ICTP)

<http://www.vscht.cz/?jazyk=en>
Faculty of Chemical Engineering, Department of Analytical Chemistry
Head of the Department / Group prof. Štěpán Urban, MSc, PhD
Web pages http://old.vscht.cz/anl/index_en.html
Tel. 220 444 043
Fax. 220 444 352
Postal address Technická 5, 166 28 Praha 6 – Dejvice
Contact person: Dr. Jan Fahnrich jan.fahnrich@vscht.cz

RADIOANALYTICAL
CHEMISTRY-nuclear
analytical chemistry
(6 ECTS) MSc

UNIVERSITY OF DEFENCE, Brno

NBC Defence Institute
Head of the Department / Group plk. doc. Ing. Zdeněk Skaličan, CSc.
<http://www.vojenskaskola.cz/school/ud/nbcdi/Pages/default.aspx>
Tel. +420 973 452 301
Fax.
Postal address NBC Defence Institute
Vita Nejedleho
68201 Vyskov, Czech Republic
Contact person: kpt. Ing. Jiří Janda, PhD
jiri.janda@unob.cz

nuclear chemistry (4 ECTS) BSc

1.7 FINLAND

Dedicated NRC programme (NRC/total ECTS credits)

UNIVERSITY OF HELSINKI

Faculty of Mathematics and Natural Sciences, Department of Chemistry, Laboratory of
Radiochemistry
Head of the Department Professor Jukka Lehto
Web pages <http://www.helsinki.fi/kemia/radiokemia/english>
Tel. + 358 2941 50 141
Postal address P.O. Box 55 (A.I.Virtasen aukio 1)
FI-00014 University of Helsinki, Finland
Contact person: Prof. Jukka Lehto jukka.lehto@helsinki.fi

1) MSc in chemistry:
specialization radiochemistry
= 83-84/120 ECTS
2) PhD in chemistry:
specialization radiochemistry
= 50/60 ECTS
* basic radiochemistry also at
BSc level

UNIVERSITY OF TURKU

Faculty of Mathematics and Natural Sciences, Department of Chemistry
(professorship in Radiochemistry)

<http://www.utu.fi/en/units/sci/Pages/home.aspx>

<http://www.turkupetcentre.fi>

Contact person: Prof. Olof Solin olof.solin@utu.fi

**RADIOPHARMACEUTICAL
CHEMISTRY-** MSc,
PhD
basic radiochemistry,
chemistry of PET-
radiopharmaceuticals,
radiochemical measuring
techniques (16 ECTS)

1.8 FRANCE

Joint programmes related to NRC

Consortium I: ParisTech (<http://www.paristech.fr/>: Ecole Polytechnique ParisTech – Mines ParisTech – Ecole des Ponts ParisTech – Arts et Métiers ParisTech – ENSTA ParisTech – Chimie ParisTech) **Université Paris Sud (XI), Ecole Centrale Paris (ECP), Supelec, l'Institut National des Sciences et Techniques Nucléaires de Saclay (INSTN)**

<http://www.master-nuclear-energy.fr/en/index.php>

1) MSc Nuclear Energy; specialization nuclear fuel cycle MSc

Consortium II: Université Paris Sud (XI), Université Paris XII, Chimie ParisTech, Mines ParisTech, Polytechnique ParisTech, ECP, INSTN

http://www.chimie-paristech.fr/en/la_formation/masters/

2) Sciences and technologies Master; chemistry option (*Master en science des matériaux, spécialité matériaux pour les structures et l'énergie*) MSc

Consortium III: University Montpellier 2, l'École Nationale Supérieure de Chimie de Montpellier (ENSCM), INSTN

<http://www-instn.cea.fr/formations/diplomes-et-titres/liste-des-diplomes-et-titres/m2-chimie-separative-materiaux-et-procedes-applications-au-cycle-du-combustible-nucleaire,24.html>

3) Separative Chemistry, materials and process (*M2 Chimie séparative, matériaux et procédés: applications au cycle du combustible nucléaire*) MSc

Consortium IV: INSTN in Cadarache in collaboration with Institut Polytechnique Grenoble and Science et Ingénierie des Matériaux et Procédés (SIMAP)

<http://phelma.grenoble-inp.fr/courses/international-master-manuen-materials-for-nuclear-energy-278507.kjsp?RH=1268753006722>

4) International Master of Material Science for Nuclear Energy (MaNuEn)

Consortium V: École des Mines de Nantes in collaboration with École nationale supérieure d'ingénieurs de Caen (ENSICAEN), Nantes University and INSTN

<http://www.mastersportal.eu/studies/42188/sustainable-nuclear-engineering-applications-management.html>

<http://www.mines-nantes.fr/en/content/view/full/7242>

5) International MSc in sustainable Nuclear Engineering: applications and management (SNEAM) with 3 specializations: *Advanced Nuclear Waste Management (ANWM), Nuclear Energy Production and Industrial Applications (NEPIA) and Nuclear Technologies for Medical Applications (NUTMA)*

Consortium VI: INSTN Grenoble in collaboration with Université Joseph Fourier Grenoble 6) European Master of Radioprotection (EMRP)
<http://www.master-emrp.eu/index.php/en/>

