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TECHNICAL ASSISTANCE AND KNOW HOW TRANSFER TO CENTRAL ASIAN COUNTRIES IN THE ENVIRONMENTAL REMEDIATION OF ULS: CURRENT STATE, OUTLOOK AND LESSONS LEARNED

Christian Kunze[1], Jürgen Hartsch[2], Thomas Metschies[3], Peter Schmidt[3], Lars Uhlig[4], Falk Wagner[4], Uwe Walter[4]

Abstract: Environmental remediation of uranium legacy sites (ULS) in Central Asia has attracted international attention for more than 15 years. In the past, activities have mainly focused on the early stages of the life cycle of environmental remediation, such as site characterisation, risk analysis, definition of remediation strategies and end states, engineering design, and environmental/social impact assessment. Rapid risk mitigation and temporary remediation measures have also been implemented.
With the creation of the Environmental Remediation Account (ERA) at the EBRD, major remediation measures can now be implemented with secure funding for the coming years.
Know-how-transfer from benchmark projects such as Wismut have played a major role in building confidence that ULS in Central Asia can be successfully remediated in line with international standards, while being compatible with local conditions. Know-how transfer will remain an important component of any remediation activities in the future, and will focus on the following: (1) to enable the authorities to enforce regulations in the implementation of remediation works, and (2) to equip local contractors with the necessary knowledge and understanding of radiation protection, health, safety, and environmental/stakeholder management.
The authors have been involved in most of the projects at ULS in Central Asia funded by the World Bank Group's International Development Agency (IDA), the EU's Instrument for Nuclear Safety Co-operation (INSC) and others. This contribution gives an overview of the history of remediation planning in Central Asia under international programs, achievements to date, current activities and, finally, an outlook to ongoing and future tasks such as the implementation of a Project Management Unit that co-ordinates remediation activities at four sites in Kyrgyzstan and Uzbekistan, monitoring and construction supervision, and, importantly, know-how transfer to the Beneficiary countries.

Kurzfassung: Die Sanierung von Uranbergbaualtlasten in Zentralasien genießt seit mehr als 15 Jahren erhöhte internationale Aufmerksamkeit. In der Vergangenheit konzentrierten sich die Aktivitäten auf die Vorbereitungsarbeiten der Umweltsanierung, wie Standortcharakterisierung, Risikoanalyse, Definition von Sanierungsstrategien und Sanierungszielen, Sanierungsplanung und Umwelt-/Sozialverträglichkeitsprüfung. Teilweise wurden provisorische Sanierungsmaßnahmen zur Gefahrenabwehr umgesetzt.
Mit der Einrichtung des Umweltsanierungsfonds der EBRD können in den kommenden Jahren prioritäre Sanierungsmaßnahmen auf gesicherter Finanzierungsgrundlage durchgeführt werden.
Der Know-how-Transfer aus erfolgreichen Projekten wie z. B. der Wismut GmbH hat maßgeblich das Vertrauen gestärkt, dass Uranbergbaualtlasten in Zentralasien in Übereinstimmung mit internationalen Standards und an die lokalen Bedingungen angepasst saniert werden können. Der Know-how-Transfer wird auch in Zukunft ein wichtiger Bestandteil aller Sanierungsarbeiten sein und sich auf Folgendes konzentrieren: (1) Durchsetzung von Umwelt- und Sozialstandards bei Sanierungsarbeiten durch die Behörden und (2) Ausstattung aller an der Sanierung Beteiligten mit dem notwendigen Wissen und Verständnis für Strahlen- und Gesundheitsschutz, Sicherheit und Umwelt-/Stakeholder-Management.
Die Autoren waren an der Mehrzahl der Projekte zur Uranbergbausanierung in Zentralasien beteiligt, die unter anderem von der Weltbank/IDA und EU/INSC finanziert wurden. Dieser Beitrag gibt einen Überblick über die Geschichte der Sanierungsplanung in Zentralasien, die bisherigen Ergebnisse, aktuelle Aktivitäten und laufende bzw. zukünftige Aufgaben wie die Einrichtung einer Projektmanagementeinheit, die die Sanie-

1 IAF – Radioökologie GmbH, Radeberg, Germany, www.iaf-dresden.de
2 GEOS Freiberg Ingenieurgesellschaft mbH, Freiberg, Germany, www.geosfreiberg.de
3 Wismut GmbH, Chemnitz, Germany, www.wismut.de
4 WISUTEC Umwelttechnik GmbH, Chemnitz, Germany, www.wisutec.de

rungsaktivitäten an vier Standorten in Kirgisistan und Usbekistan koordiniert, Monitoring und Bauüberwachung sowie vor allem den Know-how-Transfer in die Zielländer.

