CHARACTERIZATION OF U-PRODUCTION RESIDUES, CONTAINING HIGH ACTIVITY CONCENTRATIONS OF TH-230 AND RA-226 AT THE FORMER PCHP U-PRODUCTION LEGACY SITE IN UKRAINE

Tetiana Lavrova, Oleg Voitsekhovych, Sergey Todosiienko

Ukrainian Hydrometeorological Institute, Department of Environment Radiation Monitoring
Ukraine, Kiev

lavrova@uhmi.org.ua
o.voitsekhovych@gmail.com
Background

“Pridneprovsky Chemical Plant” (PChP) in Dneprodzerzhinsk is legacy of U-production facilities in Ukraine where the ambitious State Remediation program is under development.

Large area (100 ha) with gamma dose rate > 0.5 µSv/h

5- high contaminat. buildings (1 µSv/h -1 mSv/h)

Several U-tailings and number of “hot spots”

Several ponds containing high contaminated sludge (U-238, Ra-226, Th-230)

High chemical pollution of soils and groundwaters
Spatial distribution of gamma dose rate at the territory of the former "Pridneprovsky Chemical Plant"

DESIGNATIONS

- "Ferrexpo" LLC
- "Banner" State Enterprise
- "Zincorium" State Enterprise
- Fertilizer Plant CJSC (DZMU)
- "Smoly" State Enterprise
- "UCRO" LLC
- Specialized physical security service enterprise № 38

- Tailings
- Border of 50 m sanitary zone
- Borders between northern and southern sectors of the industrial site
- Railway

This map has been prepared using the gamma dose rate surveys carried out during 2010-2013 with financial support of ENVIPRO II project (Ukraine - EU/USA Cooperation Program) and was updated by the new gamma dose survey results obtained during 2015-2016 in the frame of EC UA 00710 project.
Specific features of the Site contamination

- Large amount of radioactive residues containing high activity of Uranium, Th-230 and Ra-226 are still containing in the tanks and equipment.
- Large amount of U-production residues in fine dispersed materials are presents in spills near some apparatus and leaked pipelines inside of the most contaminated buildings and at the territory.
- High activity concentrations of Th-230 and Ra-226 (from 10-50 Bq/g to 400-600 Bq/g) were identified in many places of Buildings #103, #104, 2b and also in the sludge materials.
- The characteristics of Uranium, Th-230 and Ra-226 in the different buildings and surrounding environment (soils, aerosols, river water and groundwater) are versus of type of the U-and Th containing Ores and also technology used at the PChP industrial site.
- This study is part of site characterization and remediation planning.
U-extraction technology used for different type of U-ores

U-ore residues from extraction of mineral materials from UA and countries of CIS, Bq/g

<table>
<thead>
<tr>
<th>U-238</th>
<th>Th-230</th>
<th>Ra-226</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4-3.5</td>
<td>40-600</td>
<td>1.5-22.0</td>
</tr>
</tbody>
</table>

Residues from extraction of the Phosphate U-Ore (Kazakhstan), Bq/g

<table>
<thead>
<tr>
<th>U-238</th>
<th>Th-230</th>
<th>Ra-226</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-3200</td>
<td>10-150</td>
<td>10-1700</td>
</tr>
</tbody>
</table>

Diagram:
- Uranium Ore from UA,
- Base S storage
- Ore warehouse Building 1
- Crusher (2 stages) Building 2, 3
- Wet grinding Building 4, 5
- Pulp thickening Building 28

Phosphate-Uranium Ore from Kazakhstan
- Base S storage
- Ore warehouse Building A
- Wet grinding, re-pulping Building 1B
- Leaching, sorption, desorption, neutralisation Building 2B, 2B, 2E
- Thorium removal Building 104
- Rare earths concentrates Building 95
- Nitrofos Building 77
- Phosphogypsum to tailings facility

Extraction, re-extraction, filtration, calcination Building 103
- Pulp to tailings facility
- U₃O₈
Analytical laboratory UHMI includes

High efficient gamma, alpha and LLC spectrometry devices as well as basic radiochemical and environment sample preparation facilities
Environmental samples measurement

Gamma – Spectrometry

- 4 HPGe Semiconductor Detectors 
  Type - GEM, GWL, GMX – ORTEC, BE5030 - CANBERRA

  Measurement: $^{234}$Th (238U), $^{230}$Th, $^{235}$U, $^{226}$Ra, $^{228}$Ra, $^{210}$Pb, $^{228}$Th, $^{40}$K, $^{137}$Cs, $^{241}$Am and ets.