PARIS SUD UNIVERSITY XI

Radiochemistry Group
http://www.dep-chimie.u-psud.fr/index.php?option=com_wrapper&view=wrapper&Itemid=169
Tel. 33169157343
Fax. 33169157150
Postal address Paris sud 11 university
91406 Orsay, France
Contact person: Prof. Eric Simoni simoni@ipno.in2p3.fr

Programme 1: *profile radiochemistry* MSc
Programme 2

CHIMIE PARISTECH (École nationale supérieure de chimie de Paris)

Nuclear Science Division
<http://www.chimie-paristech.fr/spip.php?page=english>
Tel. +33 1 56 81 30 56
Fax. +33 1 56 81 30 59
Postal address 11, rue Pierre et Marie Curie, 75005 PARIS, France
Contact person: Prof. Gérard Cote gerard-cote@chimie-paristech.fr

Programme 1: *profile fuel cycle engineering* MSc
Programme 2
*radioactivity also at BSc level

École des Mines of Nantes

<http://www.mines-nantes.fr/fr/Formations/Masters-of-Science/SNEWM-ANWM>
Laboratory of Subatomic Physics and Associated Technologies **SUBATECH**, which is a research laboratory co-operated by the Ecole des Mines de Nantes, **the Institut National de Physique Nucléaire et de Physique des Particules (IN2P3) of CNRS, and the Université de Nantes**
Laboratory of radiochemistry
<http://www-subatech.in2p3.fr/fr/>
Contact person: Prof. Bernd Grambow grambow@subatech.in2p3.fr

Programme 5 MSc
e.g. MSc in Advanced Nuclear Waste Management (approx. 80 cr NRC of total 120 cr)

UNIVERSITY MONTPELLIER 2

Institute of Separative Chemistry of Marcoule (in collaboration with Commissariat à l'Energie Atomique CEA, Centre national de la recherche scientifique CNRS)
Lab. des Interfaces de Matériaux en Evolution (LIME)
Institut de Chimie Séparative de Marcoule - UMR 5257
<http://www.master-chimie.univ-montp2.fr/CSMP>
Tel. : 04 66 33 92 05/ 06 30 14 43 84
Fax : 04 66 79 76 11
Postal address Université de Montpellier 2
Centre de Marcoule - Bât. 426
BP 17171
30207 Bagnols sur Cèze cédex
Contact person: Prof. Nicolas Dacheux nicolas.dacheux@icsm.fr ;
nicolas.dacheux@univ-montp2.fr

Programme 3 MSc

l'Ecole Nationale Supérieure de Chimie de Montpellier (ENSCM)

Institute of Separative Chemistry of Marcoule
http://www.icsm.fr/index.php?pagendx=app_1838&project=icsm_engl
Contact person: Ass. Prof. Luc Girard luc.girard@enscm.fr

Programme 3 MSc

GRENOBLE INP Phelma in collaboration with EDF and CEA - INSTN

Institut Polytechnique Grenoble
Science et Ingénierie des Matériaux et Procédés (SIMAP)
<http://phelma.grenoble-inp.fr/courses/international-master-manuen-materials-for-nuclear-energy-278507.kjsp?RH=1268753006722>
Contact person : Prof. Yves Brechet ybrechet@simap.grenoble-inp.fr

Programme 4: Materials for nuclear energy –qualification (11 ECTS), as separate courses for PhD studies MSc

University of Aix-Marseille

Faculty of Science
<http://edu.univ-amu.fr/en/faculty-of-science>

Master of Sciences and technologies: specialization Nuclear energy, with specific courses on nuclear materials, fusion science MSc

University of Limoges

Faculty of Science and technology
<http://www.sciences.unilim.fr/>

Master of Physics and chemistry of high performing materials: specific courses on physic and chemistry of solids, radioactivity and chemistry of uranium, characterisation techniques, cristallochemistry MSc

Lille 1 University –Science and Technology

in collaboration with National Graduate School of Engineering Chemistry of Lille (École Nationale Supérieure de Chimie de Lille, ENSCL)
<http://www.ensc-lille.fr/art106-106-182-training-at-enscl.html>

Master of Chemistry, Energy and Environment MSc

UNIVERSITY OF NICE-SOPHIA ANTIPOLIS (Université de Nice-Sophia)

in collaboration with CNRS
 Faculty of Science, Institute of Chemistry,
 Laboratoire de Radiochimie, Sciences Analytiques et Environnement
<http://unice.fr/>
<http://www.unice.fr/icn-s/?lang=fr>
 Contact person: Prof. Christophe Den Auwer christophe.den-auwer@unice.fr

ENVIRONMENTAL RADIOCHEMISTRY- environmental radioactivity radioanalytical chemistry BSc, MSc

1.9 GERMANY

Dedicated NRC programme
(NRC/total ECTS credits)**RUPRECHT-KARL UNIVERSITY OF HEIDELBERG in collaboration with Karlsruhe Institute of Technology (KIT)**

Faculty of Chemistry and Geoscience, Department of Physical Chemistry
<http://www.chemgeo.uni-hd.de/>
 Radiochemistry research group
 Head of the Group Prof. Dr. Petra Panak
 Web pages <http://www.radiochemie-heidelberg.de/>
 Tel. 07247/824469
 Fax. 07247/823927
 Postal address Im Neuenheimer Feld 253, 69120 Heidelberg
 Contact persons: Prof. Dr. Petra Panak petra.panak@kit.edu