Introduction

Environmental remediation (ER) of uranium legacy sites (ULS) in the former Soviet republics of Kyrgyzstan (KG), Kazakhstan (KZ), Tajikistan (TJ), and Uzbekistan (UZ) in Central Asia has gained increasing international attention since the early 2000's. When the New Scientist raised concerns over "millions threatened" by former uranium mines (New Scientist 2002), and the Blacksmith Institute listed Mailuu Suu (KG) as "one of the world's ten worst polluted sites" (Blacksmith Institute 2006), funding of ER related activities in Central Asia significantly gathered momentum, even though with hindsight the alarmist tone may be questioned.

The overwhelming proportion of ER related activities have been funded by international organisations, including but not limited to, the International Development Agency (IDA, World Bank Group), the European Commission (EC), the International Atomic Energy Agency (IAEA), the United Nations' Development and Environment Programs (UNDP and UNEP, respectively), the Organisation of Security and Cooperation in Europe (OSCE), the Environment and Security Initiative (ENVSEC) and others.

Activities related to ULS in Central Asia can broadly be subdivided into the following categories:

- Engineering projects, partly followed by implementation of remediation works
- Technical support
- Regulatory support
- Awareness raising, public information, and stakeholder involvement
- Networks and information exchange initiatives.

In practice there are many overlaps between these categories, and the lines between them are blurred. For example, virtually all engineering projects include strong elements of stakeholder involvement and awareness raising.

One of the key objectives of most projects has been to develop expertise in the Beneficiary countries so that, in future, ER activities can be managed by local experts with minimum input by international consultants. In order to achieve this goal, know-how transfer has played a key role in most activities under international funding.

The authors of this contribution have been involved in ER related projects in Central Asia since 2005. In fact, they have been part, in one form or another, of most World Bank and EC funded projects in this field, and in several initiatives under the aegis of the IAEA and other international organisations. An updated overview of major projects that have been implemented to date will be presented in the next Section. Based on the personal experience and views of the authors, the following Section will then turn the focus to achievements and challenges of know-how transfer in the field of ER to Central Asian countries. We attempt to critically and candidly review what works best, and which approaches may need to be modified in order to increase effectiveness. The final Section provides an outlook on ER related activities in Central Asia in the years to come. This paper builds upon earlier reports of the authors on ER activities at Central Asian ULS (Schmidt et al. 2006, 2009; Kunze et al. 2007, 2011, 2015; Kunze 2016, 2018; Kunze and Walter 2015).

Overview of international projects related to environmental remediation of ULS in Central Asia since the early 2000's

Engineering projects

In general, remediation of the ULS in Central Asia follows the standard methodology described in WS-G-3.1 (IAEA 2007), i.e., starting from thorough site characterisation, followed by an assessment of the current risk and the definition of the desired end state of the site, and an iterative process of identification, assessment, selection and optimisation of remediation options.

A major and very valuable effort under an EU TACIS project (SCK-CEN 2003) to characterise the Mailuu Suu (KG) site in the early 2000's was followed by the Disaster Hazard Mitigation Project funded by IDA between 2005 and 2013 (World Bank 2013). It included refined geotechnical characterisation of several tailings management facilities (TMF) and development of rapid risk reduction measures. These measures focused on riverbank strengthening to prevent erosion of radioactive mining waste, relocation of some waste rock dumps (including management of involuntary resettlement of a family from waste dump #5 that had to be relocated), and culminated in the relocation of TMF #3 to the engineered storage cell on TMF #6, due to the inherent geotechnical and landslide hazard of the former.

