MENV PRO

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The Environmental Science Education for Sustainable Human Health

in commemoration of Professor Armen Saghatelyan

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Environmental Radiation Protection
Radionuclides of Natural and Artificial Origin

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10 September 2021 – Friday

ENVIPRO

“Environmental Radiation Protection” module for Environmental Protection and Nature Management profession

This curriculum designed by O. Belyaeva and F.P. Carvalho

4 ECTS, 120 hours

Course goal is to develop students' knowledge about natural and artificial radioactivity, application of radioactive materials and environmental consequences of such applications, principals of radiation protection, to familiarize students with the analytical methods and equipment that applied in environmental radiological monitoring, to develop skills of human dose and dose rate estimation

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Topics of “Environmental Radiation Protection” Curriculum

1. Introduction. The structure of atoms. Stable and unstable Isotopes. Radioactive decay law. Radioactive and secular equilibrium
2. Ionizing radiation interaction with matter. Biological effects of ionizing radiation
3. The detection and measurement of radioactivity
4. Environmental radioactivity. Cosmogenic and terrestrial radionuclides. NORM and TENORM.
5. Nuclear weapon testing and environmental consequences
6. Nuclear power generation. Environmental Impacts of nuclear energy
7. Nuclear wastes: Generation and management issues
8. Nuclear events and their impact on global environment
9. Radioactivity monitoring
10. Principles of radiation protection. International conventions on nuclear safety and security. Nuclear forensics

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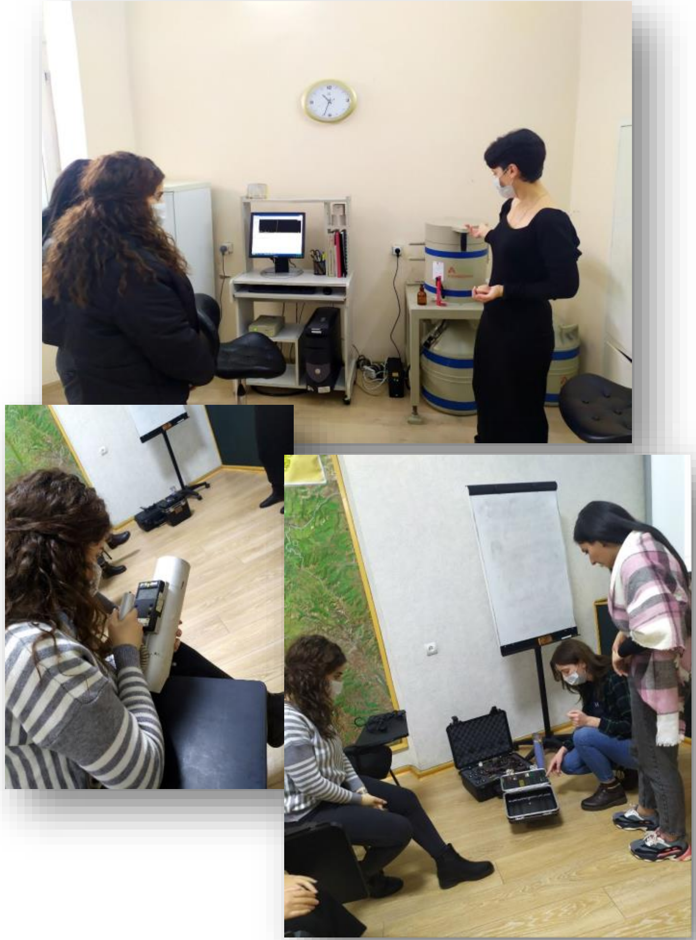
MEVIPRO and Educational and Research Laboratory for Environment Protection (#ERLEP) created favorable conditions for:

- ✓ Hosting professionals from other organizations (including potential employers) for lecturers and sharing experience



- ✓ Collaborative learning and
- ✓ Inquiry-based learning

- ✓ Project-based learning

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NORM issues in mining centers of Armenia

MENVIPRO

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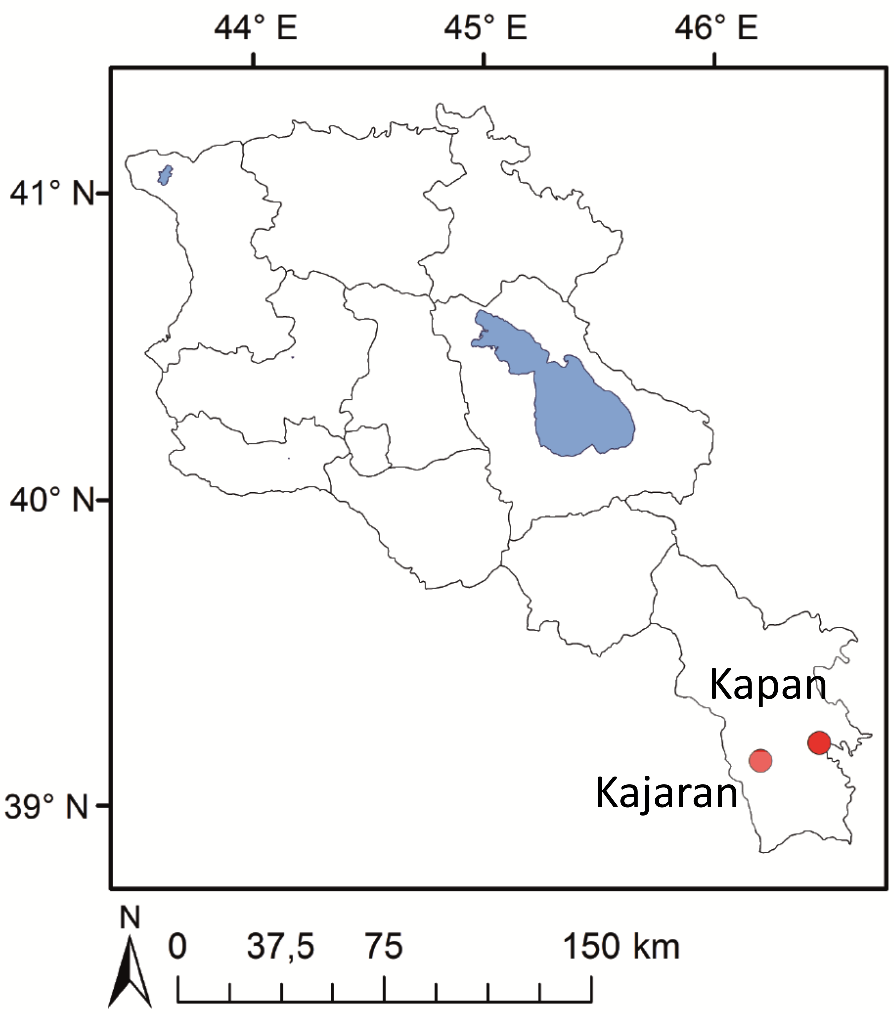
Study objects



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The aim of the study

to perform the evaluation of radioactivity levels in urban soils (gross alpha/beta activity; U-238, Th-232 and K-40) and carry out a dose rate assessment and life time cancer risk evaluation in the biggest mining centers of Armenia, i.e., at the metal mining towns of Kapan and Kajaran

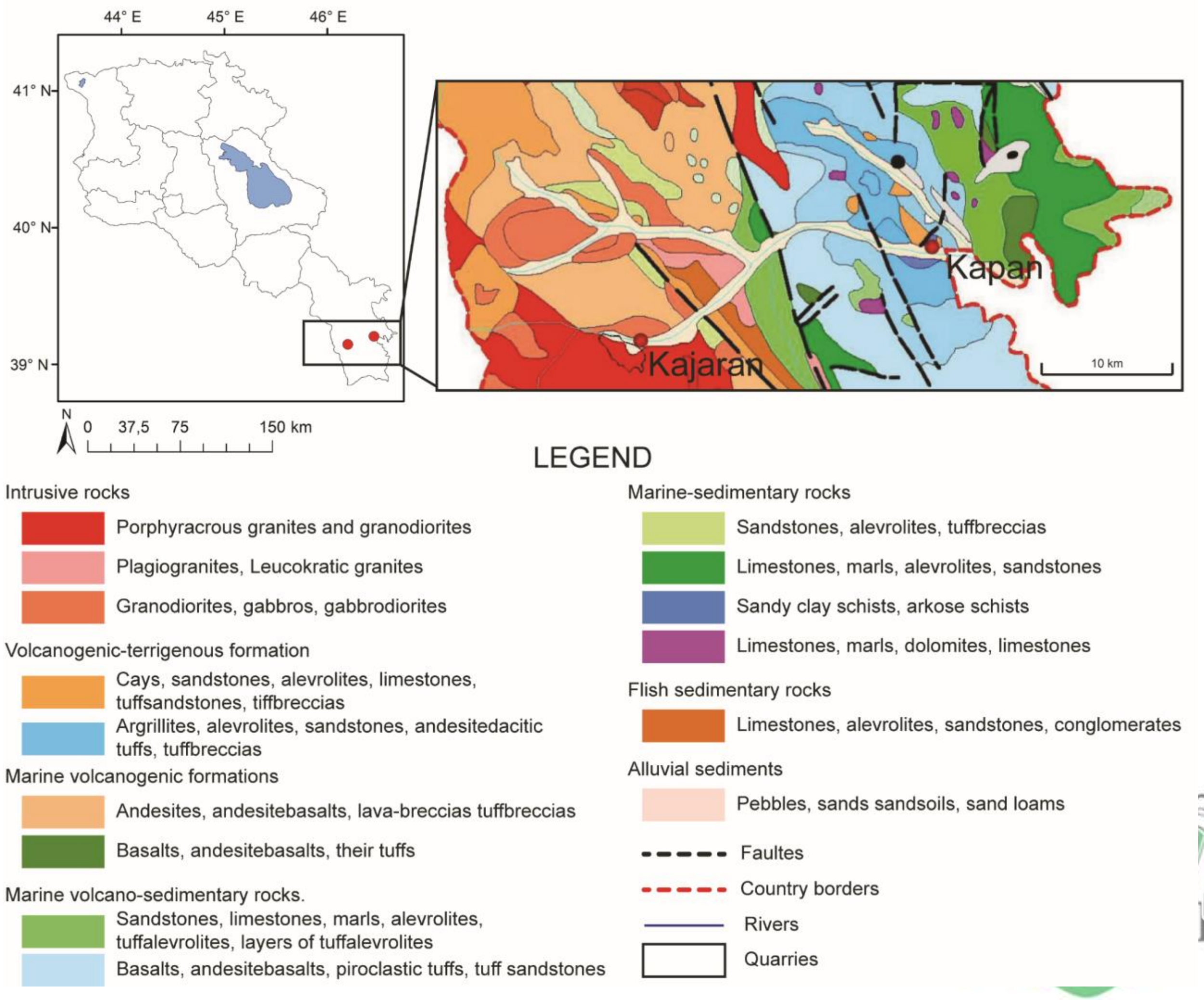
Initial information: Geology

Kapan

Jurassic volcanic (basalt, andesite) and sedimentary (breccia, limestone, dolomite and clay slate) formations