1) BSc in chemistry: specialization (module) radiochemistry = 27/180 ECTS
 2) MSc in chemistry: specialization radiochemistry = 40/120 ECTS

UNIVERSITY OF KÖLN in collaboration with Forschungszentrum Jülich

Faculty of Science, Department of Chemistry, Division of Nuclear Chemistry at the Institute of Biochemistry
http://www.uni-koeln.de/math-nat-fak/nukchem/index_e.htm
 Head of the Department / Group
 Prof. B. Neumaier (at Forschungszentrum Jülich)
 Dr. E. Strub (at University Cologne)
 Web pages <http://www.uni-koeln.de/math-nat-fak/nukchem/>
 Tel. 0049-221-470-3219
 Postal address Zülpicher Strasse 45/50674 Köln /Germany
 Contact persons: PD Dr. Erik Strub erik.strub@uni-koeln.de

1) BSc in chemistry: specialization (module) nuclear chemistry = 25/180 ECTS
 2) MSc in chemistry: specialization (module) nuclear chemistry = 43/120 ECTS
 * MSc courses applicable in PhD studies

**DRESDEN UNIVERSITY OF TECHNOLOGY in collaboration with Helmholtz
zentrum Dresden-Rossendorf** (Institute for Resource Ecology IRE)

Faculty of Science, Dept. Chemistry/Food Chemistry, Institute of Analytical
chemistry, Professorship Radiochemistry
<http://www.chm.tu-dresden.de/anc2/>
Head of the IRE Prof. Thorsten Stumpf
Tel. +49 351 260-3210
Fax. +49 351 260-3553
Postal address Dresden University of Technology, Faculty of Science, Dept.
Chemistry/Food Chemistry, Professorship Radiochemistry Postfach./01062 Dresden /
Germany
Contact person: Prof. Thorsten Stumpf t.stumpf@hzdr.de

MSc in chemistry:
specialization (module)
radiochemistry
* environmental
radiochemistry also for other
students at MSc level

FH AACHEN-UNIVERSITY OF APPLIED SCIENCES (collaboration with
Forschungszentrum Jülich FZJ and RWTH Aachen University)

Speciality Chemistry and Biotechnology, Nuclear Chemistry
<https://www.fh-aachen.de/>
Head of the Department / Group Prof. Dr. Ulrich W. Scherer
Web pages www.fh-aachen.de/2014.html
Tel. +49-241-600953894
Fax. +49-241-600953199
Postal address Heinrich-Mußmann-Str.1, D-52428 Jülich, Germany
Contact person: Prof. Ulrich W. Scherer
scherer@fh-aachen.de
FZJ: Prof. Dirk Bosbach (d.bosbach@fz-juelich.de), head of IEK6,
and Prof. Allelein and Prof. Thomauske

1) BSc in Applied Chemistry:
10-40 /180 ECTS
2) European MSc in Nuclear
Applications = *30-90/120*
ECTS

LEIBNIZ UNIVERSITY OF HANNOVER

Institute for Radioecology and Radiation Protection (IRS)
Head of the Department / Group Prof. Dr. Clemens Walther
Web pages www.zsr.uni-hannover.de
www.irs.uni-hannover.de
www.strahlenschutzkurse.de
Tel. +49-171-644 2719
Postal address Herrenhäuser Str. 2
D-30419 Hannover
Contact person: Prof. Dr. Clemens Walther
walther@irs.uni-hannover.de

MSc in analytical chemistry:
courses e.g. on
radiochemistry, radioecology,
analytics of radionuclides (14
ECTS)

MÜNCHEN UNIVERSITY OF TECHNOLOGY

Faculty of Chemistry, Institute for Radiochemistry “Radiochemie München RCM”
<http://www.rcm.tum.de>
Chair for pharmaceutical radiochemistry: Prof. Dr. H. J. Wester
Tel. +49-89-28912202
Fax. +49-89-28912204
Postal address Walther-Meissner-Str. 3
85748 Garching, Bayern, GERMANY
Contact person: Prof. Dr. H. J. Wester

MSc in chemistry: module
Pharmaceutical
radiochemistry (17 ECTS)
*individual courses at BSc
level

FREIE UNIVERSITÄT BERLIN

Institute of Chemistry and Biochemistry, Inorganic chemistry, Radiochemistry group
Head of the Department / Group Prof. Ulrich Abram
Web pages <http://www.bcp.fu-berlin.de/chemie>
<http://www.bcp.fu-berlin.de/en/chemie/chemie/forschung/InorgChem/agabram/index.html>
Tel. #49 30 838 54002
Fax. #49 30 838 52676
Postal address Fabeckstrasse 34-36
D-14195 Berlin, Germany
Contact person: Prof. Ulrich Abram Ulrich.Abram@fu-berlin.de; abram@chemie.fu-berlin.de

MSc in chemistry: module
Applied Radiochemistry and
Radiation Protection
Instruction (courses+project
work, min 20 ECTS)
* basics of radiochemistry also
at BSc level (5 ECTS)