Funded by the Instrument for Nuclear Safety Cooperation (INSC) of the EC, 4 major engineering projects have been implemented at the following ULS:

- Yangiabad and Charkesar 1 (UZ), 2013-2015, INSC Project UZ4.01/10
- Min-Kush and Shekaftar (KG), 2015-2017, INSC Project KG4.01/11-12
- Taboshar and Degmay (TJ), 2015-2018, INSC Project TJ 4.01-02/11
- Mailuu Suu (KG), 2017-2020, INSC Project KG 4.01/14 (on-going).

These four projects are very similar in their objectives and structure. The main deliverable of each of these projects is a comprehensive engineering design including fully costed Bills of Quantity (BoQ) for each of the sites. The scope of work also includes an environmental impact assessment of the proposed remediation measures, the development of a dosimetry, environmental monitoring and surveillance programs for the remediation phase and the after-care period, and stakeholder engagement activities. Modifications of the standard project structure to address site-specific conditions include the development and installation of an Early Warning and Landslide Monitoring System in Mailuu Suu under INSC Project KG4.01/14, and the design of a mine water treatment plant at Taboshar (INSC Project MC4.02/13A, 2016-2019).

Table 1 below summarises the proposed remediation measures developed under the INSC programme for six sites (note: remediation measures at Mailuu Suu are currently being specified by a consortium led by WISUTEC, however, a cost estimate was included in the Strategic Master Plan based on preliminary assumptions).

Tab. 1 Remediation measures proposed for seven sites in KG, UZ, and TJ, ready for tendering, and cost estimates (IAEA, EC 2017).

Site	Estimated cost (€ m)	Comments
Mailuu-Suu (KG)	29	Best estimate in the Strategic Master Plan, remediation strategy and cost are currently being specified under INSC project KG4.01/14
Min-Kush (KG)	4.1	Closure of seven shafts/adits and seven sinkholes; demolition of two bunkers and a mill with in situ disposal; drainage, discharge or diversion of water at three waste rock dumps
Shekaftar (KG)	3.5	Closure of six shafts and relocation of five waste rock dumps to more remote location
Degmay (TJ)	25	Removal of tailings pipeline, placement of cover on tailings facility, excavation of smaller contaminated areas around the TMF, dam toe buttress and flattening of dam, placement of cover on TMF body and dam to ensure erosion protection and prevent access to radioactive material, surface water diversion ditch, monitoring wells upstream and downstream of TMF
Taboshar/Istiqlol (TJ)	13	Excavation of areas with high gamma dose rate, dykes/berms and warning signs around open pit, concrete slabs, plugs, concrete walls or steel gates at shafts and adits, possibly backfill using crushed rock, demolition of buildings and infrastructure, partly relocation and/or concentration of waste rock dumps, not including water treatment facility
Charkesar 1 (UZ)	0.6	Closure of two shafts, one adit and five sinkholes; demolition of abandoned buildings; cleanup of small heaps of leached ore
Yangiabad (UZ)	6.3	Closure of four shafts, 23 adits and eight sinkholes; demolition of abandoned buildings and processing facilities; discharge channels for surface water; river bank protection; relocation of several waste rock dumps; and a storage cell for contaminated material
Total	**81.5**	

In 2015, the Environmental Remediation Account (ERA) for ULS in Central Asia was set up by the EBRD at the initiative of the EC (EBRD, no date). The objective of the ERA is to pool donor funds to assist the Kyrgyz Republic, Tajikistan and Uzbekistan to remediate priority sites in these countries. Implementation of the remediation works is managed by a Project Implementation Unit (PMU), which was set up in February 2019 for the remediation works in Kyrgyzstan. The PMU involves an international consultant organisation that assists the national implementing authority (in the case of Kyrgyzstan, this is the Tailings Management Agency under the Ministry of Emergency Situations). An important component of the international PMU consultant is know-how transfer in the following areas:

- Technical fundamentals (uranium legacy sites, radiation physics, remediation options)
- Roles and responsibilities of regulatory body, national/international regulations, guidance and their enforcement

- Safeguards, Environmental and Social Impact Assessment, occupational health, safety, and radiation protection, environmental and social management
- Stakeholder engagement, grievance mechanisms
- Monitoring and environmental information data management
- Environmental remediation planning and works implementation, construction supervision
- Emergency preparedness and response.