Kajaran

Tertiary volcanogenic and intrusive rocks: **monzonites** and porphyritic **granites-granodiorites**



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Initial information: Geochemical prospecting

Kapan and Kajaran

1950-s, 1970-s, airborne gamma-ray spectrometry survey (Gromov and Koltsov expedition)[1]

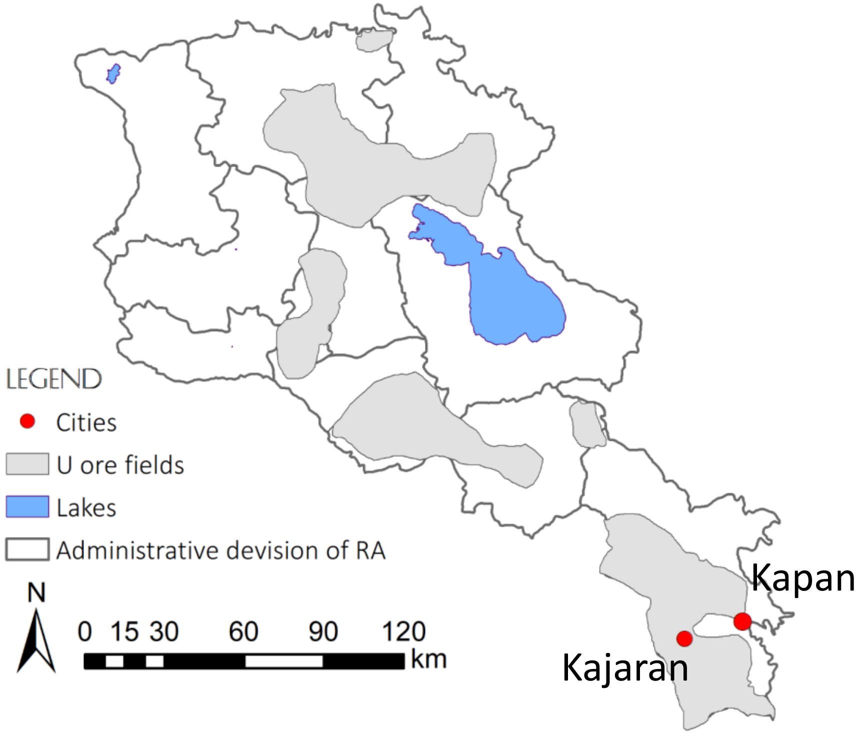
Kapan

No U mineralization known

Kajaran

Syunik U ore field

Several U depositions are located in vicinities (Lernadzor, Pkhrut, etc.)



Distribution of U ore field in Armenia[2]

[1] Republican Geological Fund [Electronic resource] // Natural resources of the Republic of Armenia. 2020. URL: https://www.geo-fund.am/en

[2] Aloyan P.G. Uranium-bearing geological formations of Armenia. Yerevan: GEOID, 2010. 185 p. (in Armenian)

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Initial information: Mineral deposits and exploration

Kapan
Copper-pyrite and gold-polymetallic deposits
Underground mining
Processing plant (ore crushing, milling, and flotation)
Two operating tailing repositories
Abandoned quarry
Numerous waste-rock piles

Kajaran
Copper-Molybdenum deposit
Open-pit mining
Processing plant (ore crushing, milling, and flotation)
Three conserved tailing repositories

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Initial Information: Comprehensive geochemical studies

Kapan[1]
Geochemical soil survey
Study of surface water pollution

Kajaran[2]
Geochemical soil survey
Study of surface water, airborne dust, agricultural soil and crops pollution
Study of heavy metals transfer in "irrigation water-soil-crops" system
Study of fodder crops and milk
Pilot study of man biosubstrates
Study of gross beta activity distribution pattern
Study of indoor radon


Science of the Total Environment 639 (2018) 900–909

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Continuous impact of mining activities on soil heavy metals levels and human health

Gevorg Tepanosyan *, Lilit Sahakyan, Olga Belyaeva, Shushanik Asmaryan, Armen Saghatelyan

HIGHLIGHTS

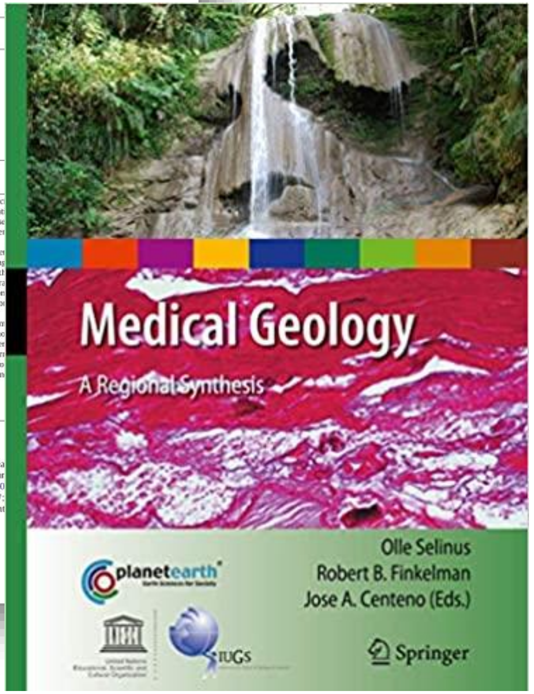
- Anthropogenically predominant groups of elements include Mo, Cu, Zn and Pb.
- Superposition of natural and anthropogenic factors formed highly polluted areas.
- Multi-elemental non-carcinogenic risk to children health detected.

GRAPHICAL ABSTRACT

ARTICLE INFO

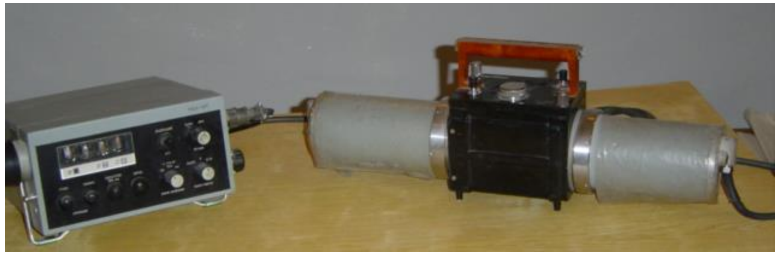
ABSTRACT

1. Introduction



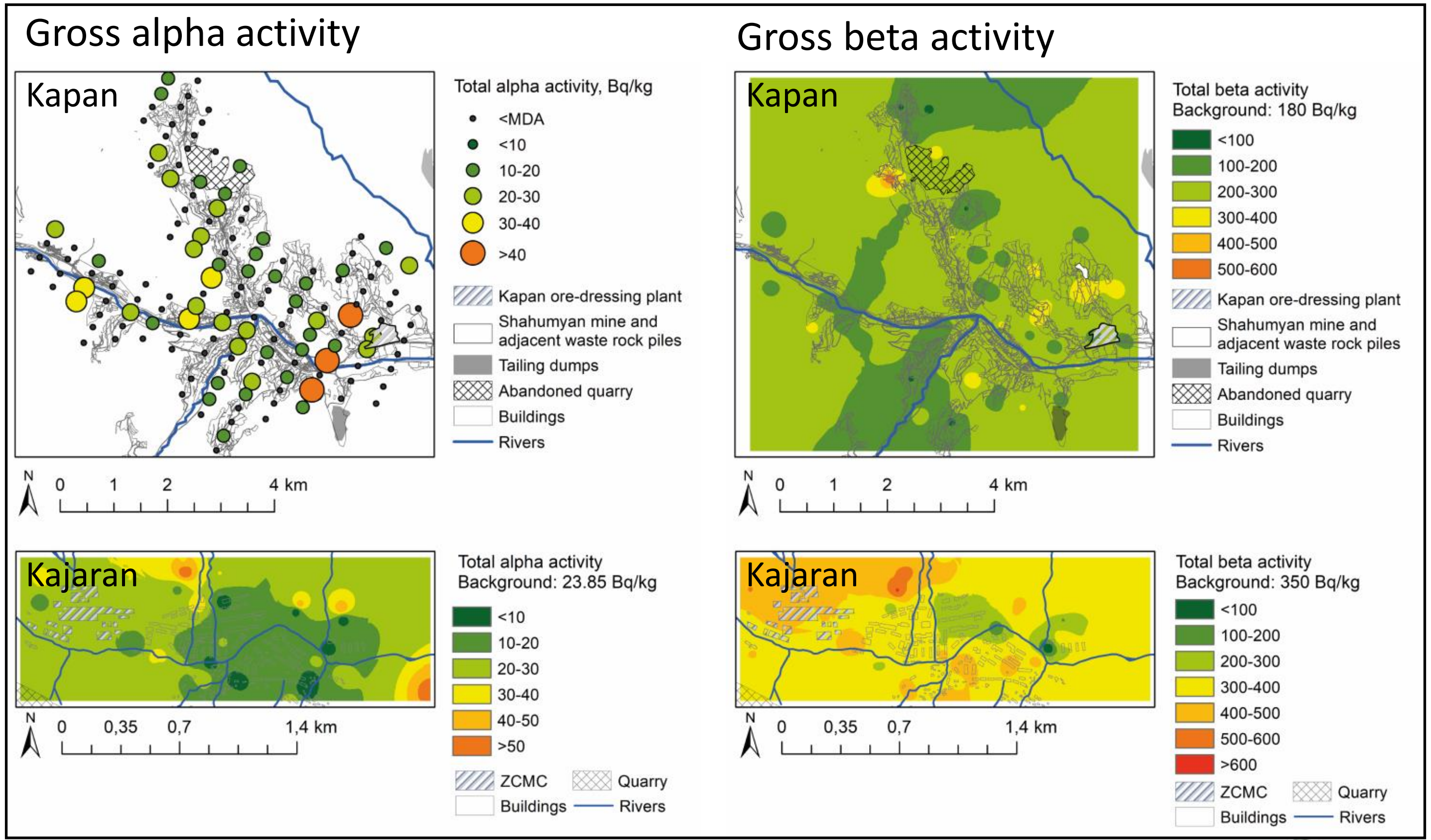
[1] Saghatelyan A., Sahakyan L. Belyaeva O. Polluted Irrigation Waters as a Risk Factor to Public Health. Chemistry Journal of Moldova. General, Industrial and Ecological Chemistry. 2012, 7 (2), p. 84-88. DOI: dx.doi.org/10.19261/cjm.2012.07(2).11
[2] Saghatelyan, A., Gevorgyan, V., Arevshatyan, S., Sahakyan, L., 2008. Ecological and geochemical assessment of environmental state of the city of Kajaran. CENS, Yerevan (in Armenian)