	FOCUS of EDUCATION-NRC course topics (ECTS credits)	Level
<p>KARLSRUHE INSTITUTE OF TECHNOLOGY Fakultät für Chemie und Biowissenschaften Institute for Nuclear Waste Disposal (INE) http://www.kit.edu/kit/english/ Contact person: Prof. Horst Geckeis horst.geckeis@kit.edu</p>	nuclear waste management, radioanalytics etc.- <i>see U Heidelberg</i>	
<p>JOHANNES GUTENBERG UNIVERSITY, MAINZ Department of Chemistry, Pharmacy and Geosciences, Institute of Nuclear Chemistry http://www.kernchemie.uni-mainz.de/ Head of the Department / Group Prof. Dr. Tobias Reich Tel. +49-6131-39-25250 Fax. +49-6131-39-27250 Postal address Fritz-Strassmann-Weg 2 55122 Mainz, Germany Con tact person: Univ.-Prof. Dr. Tobias Reich tobias.reich@uni-mainz.de</p>	nuclear and radiochemistry (including topics such as actinides chemistry, radiopharmaceutical chemistry)	BSc
<p>TU CLAUSTHAL Institute of Disposal Research http://www.ielf.tu-clausthal.de/en/ueber-uns/ Contact person: Prof. Klaus-Jürgen Röhlrig klaus.roehlig@tu-clausthal.de</p>	radioactive and hazardous waste management; isotopic geochemistry (under <i>MSc in Radioactive and Hazardous Waste Management</i>)	MSc

1.10 GREECE

	FOCUS of EDUCATION-NRC course topics (ECTS credits)	Level
<p>ARISTOTLE UNIVERSITY, Thessaloniki Faculty of Sciences, Department of Chemistry, Laboratory of Inorganic Chemistry (Radiochemical laboratory) http://www.chem.auth.gr/index.php?lang=en Head of the Group Prof. Dr. Panagiotis Misaelides Web pages http://www.chem.auth.gr Tel. +30 2310 997789 Fax. +30 2310 997753 Postal address Laboratory of Inorganic Chemistry, Department of Chemistry, Aristotle University, GR-54124 Thessaloniki, Greece Contact person: Dr. Panagiotis Misaelides misailid@chem.auth.gr</p>	basic nuclear and radiochemistry	BSc, MSc
<p>UNIVERSITY OF PATRAS School of Natural Sciences, Department of Chemistry, Division of Physical, Inorganic and Nuclear-Radiation Chemistry, Radiochemistry Group http://www.chem.upatras.gr/index.php?lang=en Tel. Head of the Department : (+302610) 997915, 997181 Fax. (+302610) 997153 for the Head of the Department Postal address UNIVERSITY OF PATRAS, Department of Chemistry, Patras -26 500- GREECE Contact person: Symeopoulos Vasilios bds@chemistry.upatras.gr</p>	ENVIRONMENTAL RADIOCHEMISTRY- principles and applications of nuclear chemistry	BSc (MSc)

NATIONAL TECHNICAL UNIVERSITY OF ATHENS, NTUA

School of Chemical Engineering, Laboratory of General Chemistry

<http://www.chemeng.ntua.gr/>

Head of the School Professor Emmanuel G. Koukios

Tel. 0030 2107723096

Fax. 0030 2107723188

Postal address 9, Heroon Polytechniou Str., Zografou Campus,
Athens 15 780, Greece

Contact person: Assoc. Professor Zaphiris G. Loizos

zloizos@chemeng.ntua.gr

radiochemistry, nuclear
chemistry-nuclear technology, BSc,
radiation chemistry- MSc
photochemistry

1.11 HUNGARY

Dedicated NRC programme (NRC/total ECTS credits)

UNIVERSITY OF PANNONIA, Veszprem

Institute of Radiochemistry and Radioecology

Head of the Department / Group Prof. Tibor Kovács

Web pages <http://radio.mk.uni-pannon.hu>

Tel. +36 88 624 178

Fax. +36 88 624 178

Postal address H-8201 Veszprem, PO Box 158

Contact person: Ass. Prof. Edit Tóth-Bodrogi

bodrogi@almos.uni-pannon.hu

1) BSc in environmental
engineering: specialization
radioecology = 30/210 ECTS
2) MSc in environmental
engineering: specialization
radioecology = 47/120 ECTS
3) MSc in chemical
engineering: radiochemical
technology = 56/120 ECTS
4) PhD in chemistry:
specialization radiochemistry
= 20/180 ECTS
* for other students basics of
radiation, radioecology etc. at
BSc level

DEBRECEN UNIVERSITY (collaboration with Institute of Nuclear Medicine of the
university and the Institute of Nuclear Research of Hungarian Academy of Sciences)

Department of Colloid and Environmental Chemistry, Isotope and Environmental
Chemistry Group

Head of the department/group István Bányai/Noemi M. Nagy

Web pages http://dragon.unideb.hu/~kolloid/isotope/main_i.html

Tel. 3652512900/22263

Fax. 3652310122

Postal address Egyetem square 1. / Debrecen / Hungary, H-4010

Contact person: Ass. Prof. Noemi M. Nagy noemi@tigris.unideb.hu

MSc in Chemistry: BSc,
specialization (module) MSc
Radiochemistry = 30/120
ECTS
*basic radiochemistry courses,
radioanalytical chemistry at
BSc level

FOCUS of EDUCATION- NRC course topics (ECTS credits) Level

EÖTVÖS LORÁND UNIVERSITY, Budapest

Faculty of Science, Institute of chemistry, Department of Analytical Chemistry

(Laboratory of Nuclear Chemistry) <http://www.chem.elte.hu/en/main>

<http://www.chem.elte.hu/departments/magkem/eng/index.html>

Contact person: Prof. Zoltán Homonnay homonnay@para.chem.elte.hu

RADIOANALYTICAL BSc,
CHEMISTRY- MSc
nuclear chemistry,
radioanalytical chemistry,
nuclear methods with
applications in biology,
nuclear investigation methods,
radiation chemistry and
technology (total 17 ECTS)

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS (BME)

Faculty of Natural Sciences, Institute of Nuclear Techniques (INT), Department of Nuclear Techniques

<http://www.reak.bme.hu/en/home.html>

Contact person: Dr. Imre Szalóki szaloki@reak.bme.hu

radioactive waste, nuclear measuring techniques, radiation chemistry etc.