  The calibration: by the soil standard sample SRM (IAEA-434), IAEARGU-1 and IAEA-RGTh-1

Alpha Spectrometry

- U-238, 234, Th-232, 230, 228 and Po-210

LS Spectrometry

- Gross alpha-, beta-activity, 
  U-238+ 234, Ra-226
Simplified methods for U-Th series radionuclides determination in waters (UMF-2000, and LLC)

UMF-2000
V - 0.5 L,
Tracer $^{232}$U - 0.135 Bq
$\tau = 12000$ s

$^{238}$U, 4198 keV
$^{234}$U, 4773 keV
$^{232}$U, 5320 keV

CEA-01
V - 0.5 L,
Tracer $^{232}$U - 0.135 Bq
$\tau = 15000$ s

$^{238}$U, 4198 keV
$^{234}$U, 4773 keV
$^{232}$U, 5320 keV
Complex of U-containing ore materials milling, grinding, settling purification and final U-extraction-calcination (Building 103) and Th-extraction and purifications (Buildings 2b and 104)
Detailed gamma survey was supported by EC-UA partnership project
Specific Feature of radiological hazards in the Building 104 is high specific activities of Th-230 identified in the spill and extraction columns.

Data UHMI & Ecomonitor, 2016

<table>
<thead>
<tr>
<th>Samples</th>
<th>Activity concentration, Bq/g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pb-210</td>
</tr>
<tr>
<td>S104-01</td>
<td>19.3</td>
</tr>
<tr>
<td>S104-02</td>
<td>0.8</td>
</tr>
<tr>
<td>S104-07</td>
<td>21.4</td>
</tr>
<tr>
<td>S104-09</td>
<td>30.8</td>
</tr>
</tbody>
</table>

Specific reference activity concentration levels for (U-Th decay series) -- Th-230 – 1 Bq/g μSv/h
Radiological Hazards containing materials with high activity concentrations of U, Ra-226 and Th-230 around sludge ponds

Selected “hot spots” to be removed around ponds 230 and 220
Sludge materials in sedimentation pond 230 (cell 12) are highly contaminated by Th-230 (15-240 Bq/g) and toxic metals (Arsenic). Other materials in the pond 220 can be released from regulatory control.
Dredging of the bottom sediment in Konoplyanka river may significantly improve ecological situation at the surrounding areas.
Contaminants from the PChP ULS Inlet to the River Konoplyanka and mainly deposited in the bottom sediment Contaminated water inflow to the Dnieper reservoir
Dniepr reservoir has accumulate contaminants from PChP site. Impact of the PChP site via aquatic pathways are very low.
The State Program (2016-2017) is under implementation

The program is developed to provide Safe management at the legacy site, to support functions of the SE “Barrier” (Operator) ensure its functions such as:

- Site Safety management (radiological and non-radiological), –surveillance and monitoring
- Preparedness to further and ongoing remediation activities to be implemented in the frame of EC projects (2017-2020)
- Provision security and Radiation protection at the site
- Coordination and support of the site investigation and actions for remediation strategy planning (national and international)
- Public communication and data management
In the Frame of EC project planned for 2017-2018 the Emergency Measures to Improve Safety and Stability at the most contaminated facilities will be implemented. The tasks are following:

To fix or collect high contaminated dispersed materials in the buildings of the former U-extraction facilities (103 and 104)

To stabilize the most contaminated buildings (sealing windows and walls), Repair tailings covers, decontaminate some hot spots, establish fences and more strict radiation protection control actions.

- It may help significantly reduce the immediate radiological risk until implementation of remediation actions (including establishment of boundaries)
- To raise awareness on and near the site about the conditions of the site and measures to mitigate the risk.
Specific tasks to be implemented

- Development of special enterprise for decontamination, recycling and possible re-processing of the wastes to be generated during remediation
- Vacuum and wet decontamination techniques may be used and tested for its possible application for selected premises which high contaminated by dispersed residues and spills.
- Decontamination technologies used in EU and USA for clean-up and radioactive waste management of the high contaminated (U-Ra) dispersed materials
Acknowledgement

We appreciate very much to EC funds making possible to complete basic site characterization studies in the frame of EC-UA U4.01/10G also project partners (FACILIA AB, WISMUT GEO), JSO-UA) as well as Ministry of Energy and Coal Industry and Regulatory body of Ukraine on deep concern and efforts to support this study. Also we appreciate IAEA for sufficient consulting and financial support making possible to present this report on the NORM Symposia

Thank you very much with hope on further cooperation to be developed