During the pledging conference in London on 9 November 2018 pledged funds rose by more than € 10m (EBRD 2018) to approximately € 30m. However, there is still a funding gap of € 50 m (EC 2019).

Apart from programmes of "western" organisations, there is an Intergovernmental Programme of Russia and several Central Asian countries (Rosatom 2018) to remediate mine waste facilities at selected ULS, including Min-Kush (KG) and Taboshar (TJ). Duplication with EC-funded activities at those sites has been minimised by clearly delineating the scope of work under each of the programmes.

Technical and regulatory support projects

Apart from the engineering projects that primarily aim to produce design documents for remediation works, there is a wide range of projects mainly funded by international organisations that are intended to provide additional technical and regulatory support to the beneficiary countries in a broad range of disciplines. A few are mentioned in the following for illustration, without claiming completeness:

Between 2006 and 2008, the Federal Agency for Geosciences and Resources of Germany (BGR) carried out a comprehensive survey of the seepage, groundwater, surface and drinking water quality in the Mailuu Suu region. This effort produced quality data that are a key input to the hydrogeological baseline characterisation of the ULS under INSC project KG4.01/14 (see above).

The EC INSC project "Establishment of a legislative and regulatory framework, regional watershed monitoring system and capacity building for remediation of uranium mining legacy sites in Central Asia" (REG4.01/10, 2014-2017) covered a multitude of activities ranging from regulatory support, to the establishment of a transboundary monitoring system and an environmental information system, to capacity building in the field of chemical and radiological analyses. Know-how transfer was an essential part of the project.

The project Transboundary Monitoring of Pollution after Natural Disasters (TRANSPOND 2017-2020, implemented by IAF, WISUTEC, and the University of Applied Sciences of Magdeburg-Stendal) is funded by the Federal Ministry of Education and Research of Germany (BMBF). It includes a strong hands-on component to introduce simple, reliable and robust laboratory methods to determine the transport of radionuclides in transboundary watercourses between Kyrgyzstan and Uzbekistan, and a ready-to-use environmental information system that can be jointly used by both countries (Kunze et al. 2018).

The project "Development of a UAV (Unmanned Aerial Vehicle)-based Gamma spectrometry for the Exploration and Monitoring of Uranium Mining Legacies" (DUB-GEM 2019-2022, implemented by BGR, IAF and Third Element Aviation) is also funded by BMBF (BGR 2019). Its objective is the joint development and field test activities in Kyrgyzstan, Uzbekistan, and Kazakhstan. This will allow Central Asian countries to rapidly and cost-efficiently survey ULS with high spatial and energy resolution, compared to conventional walk-over surveys and manual sampling on one hand, and helicopter flyovers on the other.

Wismut GmbH is currently assisting the Agency for Tailings Management under the Kyrgyz Ministry of Emergency in the use of equipment for in-situ monitoring at ULS. The project is fun-

ded by the IAEA and will be completed 2021. It includes training courses, joint field measurement campaigns and practical work at calibration facilities at Wismut sites.

Since 2008, the Norwegian Radiation Protection Authority (NRPA) has collaborated with Central Asian countries to improve the regulatory basis for management of wastes from the former uranium production industry, in order to harmonize it with the IAEA Safety Standards and other international recommendations on good practices (NRPA 2018).

Related networks, initiatives and projects

There are various international organisations that are actively involved in ER projects in Central Asia. For example, through the Coordination Group for Uranium Legacy Sites - CGULS (IAEA-CGULS, no date), the IAEA supports a network of national and international organizations and institutions concerned with the remediation and the safe management of residues at ULS, most of which are located in Central Asia. CGULS comprises the IAEA, the European Commission, the Commonwealth of Independent States and the European Bank for Reconstruction and Development. Germany, Norway, France and Belgium as well as other Member States support the Group. On behalf of the EC, CGULS also carries out the peer review of deliverables prepared under the INSC-funded engineering projects (see above), engaging a team of independent experts. This raises the profile of the proposed remediation projects and helps build confidence in the international donor community, e.g., within the EBRD's ERA, that proposed remediation measures are realistic and comply with international best practice.

Similarly, the Network of Environmental Management and Remediation of the IAEA (Environet) brings together ER experts from all over the world, with a strong presence of participants from Central Asia. Environet is a platform that was created to inspire countries to share their knowledge and experience as well as to promote and facilitate collaboration (IAEA-Environet, no date).