BSc,
MSc

1.12 ITALY

	FOCUS of EDUCATION-NRC course topics (ECTS credits)	Level
<p>UNIVERSITY OF MILAN (Università degli Studi di Milano) in collaboration with Istituto Nazionale di Fisica Nucleare Sezione di Milano (INFN) and Italian Society of Chemistry</p> <p>Laboratorio Acceleratori e Superconduttività Applicata Interdivisional, Group of Radiochemistry and Radiation Chemistry</p> <p>http://www.lasa.mi.infn.it/</p> <p>Head of the Group Prof. Mauro L. Bonardi</p> <p>Web pages http://www.GIR.mi.infn.it</p> <p>Tel. +39 02 503 19575 / 17257 / 19568</p> <p>Fax. +39 02 503 19543 / 17695</p> <p>Postal address V.le F.lli CERVI 201</p> <p>I-20090 Segrate, Milano, Italy</p> <p>Contact person: Prof. Mauro Bonardi</p> <p>Mauro.Bonardi@mi.infn.it</p>	<p>basic radiochemistry, radiopharmaceutical chemistry, environmental radioactivity (10 ECTS)</p>	<p>BSc, MSc</p>
<p>UNIVERSITY OF PAVIA</p> <p>Faculty of Mathematical, Physical and Natural Sciences, Department of chemistry</p> <p>www.unipv.eu;</p> <p>http://chimica.unipv.eu/site/home.html</p> <p>Head of the Department / Group Antonella PROFUMO</p> <p>Tel. xx39-0382-987334</p> <p>Fax. xx39-0382-528544</p> <p>Postal address Viale T. Taramelli, 12 I 27100 Pavia</p> <p>Contact person: Ass. Prof. Massimo Oddone massimo.oddone@unipv.it</p>	<p>radiochemistry (6 ECTS)</p>	<p>BSc</p>
<p>UNIVERSITY OF NAPOLI</p> <p>Faculty of Science, Department of Chemical sciences</p> <p>http://www.international.unina.it/</p> <p>http://chemicalsciences.unina.it/</p> <p>Contact person: Prof. Augusto De Renzi</p> <p>augusto.derenzi@unina.it</p>	<p>chemistry of radioisotopes</p>	<p>MSc</p>

1.13 THE NETHERLANDS

Dedicated NRC programme (NRC/total ECTS credits)

DELFT UNIVERSITY OF TECHNOLOGY

Faculty of Applied Sciences, Department of Radiation Science and Technology

<http://www.tudelft.nl/live/pagina.jsp?id=70f9805f-de88-4790-83dc-b5b04db554a6&lang=en>

Head of the Department prof. dr. H. Th. Wolterbeek

Postal address: Mekelweg 15, 2629 JB Delft

The Netherlands

Fax : +31 (0)15 278 3906

Contact person: Prof.

A.G.Denkova@tudelft.nl; H.T.Wolterbeek@tudelft.nl

1) MSc in Chemical engineering or Applied physics: specialization nuclear science and engineering = 30-70 /105 ECTS

1.14 NORWAY

Dedicated NRC programme (NRC/total ECTS credits)

NORWEGIAN UNIVERSITY OF LIFE SCIENCES, ÅS

Department of Plant and Environmental Sciences, Environmental Chemistry

<http://www.umb.no/ipm-en>

<http://www.umb.no/study-options/article/european-master-of-science-in-radioecology>

Head of the Department / Group Øystein Johnsen / Brit Salbu

Tel. +47 64965540

Fax. +47 64966007

Postal address P.O. Box 5003, NO-1432 Ås, Norway

Contact person: Ass. Prof. Lindis Skipperud

Lindis.skipperud@nmbu.no

1) EurMSc in radioecology = 90/120 ECTS
2) MSc in chemistry: specialization radiochemistry = 90/120 ECTS
3) PhD in chemistry: specialization nuclear and radiochemistry = 20-60/60 ECTS
* radiochemistry/radioecology also for other students at MSc level

UNIVERSITY OF OSLO, UiO

Department of Chemistry, Nuclear Chemistry Section

<http://www.kjemi.uio.no/english/>

<http://www.mn.uio.no/kjemi/english/research/groups/nuclear/index.html>

Head of the Department / Group D. of Chemistry head: Jo Døhl

Nuclear Chemistry Section head: Jon Petter Omtvedt

Tel. +47 228 55 446 (C. department), +47 957 83 857 (Omtvedt)