Verification of data: gross alpha/beta counting



РКБ4-1еМ (Russia)

Alpha/Beta Counting System iMatic (Canberra)



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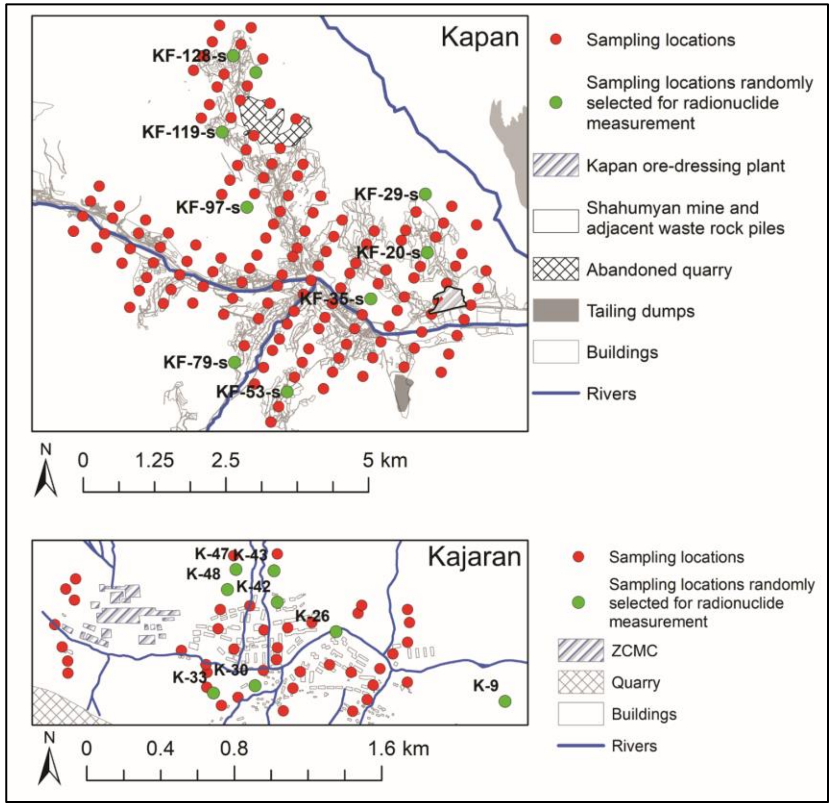
Verification of data: Outcomes

1. Previous data was not correlated with the newly obtained results
2. Data and existed soil samples were not enough to achieve the stated goal

Collection of data: Selection of achieve soils and additional sampling

1. Selection of 10 samples per a city based on gross alpha/beta activities levels



2. Additional sampling od waste-rock piles, tails and sludge from operating tailing repository

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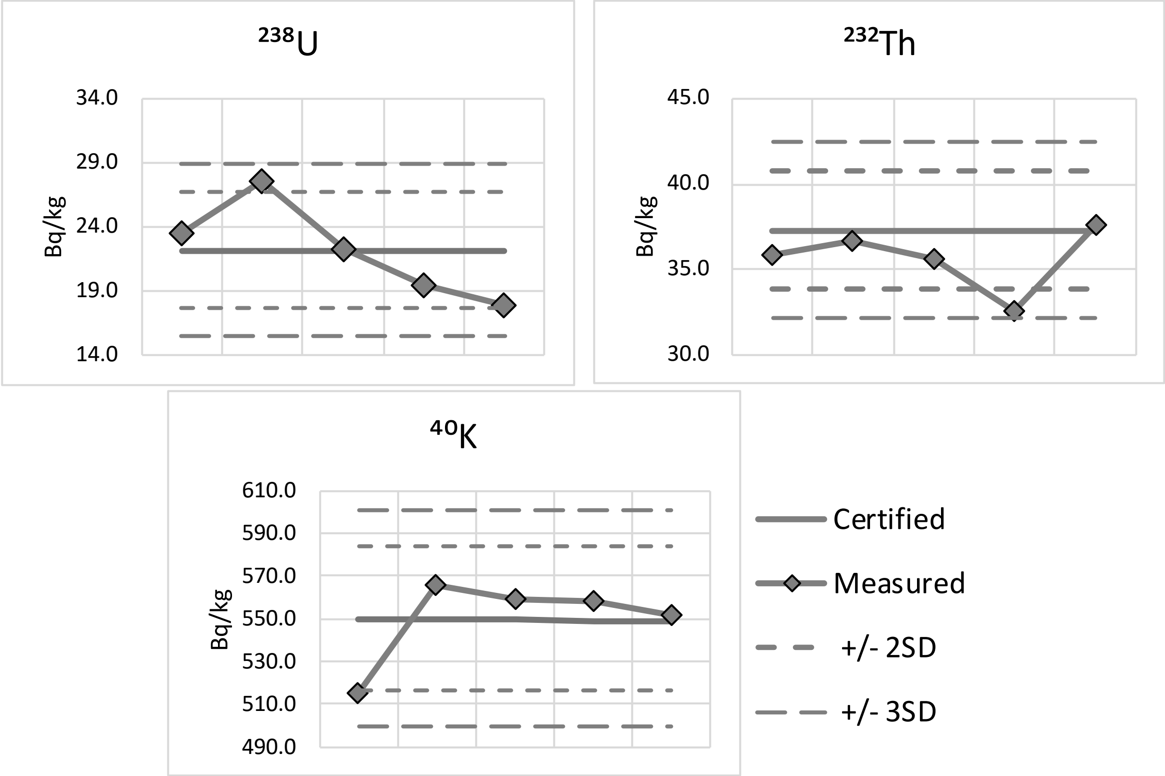
Lab work: Gamma spectrometry

Gamma spectrometry system by CANBERRA
HPGe detector with energy resolution of 1.8 keV FWHM for the 1332 keV energy line of ^{60}Co; DSA-1000 multichannel analyser; Genie2000 and LabSOCS



QA: Analysis of Certified Reference Material (IAEA-447)

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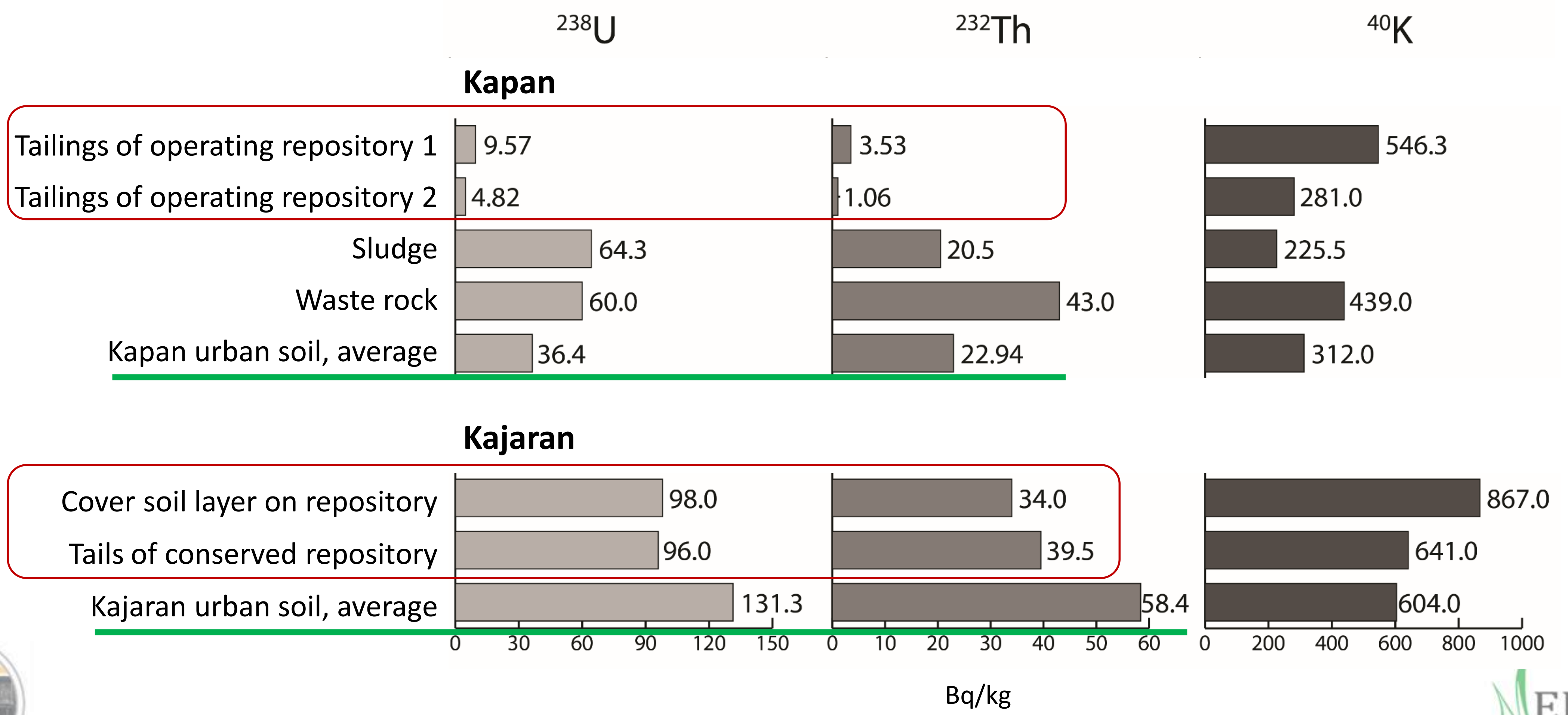
Analysis of data