Over many years, the IAEA has provided Central Asian countries with high-quality hardware, such as environmental monitoring, laboratory and radiometry equipment (e.g., gamma spectrometers). Recently there has been increasing attention to the practical use of the equipment by the recipient organisations, including hands-on training of operators, so that the delivered goods can actually be put to beneficial uses for the recipients.

Mainly through support from the IAEA, since 2005 more than 30 experts from Central Asia have received training at Wismut sites on topics such as site characterisation, remediation planning and implementation, environmental monitoring, dosimetry, water treatment, and others.

The national and local Aarhus Centers of Central Asian Countries, under the aegis of the OSCE (OSCE, no date), have been active for several years in the organisation of awareness-raising and training events for local experts, both in the technical and social/socio-economic sphere. Aarhus Centers are closely involved in stakeholder engagement activities that accompany engineering-focused projects.

Know-how transfer to Central Asian Beneficiary countries: Achievements and Challenges

Within the scope of the nearly all projects and initiatives that are outlined in above, there have been significant efforts of know-how transfer to Central Asian Beneficiary countries over the last 15 years. However, no comprehensive assessment of the effectiveness of all those measures, let alone of potential synergies and/or duplications, has been carried out to date, to the authors' best but restricted knowledge. Therefore, it may be worthwhile to provide a subjective perspective,

based on anecdotal evidence from dozens of training courses both in Central Asia and Europe, and collaboration with local experts in the Beneficiary countries.

Achievements

Looking back to the beginnings of ER project activities in Central Asia in the mid-2000's, it is easy to see significant progress in theoretical knowledge and practical experience acquired by Central Asian experts, that can be directly attributed to the continuous awareness raising, know-how transfer and training measures within the projects and other activities described above. This holds for staff of governmental organisations as well as for personnel of commercial contractors that have been involved in biophysical and social/socio-economic surveys, modelling of environmental impacts, engineering design, and other technical tasks.

Examples to support this statement include, but are not limited to, the following:

- New radiochemical methods for nuclide analyses have been successfully adopted under the TRANSPOND project. They help increase the monitoring capabilities of local laboratories in Kyrgyzstan and Uzbekistan making best use of limited financial resources.
- The PMU for the implementation of remediation works in Kyrgyzstan under the EBRD ERA has recruited local experts who have acquired substantial ER-related knowledge over the last years through various training events provided by the IAEA and under the INSC projects.
- Extensive training opportunities have been offered to Central Asian experts under some of the INSC projects. Each of the five INSC engineering projects listed above included at least two intense workshops in Western Europe for representatives of all relevant regulatory authorities. The purpose of these workshops was to train participants in using the methodologies, approaches to solving technical and socio-economic problems at ULS, take decisions on remediation strategies jointly and to enable participants to defend decisions taken in their home countries, regions and communities. These workshops have helped increase in-country support for the engineering solutions developed under each of the projects.
- During the UNEP/UNDP "train-the-trainer" courses in Kyrgyzstan and Tajikistan (UNDP, no date), 9 and 11 trainees, respectively, received intensive training on technical as well as socio-economic aspects of uranium legacy sites and have successfully passed exams that included realistic case studies. They will, in turn, disseminate the acquired knowledge within their organisations and communities.

These examples are very encouraging and demonstrate that training and know-how transfer have fallen on fertile ground. Many more examples would be worth mentioning but must be omitted here for lack of space.

Challenges

The ultimate benchmark of know-how transfer in the field of ER is how well the recipients are able to conceptually prepare, plan, and manage an ER project on their own. On one hand, considerable resources, both personal and financial, have been spent on know-how transfer. On the other hand, there is still some way to go until the desired goal is reached. There are a few observations and barriers that are briefly discussed in the following, based on anecdotal evidence of the authors' many years working in Central Asia:

- ER of ULS was a niche in Eastern Germany when ER landmark projects such as Wismut were initiated. It took years for the authors of this paper to acquire the knowledge and experience required to successfully lead ER projects. It is not surprising then that experts

in Central Asia are going through the same learning curve, which does take time and requires patience.