Postal address P.O. Box 1033 – Blindern

NO-0315 Oslo, Norway

Contact person: Prof. Jon Petter Omtvedt

j.p.omtvedt@kjemi.uio.no

1) MSc in chemistry: specialization nuclear chemistry=80-100/120 ECTS
2) PhD in chemistry: specialization nuclear chemistry = 40/50 (plus thesis 130) ECTS
* radioactivity and radiochemistry also at BSc level

	FOCUS of EDUCATION-NRC course topics (ECTS credits)	Level
UNIVERSITY OF BERGEN, UiB Faculty of Mathematics and Natural Sciences, Department of Chemistry Head of the Department / Group http://www.uib.no/en/kj Tel. +47 55 58 34 44 Fax: +47 55 58 94 90 Postal address Realfagbygget, Allégt. 41, N-5020 BERGEN Contact address: post@kj.uib.no	Radiochemistry and radioactivity (10 ECTS)	MSc

1.15 POLAND

	Dedicated NRC programme (NRC/total ECTS credits)	
MARIA CURIE SKŁODOWSKA UNIVERSITY (UMCS), LUBLIN Faculty of Chemistry, Department of Radiochemistry and Chemistry of Colloids http://www.umcs.pl/en/faculty-of-chemistry.2650.htm Head of the Faculty prof. dr hab. Stanisław Chibowski Tel. +48 81 537 56 02 Fax. +48 81 533 28 11 Postal address. M. Skłodowskiej - Curie 3 Sq. 20-031 Lublin, Poland Contact person: Academic teacher Elżbieta Grządka egrzadka@wp.pl	1) MSc in analytical chemistry: specialization radiochemistry * radiochemistry and radioisotopic techniques also at BSc level	
UNIVERSITY OF GDANSK Faculty of Chemistry, Chair of Analytical and Environmental Radiochemistry http://en.ug.edu.pl/ Head of the Department / Group Prof. Bogdan Skwarzec Web pages http://chem.arch.ug.edu.pl/en/ Tel. (48 58) 5235338; 5235416 Fax. (48 58) 5235472; 5235416 Postal address Sobieskiego 18/19 80-952 Gdańsk, Poland Contact persons: Prof. Bogdan Skwarzec bosk@chem.univ.gda.pl ; Dr. Dagmara Strumińska-Parulska strumyk@chem.univ.gda.pl	1) MSc in environmental protection: specialization radiochemistry 2) MSc in chemistry: specialization nuclear and radiochemistry 3) PhD in chemistry: specialization nuclear and radiochemistry	
	FOCUS of EDUCATION-NRC course topics (ECTS credits)	Level
UNIVERSITY OF WARSAW Faculty of Chemistry, Division of Physics and Radiochemistry, Laboratory of Radiochemistry http://en.uw.edu.pl/ ; http://www.chem.uw.edu.pl/ Head of the Department / Group Prof. Paweł Kulesza Web pages http://www.chem.uw.edu.pl/labs/lr.php?head=Laboratory%20of%20Radiochemistry Tel. +48 22 822 02 11 Fax. + 48 22 822 59 96 Postal address Pasteura 1 02-093 Warsaw, POLAND Contact person: Prof. Jerzy SZYDŁOWSKI jszydlow@chem.uw.edu.pl	nuclear chemistry, nuclear energy and radioactivity, radiopharmaceutical synthesis and its application in medicine, isotope effects (20 ECTS)	BSc, MSc

NICOLAUS COPERNICUS UNIVERSITY, Torun
Faculty of Chemistry, Department of Nuclear Chemistry
<https://www.umk.pl/en/>
<https://www.umk.pl/en/university/faculties/foch/>
<http://www.chem.uni.torun.pl/>
Contact person: Prof. Alexandre G. Chostenko chost@chem.uni.torun.pl

nuclear chemistry

BSc,
MSc

INSTITUTE OF NUCLEAR CHEMISTRY AND TECHNOLOGY, Warsaw
a) Centre for Radiochemistry and Nuclear Chemistry
b) Laboratory of Nuclear Analytical Methods
Head of the Department / Groups a) Jerzy Narbutt; b) Halina Polkowska-Motrenko
Web pages www.ichtj.waw.pl
Tel. a) +4822 504 1126; b) +4822 504 1078
Fax. +4822 811 1532
Postal address Dorodna str. 16 / 03-195 Warszawa / Poland
Contact person: Jerzy Narbutt j.narbutt@ichtj.waw.pl

coordination chemistry,
nuclear chemistry

MSc,
PhD

1.16 SLOVAKIA

Dedicated NRC programme
(NRC/total ECTS credits)

COMENIUS UNIVERSITY, BRATISLAVA
Faculty of Natural Sciences, Department of Nuclear Chemistry
<http://www.fns.uniba.sk/>
Head of the Department / Group Assoc. Prof. L. Matel, PhD.
Web pages <http://www.fns.uniba.sk/index.php?id=2389>
Tel. +421 60296397
Fax. +421 60296397
Postal address Mlynska dolina / 84215 Bratislava
Contact person: Prof. Pavol Rajec rajec@fns.uniba.sk

1) MSc in chemistry:
specialization Nuclear
Chemistry and Radioecology
= 100/120 ECTS
2) PhD in chemistry:
specialization Nuclear
Chemistry = 218/240 ECTS
* basic radiochemistry (I-II)
also at BSc level