1. Descriptive statistics
2. Calculation of radiological hazard and health risk indices

   Radium Equivalent Activity (*RaEq*): $RaEq = C_U + 1.43C_{Th} + 0.077C_K$
   Outdoor Gamma Absorbed Dose Rate (*ODRA*): $ODRA = 0.462C_U + 0.604C_{Th} + 0.0417C_K$
   Annual Effective Dose Equivalent: $AEDE = ODRA \times DCF \times OF \times T$
   Excess Lifetime Cancer Risk (ELCR): $ELCR = AEDE \times DL \times RF$

3. Visualization of the spatial distribution of soil gross alpha/beta activity, radionuclide activity concentration and levels of calculated radiological hazard and health risk indices using ArcGIS software

Results: NORM in mining wastes



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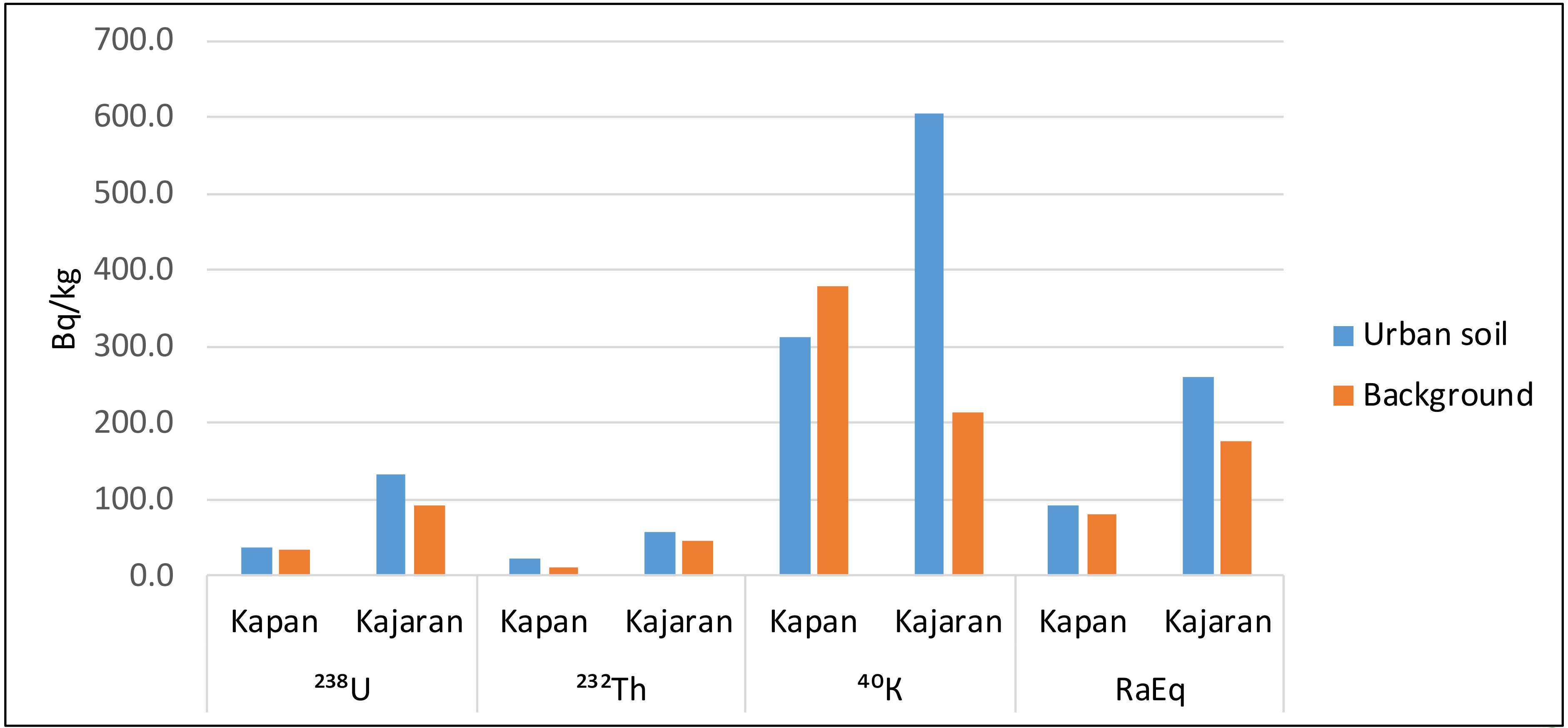
Results: NORM in urban soils



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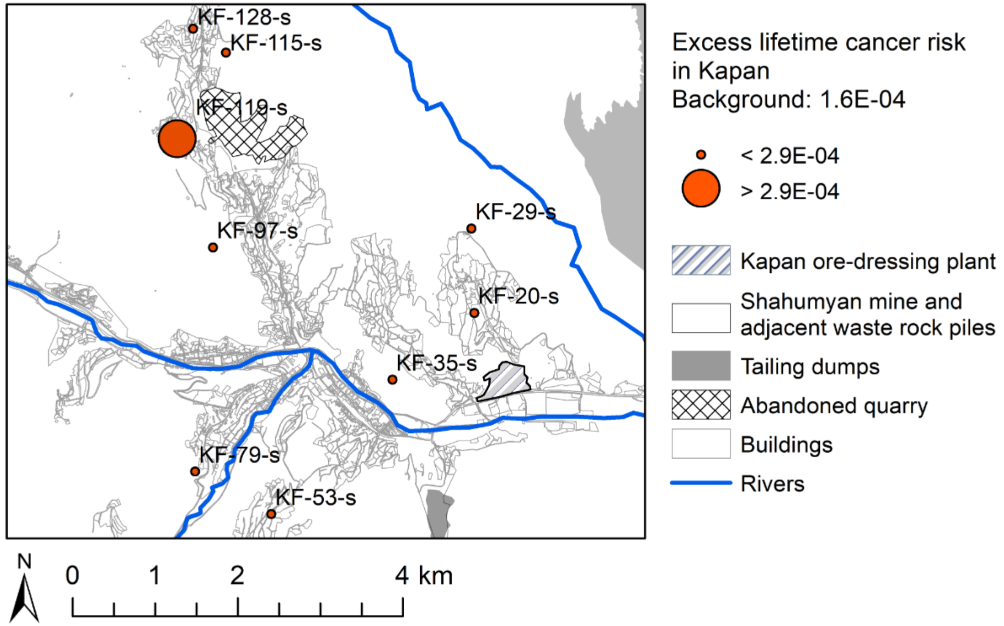
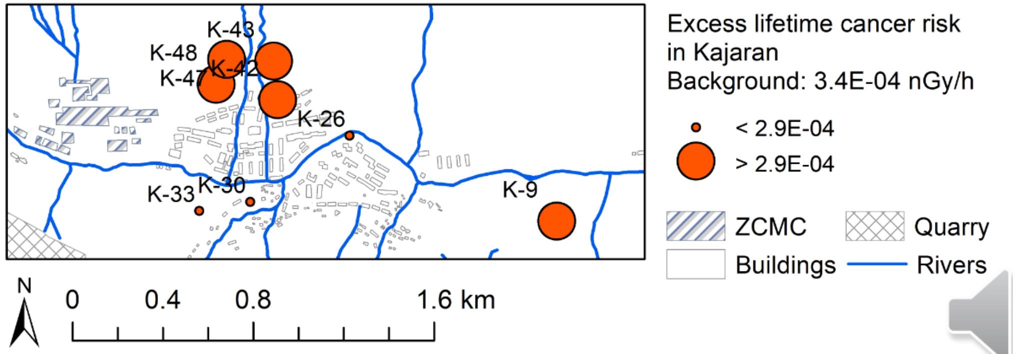
Results: Excess lifetime cancer risk

The mean level of ELCR in **Kapan**, calculated at 1.9E-04, was notably lower than world average.

In **Kajaran**, the ELCR values exceed the world average level of 2.9E-04.





Conclusion[1]

The main conclusion drawn from the radioactivity surveys is that in Kapan the soil radioactivity levels, although enhanced by metal mining, are not a significant risk factor to human health. In Kajaran, the soil radioactivity levels in some areas were above the background values, but radionuclides originated in a natural and unmodified geogenic source and not from mining activities.