- Pay rates in the public sector where most of the Central Asian ER experts are employed are often miserably low. Staff from the public sector are attracted to better-paid jobs in private businesses that are often unrelated to ER, or altogether to much better paid positions abroad. When trained people leave the organisation, it takes a new hire to train again and close the gap.
- Experts from Central Asia tend to be overwhelmed by the sheer size of western ER projects, both in terms financial and physical. The billions of euros or dollars that are spent on ER of uranium mining legacies in Germany or the US may sound impressive, but often they intimidate and discourage people with more modest financial resources. In a sense, Central Asian experts often associate the transferred know-how with something that is unachievable for them anyway.
- Since the IDA funded DHMP in Mailuu Suu (KG), some temporary protection measures by the Geneva-based FSD on tailings no. 1-9, Buston (TJ), in 2013-14 (IAEA, EC 2017) and preparatory roadworks by Rosatom at Min-Kush (KG) (Rosatom 2018) that are currently delayed, no visible large-scale remediation works have been implemented to date. This has led to some fatigue and made efforts to learn and use the acquired knowledge less attractive.
- There seems to be a tendency among beneficiary organisations in Central Asia to rely on full-service packages provided by international organisations. This is contrary to the objective that beneficiaries should develop strong ownership and pride of project results, or learn from mistakes to avoid them in future. To be fair, this attitude has been nurtured by the funding agencies and consultants themselves in an attempt to run projects smoothly, avoid conflicts and stay within very short time frames that simply do not allow for trials and errors by local experts that would be so important in a learning process.
- While there are marked differences between countries and organisations, senior staff of Central Asian organisations are more likely to be sent to international conferences, workshops or training courses than lower ranks at the operational level. At the same time, the authors have observed that people at lower levels in an organisation are often more motivated to learn and grasp professional development opportunities than the higher echelons who take trips to Europe (with the associated benefits) for granted. This can have discouraging effects on those who do the legwork and whose commitment and enthusiasm is essential for the success of ER strategies.
- Finally, language barriers are probably the greatest barrier to know-how transfer. Most of the literature, offline and online training materials, equipment manuals, and communication in the international ER community are in English. While most of the barriers listed above are beyond control of the individual experts, improving one's language skills can be done at an individual basis.
- In the meantime, the availability of Russian-speaking experts in international consultants' teams is an essential asset for the success of training and know-how transfer.

Based on these observations, tentative proposals for three priority steps to make know-how transfer to Central Asia in the field of ER of ULS more lasting and effective are developed in the following:

- Avoid sophisticated technical approaches, even if they would be standard in Western countries. Simple technical solutions lower the barriers and make it more likely that they are actually implemented.
- Operational staff should be selected for training. Higher ranking officials in organisations should nominate motivated staff members to attend workshops, conferences etc.

- Trainees should try much harder than in the past to learn English, which is the only way to get access to a broader body of training materials, know-how, and exchange with the international community.

Conclusions and outlook

As can be seen from the previous sections, an impressive number of international activities have unfolded in the past 15 years to remediate ULS in Central Asia. The global community has provided substantial resources, and significant achievements towards remediation of the ULS are visible. It is important to note that many of these activities have been continuous instead of one-off.

In the foreseeable future, the authors expect that the following will be achieved in relation to ER of ULS in Central Asia:

- Completion of INSC Project Mailuu Suu (KG4.01/14), resulting in a remediation strategy agreed with all relevant stakeholders, engineering designs and an EIA that will successfully pass regulatory review and permitting in KG, so that the works can be tendered, contracted, and executed
- Implementation of the remediation works at Min-Kush and Shekaftar (KG) under the EBRD ERA, with completion of works anticipated until 2022
- Set-up of the PMU in Uzbekistan and start of the implementation of remediation projects at Yangiabad and Charkesar 1 under the EBRD ERA
- Successful development of terrestrial and airborne radiation monitoring, and environmental information management in KG and UZ under the TRANSPOND and DUB-GEM projects by 2020 and 2022, respectively.
- Know-how and training activities will continue, taking the lessons learned into account, as described above.

Most importantly the EBRD ERA will be a great opportunity for the global donor community and the beneficiary countries to demonstrate that ER does work and can be successfully implemented at ULS in Central Asia.

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