**FOCUS of EDUCATION-
NRC course topics** (ECTS
credits)

Level

UNIVERSITY OF SS. CYRIL AND METHODIUS IN TRNAVA
Faculty of Natural Sciences
<http://fpv.ucm.sk/en/>
Department of Ecochemistry and Radioecology
<http://fpv.ucm.sk/en/department-of-ecochemistry-and-radioecology.html>
Head of the Department / Group Assoc. prof. Dr. habil. RNDr. Juraj Lesný, PhD.
Web pages <http://ker9.webnode.sk/>
Tel. +421 33 59 21 455
Fax. +421 33 59 21 403
Postal address Nám. J. Herdu 2
SK-917 01 Trnava, Slovak Republic
Contact person: Dr. Miroslav Horník hornik@ucm.sk

ENVIRONMENTAL RC-
nuclear chemistry,
nuclear analytical methods
and environmental analytical
chemistry etc. (25 ECTS)

BSc,
MSc,
PhD

TECHNICAL UNIVERSITY OF ZVOLEN
Faculty of Ecology and Environmental Sciences, Department of Environmental
Engineering <http://www.tuzvo.sk/en>
Contact person: Prof. Juraj Ladomerský ladomer@vsld.tuzvo.sk

ENVIRONMENTAL RC-
radioecology, nuclear
analytical methods

BSc,
MSc

1.17 SLOVENIA

	FOCUS of EDUCATION-NRC course topics (ECTS credits)	Level
<p>JOŽEF STEFAN INTERNATIONAL POSTGRADUATE SCHOOL, LJUBLJANA (in collaboration with J Stefan Institute, University of Nova Gorica, University of Ljubljana, University of Primorska) http://www.mps.si/splet/index.asp?lang=eng J Stefan Institute, Group for Radioecology Contact person: Dr. Borut Smodiš borut.smodis@ijs.si</p>	ENVIRONMENTAL RC-radioecology, radioactive and nuclear methods for the study of processes	MSc, PhD

1.18 SPAIN

	FOCUS of EDUCATION-NRC course topics (ECTS credits)	Level
<p>UNIVERSITY OF BARCELONA (Universitat de Barcelona) Faculty of Physics and Chemistry, Department of Analytical Chemistry http://www.ub.es/dqa/eng/index_eng.html Contact person: Prof. Montse Llaurado montse.llaurado@ub.edu</p>	radiochemical techniques	MSc
<p>UNIVERSITY OF GRANADA (Universidad de Granada) Faculty of Science, Department of Inorganic Chemistry http://qiserver.ugr.es/asignaturas.html Contact person: Prof. María Domingo García mdomingo@ugr.es</p>	radiochemistry	MSc

1.19 SWEDEN

	Dedicated NRC programme (NRC/total ECTS credits)
<p>CHALMERS UNIVERSITY OF TECHNOLOGY, Gothenburg Department of Chemistry and Chemical Engineering / Nuclear Chemistry and Industrial Materials Recycling http://www.chalmers.se/chem/EN/divisions/nuclear-chemistry Head of the Department / Group Prof. Christian Ekberg Fax. +46(0)31-772 29 31 Postal address Kemivagen 10 412 96 Göteborg Sweden Contact person: Ass. prof. Teodora Retegan tretegan@chalmers.se</p>	1) MSc in Nuclear Science and Technology: specialization Nuclear engineering = 75/120 ECTS 2) PhD in Chemistry: specialization Nuclear Chemistry = 60/60 ECTS

KTH ROYAL INSTITUTE OF TECHNOLOGY, Stockholm

The School of Chemical Science and Engineering, Department of Chemistry, Applied Physical Chemistry (Nuclear Chemistry)

Head of the Department Prof. Mats Jonsson

Web pages <https://www.kth.se/en/che/departments/chemistry>

<https://www.kth.se/en/che/divisions/tfk/research/djupforvar>

<https://www.kth.se/student/kurser/org/KD>

Tel. +46 8 790 9123

Fax. +46 8 790 8772

Postal address KTH Chemical Science and Engineering, Nuclear Chemistry, Royal Institute of Technology, SE-100 44 Stockholm, Sweden

Contact person: Prof. Mats Jonsson matsj@kth.se

1) MSc in Chemical engineering or Molecular Science and Engineering: “specialization” Nuclear chemistry = 52,5/120 ECTS
2) PhD in Chemistry: specialization Nuclear Chemistry

1.20 SWITZERLAND

	FOCUS of EDUCATION-NRC course topics (ECTS credits)	Level
UNIVERSITY OF BERN in collaboration with Paul Scherrer Institute (PSI) a) Department of Chemistry and Biochemistry, Radiochemistry Group http://www.dcb.unibe.ch/content/index_eng.html b) Paul Scherrer Institut, Laboratory for Radiochemistry and Environmental Chemistry http://www.psi.ch/lch/laboratory-of-radiochemistry-and-environmental-chemistry Head of the Department / Group Prof. Dr. Andreas Türler Web pages http://lch.web.psi.ch/ Tel. +41 56 310 2401 Fax. +41 56 310 44 35 Postal address CH-5232 Villigen PSI Contact person: Prof. Dr. Andreas Türler andreas.tuerler@psi.ch	nuclear and radiochemistry courses, seminar on radio- and environmental chemistry (>20 ECTS)	BSc, MSc, PhD
TECHNICAL UNIVERSITY OF ZURICH (Die Eidgenössische Technische Hochschule Zürich, ETHZ) Swiss Federal Institute of Technology Zürich, Institute of Pharmaceutical Sciences, http://www.chab.ethz.ch/index_EN http://www.radiochem.pharma.ethz.ch/ Contact person: Prof. Roger Schibli (ETHZ, PSI Villigen, University Hospital Zurich) roger.schibli@psi.ch	RADIOPHARMACEUTICAL CHEMISTRY radiopharmaceutical chemistry (also as a module under <i>European specialization certificate in radiopharmacy</i>)	MSc
UNIVERSITY OF ZURICH Department of Chemistry, Medicinal Inorganic Chemistry http://www.chem.uzh.ch/index.html Contact person: Prof. Roger Alberto ariel@aci.uzh.ch http://www.chem.uzh.ch/research/alberto.html	RADIOPHARMACEUTICAL CHEMISTRY radiochemistry, radiopharmaceutical, chemistry	MSc