Generally with this study no significant radiological risks were identified in the region in relationship with copper and gold-polymetallic ore mining, and transport of naturally occurring radionuclides from quarries and waste rock piles into urban soils. Further investigations on enhanced environmental radioactivity in relationship with other phases of the milling process, namely ore smelters, are still needed in order to complete the assessment of occupational radiation exposure to NORMs

[1] Belyaeva, O., Pyuskyulyan, K., Movsisyan, N., Saghatelyan, A., Carvalho, F.P., 2019. Natural Radioactivity in Urban Soils of Mining Centers in Armenia: Dose Rate and Risk Assessment. Chemosphere 225, 859e870. https://doi.org/10.1016/j.chemosphere.2019.03.057

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NORM and Cs-137 in urban environment

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Environmental radioactivity studies in Yerevan

The aim of this study was to assess the activity concentrations of naturally occurring ^{226}Ra, ^{232}Th, ^{40}K and artificial ^{137}Cs radionuclides in the soils of Yerevan and reveal potential factors of their redistribution and assess dose rate and related human health risk.

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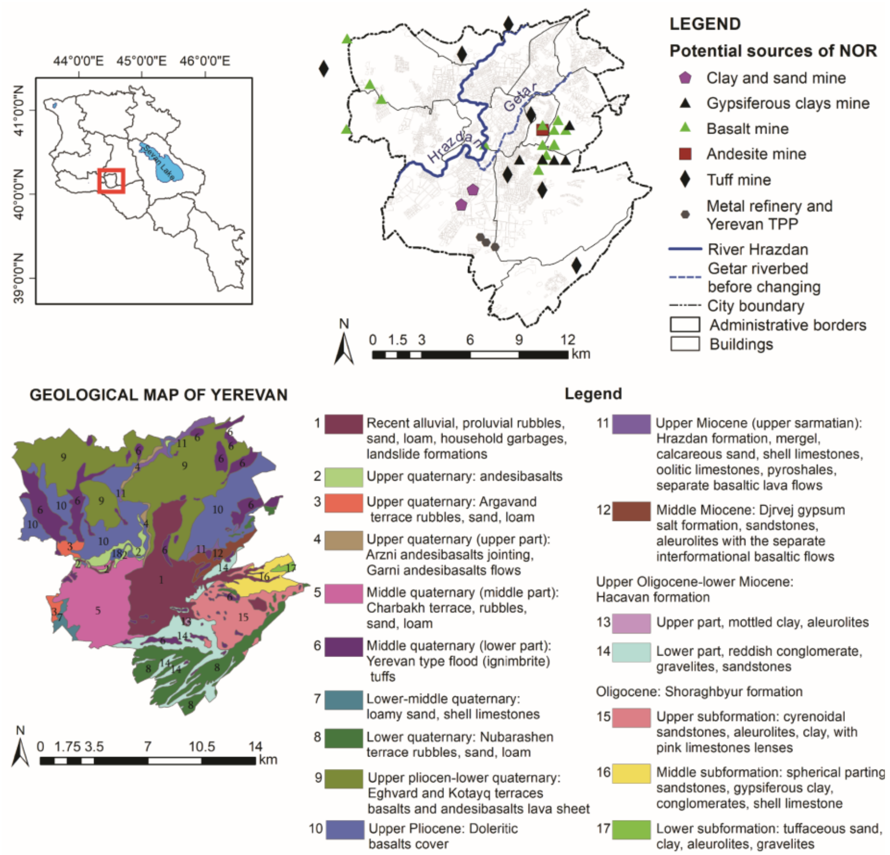
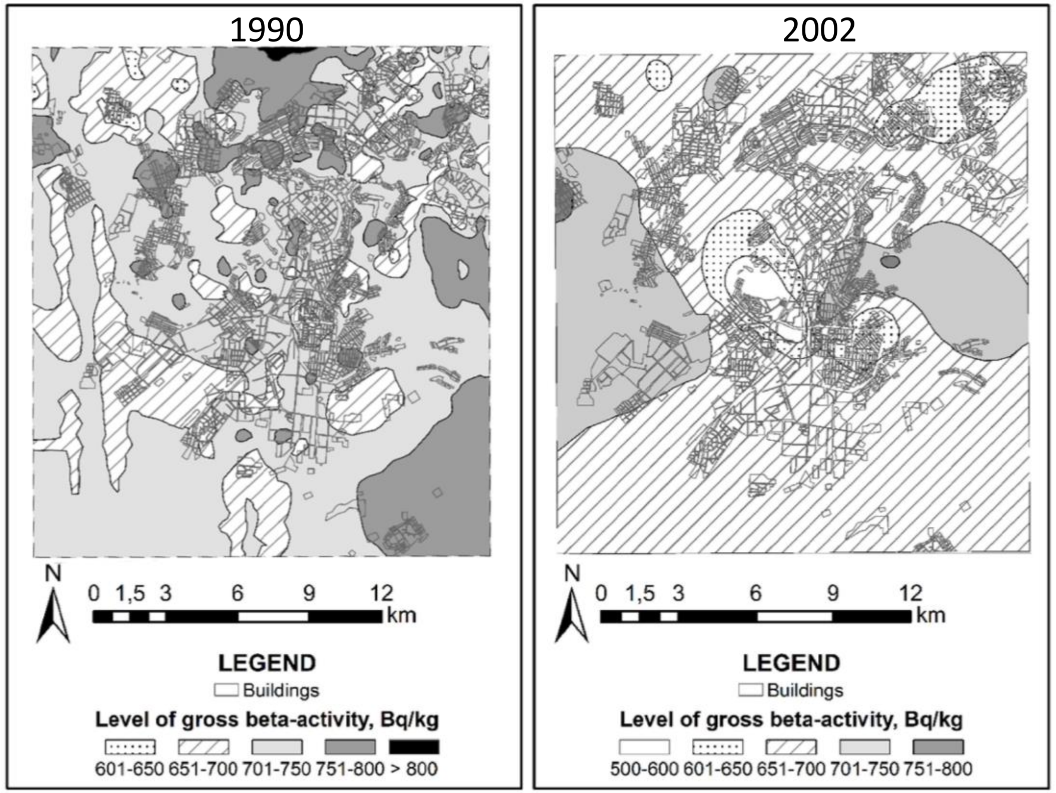
Initial information



Geological structure(Avetisyan et al., 1974), Potential sources of NORM (Geological Service of RA, 2019)



Radioecological studies based on geochemical survey Ananyan & Nalbandyan 2001; Nalbandyan & Karapetyan2003)

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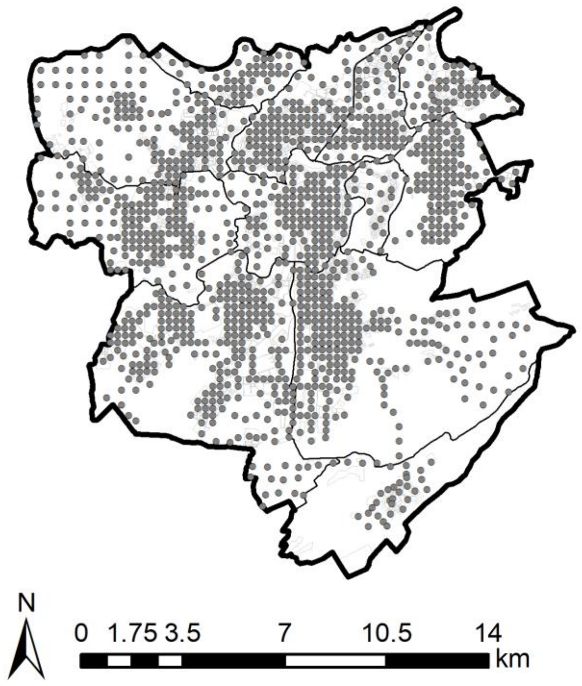
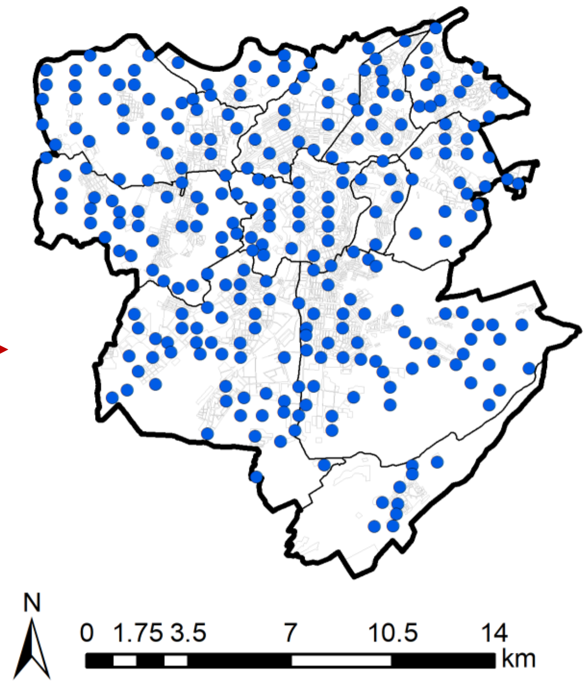
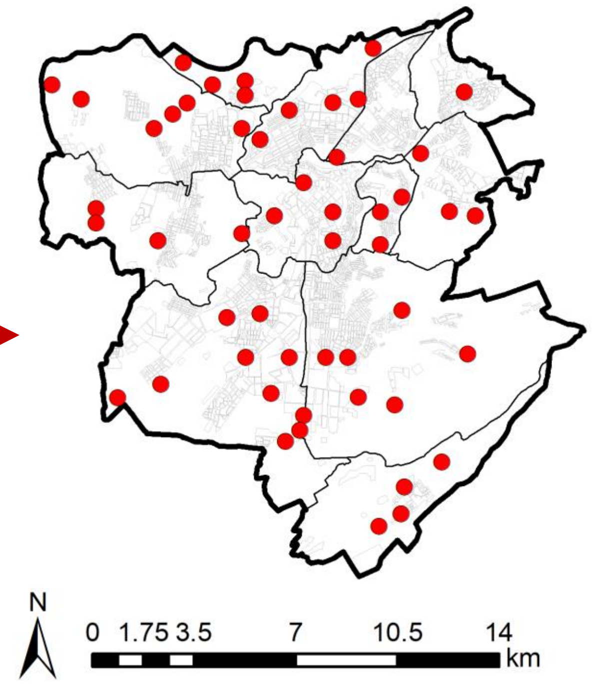
Planning and Optimization



Initial geochemical survey
Sc: 1:25000
1356 soil samples

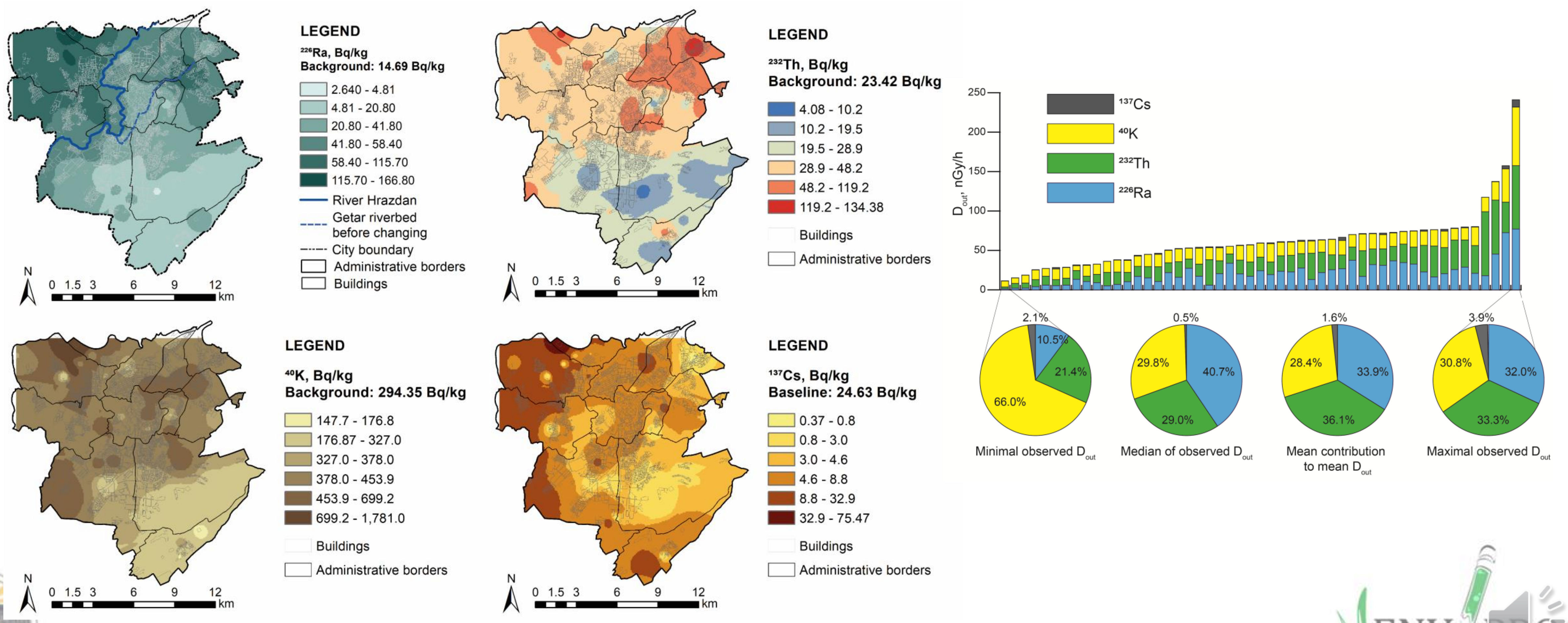


Soil samples selected for
alpha/beta counting
278 soil samples



Soil samples selected for NORM
and Cs-137 identification
52 soil samples

Special pattern and dose rates



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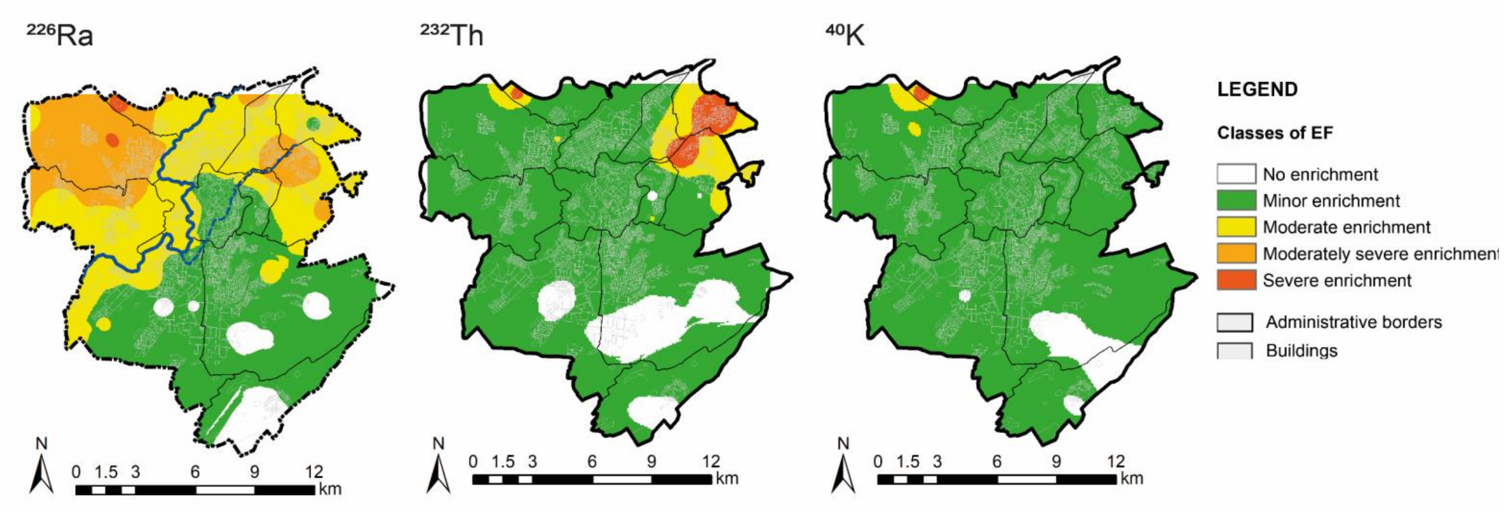
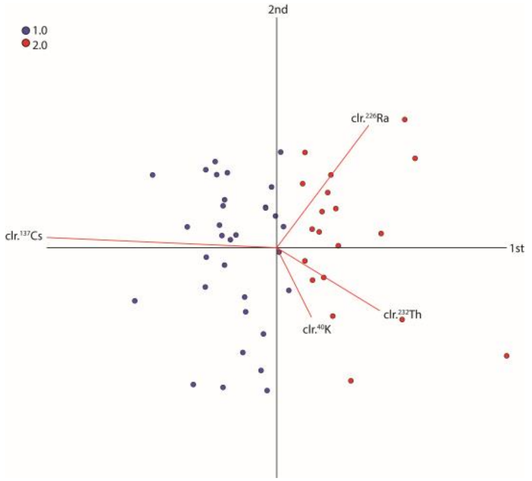
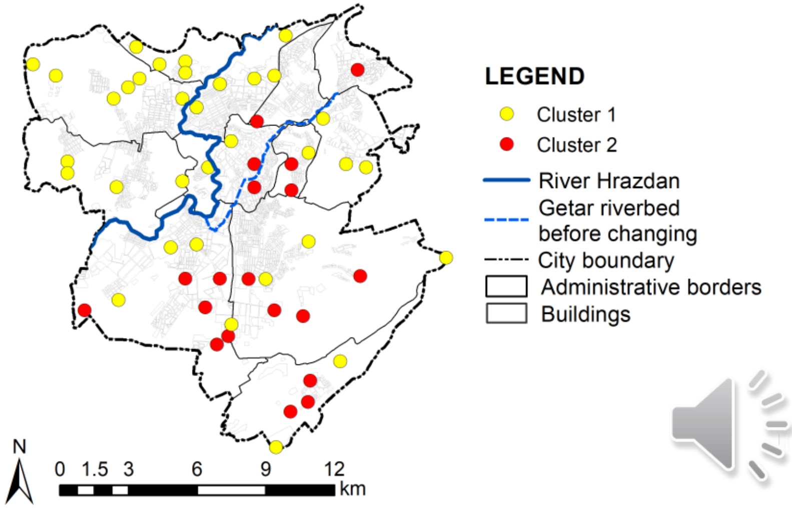
Geochemical assessment of distribution patterns of NORM

Spatial distribution of NOR in the soil of Yerevan mainly depends on the geological structure of the area. The highest activity levels of NOR were observed in the northern and central parts where igneous rocks are dominating. The geological basis of the southern part of Yerevan consists of alluvial deposits characterized by lower levels of NOR. Operation of Yerevan TPP (natural gas combustion) and the metal refinery plants that are situated in the south of the city did not affect enhancing activity concentration of radionuclide in adjacent soils. On the contrary, natural stones and gypsum mines in the eastern part were revealed as possible sources of NOR.