1.21 TURKEY

	Dedicated NRC programme (NRC/total ECTS credits)	
<p>EGE UNIVERSITY, Izmir Institute of Nuclear Sciences Head of the Institute: Prof. Dr. Perihan UNAK Web pages: http://nbe.ege.edu.tr/en/ Tel. +90-232-3113434 Fax. +90-232-3113433 Postal address Institute of Nuclear Sciences, 35100 Bornova-Izmir, TURKEY Contact person: Prof. Dr. Perihan UNAK perihan.unak@ege.edu.tr http://akademik.ege.edu.tr/?q=tr/bilgiler&id=888</p>	<p>1) MSc in Nuclear Sciences: specialization Nuclear Technology or Nuclear Applications, 2) PhD in Nuclear Technology or in Nuclear Sciences (Nuclear Applications) * basic courses at BSc level</p>	<p>BSc, MSc, PhD</p>
	FOCUS of EDUCATION-NRC course topics (ECTS credits)	Level
<p>BILKENT UNIVERSITY, Ankara Science Faculty, Department of Chemistry http://www.fen.bilkent.edu.tr/~cvchem/ Contact person: Prof. Hasan Erten erten@fen.bilkent.edu.tr</p>	<p>nuclear and radiochemistry, environmental radiochemistry (15 ECTS)</p>	<p>MSc</p>
<p>MIDDLE EAST TECHNICAL UNIVERSITY (METU), Ankara Chemistry Department http://www.chem.metu.edu.tr/ Contact person: Prof. E. Hale Gokturk ghale@metu.edu.tr</p>	<p>nuclear analytical techniques</p>	<p>BSc</p>

1.22 UK

	Dedicated NRC programme (NRC/total ECTS credits)
<p>UNIVERSITY OF LOUGHBOROUGH Department of Chemistry, Environmental Radiochemistry Group Head of the Department / Group Professor Peter Warwick Web pages http://www.lboro.ac.uk/departments/cm/ Tel. ++44 (0)1509 2222550 Fax. ++44 (0)1509 223925 Postal address Department of Chemistry, Loughborough University, Loughborough, Leicestershire LE11 3TU Contact person: Dr. Nick Evans N.D.M.Evans@lboro.ac.uk</p>	<p>1) BSc/MChem in Chemistry: part radiochemistry</p>
<p>KING'S COLLEGE LONDON (in collaboration with Engineering and Physical Sciences Research Council EPSRC and industrial partners) Faculty of Life Sciences and Medicine, Division of Imaging Sciences and Biomedical Engineering, Department of Imaging Chemistry and Biology // EPSRC Centre for Doctoral Training http://www.kcl.ac.uk/lsm/research/divisions/imaging/departments/imaging/index.aspx www.imagingcdt.com contact person: Prof. Phil Blower philip.blower@kcl.ac.uk</p>	<p>1) MSc in Radiopharmaceutics & PET Radiochemistry = 90 ECTS</p>

	FOCUS of EDUCATION- NRC course topics (ECTS credits)	Level
<p>UNIVERSITY OF MANCHESTER in collaboration with University of Sheffield</p> <p>a) School of Chemistry b) NUCLEAR FIRST DOCTORAL TRAINING CENTRE Head of the Department / Group Christopher Whitehead/ Francis Livens/Nicholas Bryan Web pages http://www.chemistry.manchester.ac.uk/ http://www.chemistry.manchester.ac.uk/postgraduate/nuclearfirst Tel. +44 161 275 4647 Fax. +44 161 275 4598 Postal address Centre for Radiochemistry Research / The University of Manchester/ School of Chemistry/ Manchester M13 9PL / UK Contact person: Prof. F.R. Livens francis.livens@manchester.ac.uk</p>	<p>nuclear and radiochemistry; broad variety of NRC courses under doctoral training programme</p>	<p>BSc; PhD</p>
<p>UNIVERSITY OF SOUTHAMPTON http://www.southampton.ac.uk National Oceanography Centre Southampton University of Southampton's Geosciences Advisory Unit (GAU) Head of the Group Prof. Ian Croudace Web pages http://noc.ac.uk/science-technology Postal address University of Southampton Waterfront Campus European Way Southampton SO14 3ZH United Kingdom Contact person: Dr. Phil Warwick phil.warwick@noc.soton.ac.uk</p>	<p>ENVIRONMENTAL RADIOCHEMISTRY- environmental radioactivity and radiochemistry (7.5 ECTS)</p>	