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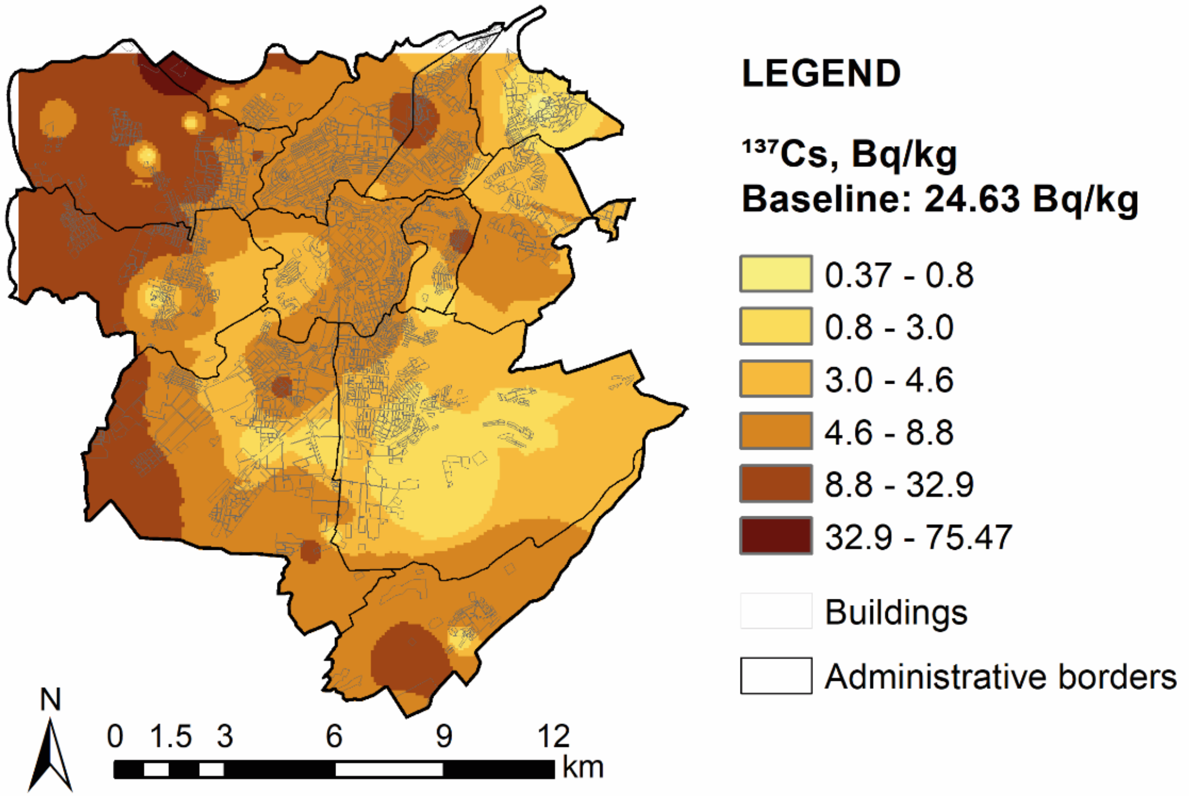
Activity concentrations of Cs-137 in soils of Yerevan[1]

Global radioactive fallout was estimated as the main contributor of artificial ^{137}Cs in Yerevan. The activity concentration of fallout radionuclide ^{137}Cs was within the range typical for altitudes studied, the highest values of ^{137}Cs activity were observed at the highest altitude located in the north-west of Yerevan.



[1] Belyaeva, O., Movsisyan, N., Pyuskyulyan, K., Sahakyan, L., Tepanosyan, G., Saghatelyan, A., 2021. Yerevan soil radioactivity: Radiological and geochemical assessment. Chemosphere 265, 129173. https://doi.org/10.1016/j.chemosphere.2020.129173

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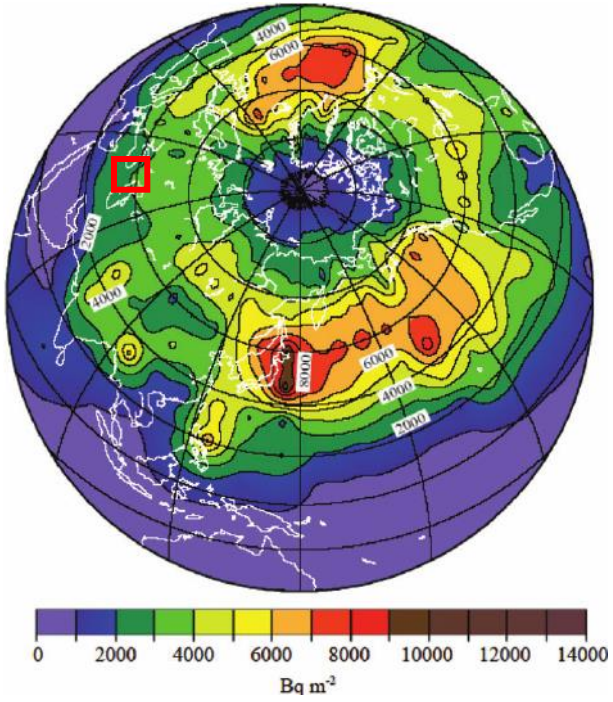
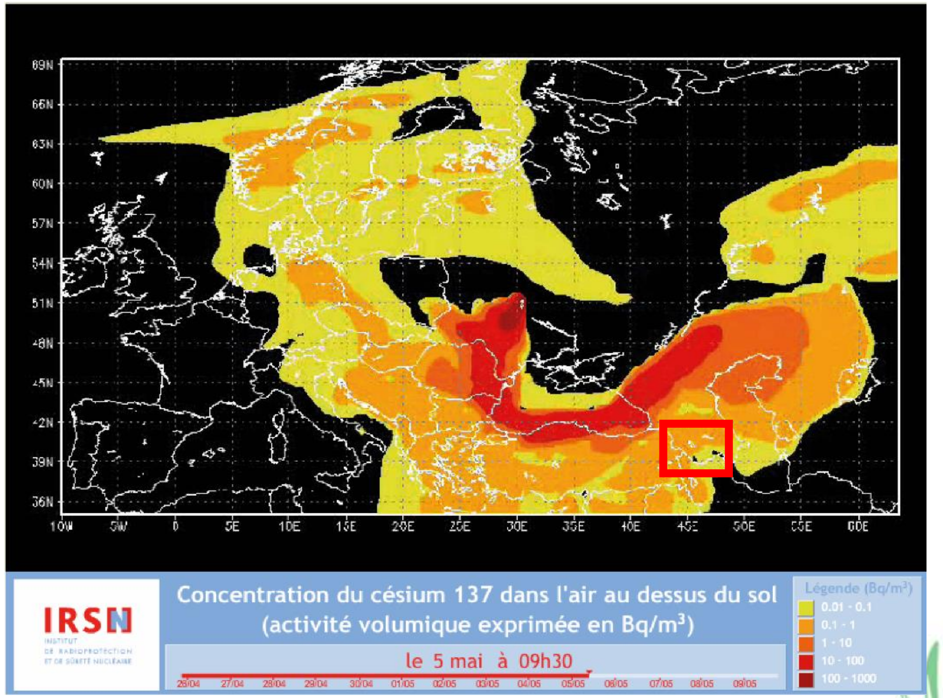
Main sources and distribution pattern of Cs-137 in Armenia

Global distribution of Cs-137 and Armenia

Re-constructed global 137Cs fallout as of 1 January, 1970 (Bq/m^2)
(*Aoyama et al. J Environ Monit, 2006*)



Graphic reconstruction of the path of the Chernobyl radioactive plume
(*IRSN, 2005)*



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Aim of the study

This particular research was done to study the altitude-dependent distribution of ^{137}Cs in soils and dry atmospheric depositions. Observation stations were arranged on the southern and eastern slope of the Aragats mountain massif.

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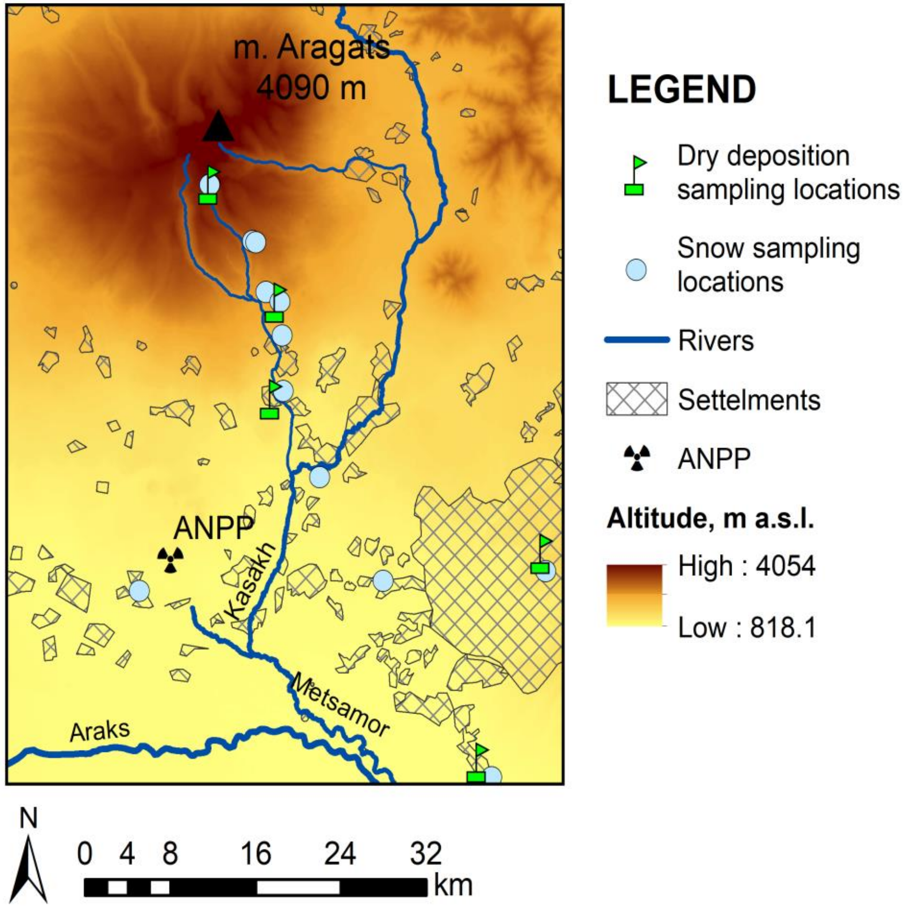
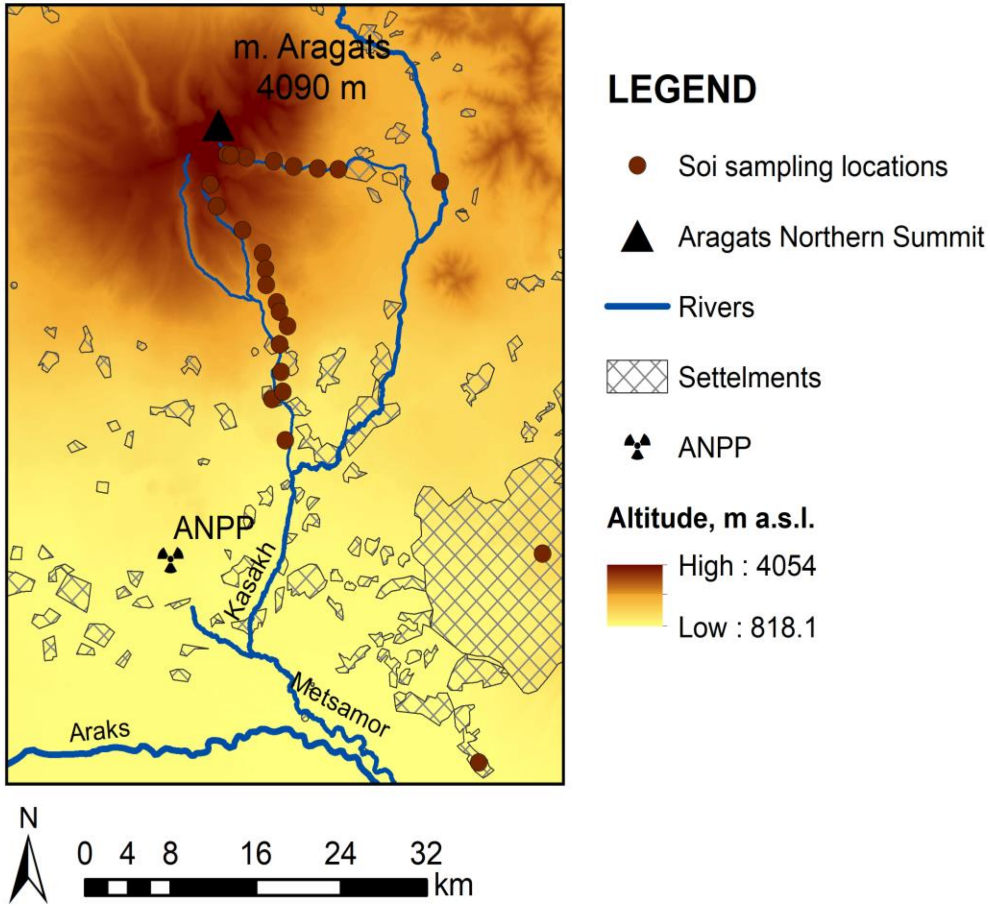
Judgmental sampling





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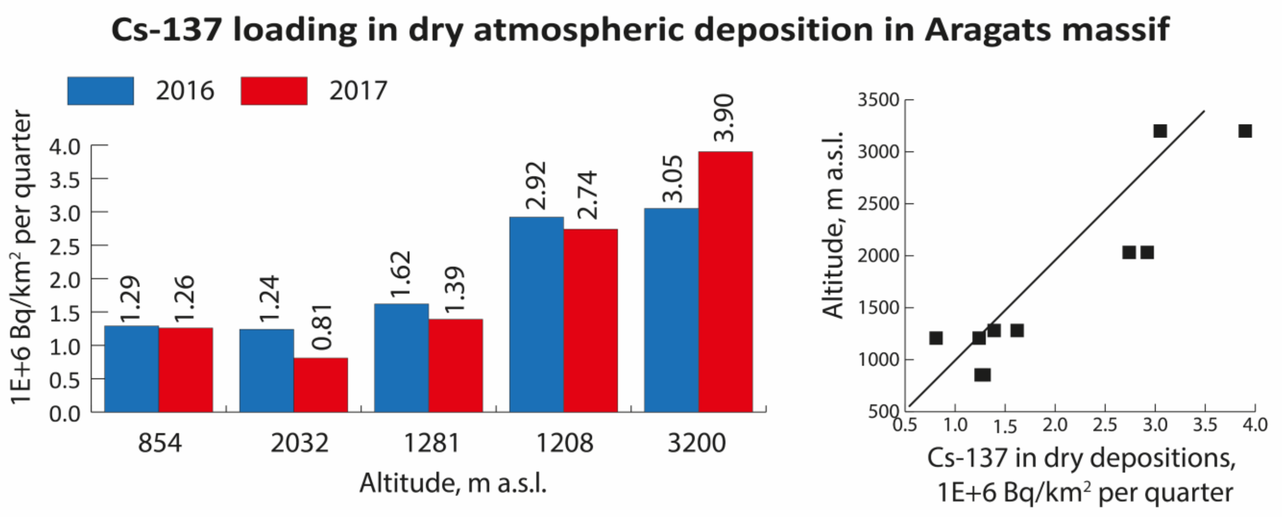
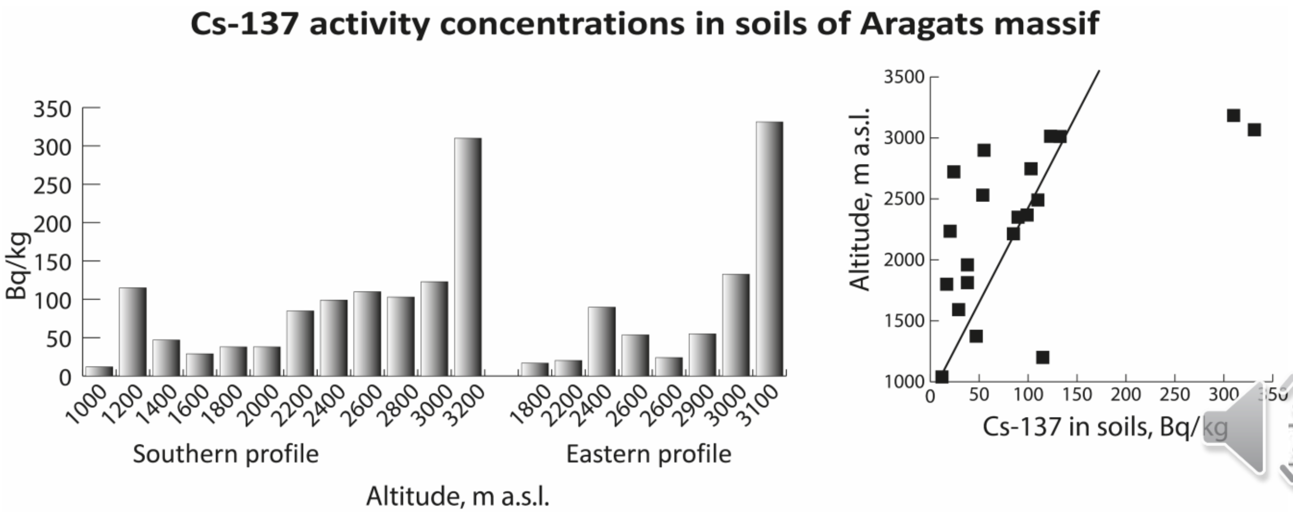
Results[2]





[1] Pyuskyulyan, K., LaMont, S.P., Atoyan, V., Belyaeva, O., Movsisyan, N., Saghatelyan, A., 2020. Altitude-dependent distribution of 137Cs in the environment: a case study of Aragats massif, Armenia. Acta Geochim. 127–138. https://doi.org/https://doi.org/10.1007/s11631-019-00334-0

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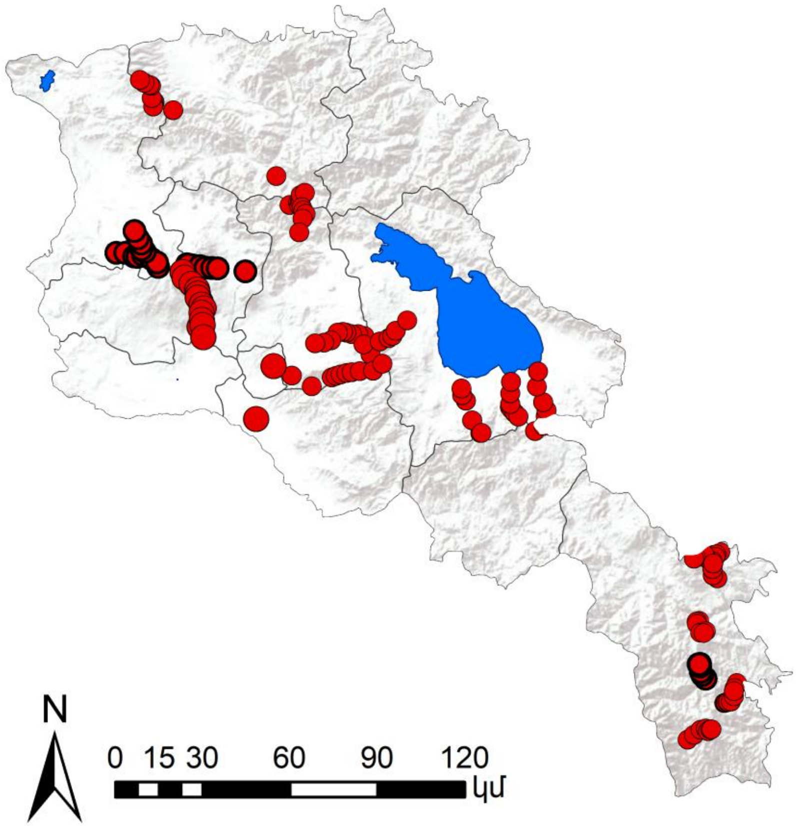
Continuation: NORM Baselines and Cs-137 National Inventory



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Thank you for your kind attention!

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