CASE STUDY

MINING CONTROVERSIES: PUBLICK HEALTH RISKS VERSUS ECONOMIC BENEFITS

BY TOXLEARN4EU
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METHOD	Problem-base learning (PBL)
DURATION	5 days (duration can be adjusted)
STUDENT WORKLOAD	6-7 hours/day
PROJECT TILE	Mining Controversies: Public Health Risks versus Economic Benefits
PROJECT CONTEXT	Human populations exposed to mining contamination-OreValley case
SUBJECT/COURSE	Toxicology
OTHER SUBJECT AREAS	Ecotoxicology, Human Biomonitoring, Risk/Hazard identification and evaluation, Risk Communication
SUPPORTING MATERIAL/ DOCUMENTATION	Online courses within ToxLeran4EU project WP3, WP4, WP5 (available on toxlearn4eu.eu/) Students should consult materials/bibliography related to biological and environmental endpoints, environmental exposure limit values to contaminants (either national or international) for general population (e.g WHO) and workers (e.g EEA, OSHA, NIOSH,), and the International Agency for Research on Cancer (IARC) (monographs). Other sources include FAO/WHO (Joint Codex Alimentarius Commission. Food additives and contaminants. Food Standards. CXS_193e PDF)
IMAGES	Images (Orevalley logo and "aerial photo") were created using Adobe Firefly. Final "photo" was further edited using microft office tools

PBL PROJECT DESIGN TEMPLATE

DISCLAIMER: *The scenario depicted in this PBL is a case study created for educational purposes as part of ToxLearn4EU project. It is designed to facilitate problem-based learning in the subjects of Toxicology and related areas. Names and descriptions are fictional and any resemblance to, actual group of persons, living or dead, locations or actual events is purely coincidental.*

GOAL	Assess the potential health impact resulting from mine contamination, using environmental and biological data. Train on tools for hazard identification, risk assessment, and risk communication. Develop skills in interdisciplinary collaboration to synthesize findings and propose sustainable solutions. Engage in discussions and critical evaluations to enhance understanding of public health policies and community engagement strategies in response to environmental risks.
ENTRY EVENT:	A special report by the principal news channel has revealed that the Mining Company is seeking to renew its 100-year-old license to continue and expand operations at the OreValley mines. It also reports that an environmental activist group known as EcoCypher carried out biological and environmental analysis that reveal the environmental and health risks associated to the mine exploitation. The group threatens to publish online these findings. Following the news report, although no documents were published, misleading information and incorrect data began circulating on social media, both condemning and supporting the mine's expansion plans, resulting in widespread panic among OreValley and surrounding village populations. Local populations are strongly dependent on agriculture, farming and mining activity. The OreValley village authority seized the EcoCypher documents and has scheduled an initial general assembly with key stakeholders to address this issue. Representatives from four main societal groups— the Community, the Mining Company, Insurance Companies/Mining Workers' Union, and Environmental Activists—will participate in this first discussion, which is set to take place within the next five days. All documentation will be given upon request.
ROLE/ CHALLENGE	Divide the class into 4 main groups representing: - Community - Mining Company - Companies/Mining Workers' Union - Environmental Activists

	The village local authority group that will mediate the discussion may include the teacher and students. These groups will present arguments science driven to defend their position in the general assembly
AUTHENTIC AUDIENCE	Optional: e.g. local Environmental activists, Municipalities representatives (educational departments), Education Councils or Committees. This PBL can be also extended to include other students and/or the academic community, particularly in the fields of Health, Social Communication, Sociology, Psychology, Management, and Economics.
SITUATION	First meeting held by the village local authority with representatives of 4 main stakeholders to discuss if the Mine Company should continue and expand or if there is evidence that it should be closed due to its impact in the environment and human health.
PRODUCT/PERFORMANCE	- Data-driven discussion on Public Health Risks versus Economic Benefits - Data sheets with results from environmental and human biomonitoring data are available and can be provided upon request - ToxLearn4EU project tools and lectures
DRIVING QUESTION	Orevaley mine: a public health problem? or an essential economic resource for the region?
CONTENT AND SKILLS STANDARDS/21ST COMPETENCIES	• Collaboration between peers • Communication skills • Critical Thinking
TOOLS (can be adjusted)	
Learning Outcomes/Targets	• Assessment of environmental contamination and its health impacts. • Understanding mining activities' socioeconomic implications. • Critical analysis of environmental policy and community advocacy. • Data interpretation and biomonitoring analysis.
Checkpoints/Formative Assessments	• Review and analysis of environmental monitoring data (e.g., soil, water, dust). • Discussion on biomonitoring results in humans. • Draft position statements for each stakeholder group. • Feedback from teachers and peers on presentations.

Instructional Strategies For All Learners	• Provide real or simulated environmental and human biomonitoring data. • Facilitate group discussions and role-play preparation. • Optional: invite experts (if available) to guide students on specific topics.
Final Product(s)	A simulated municipal assembly presentation, including stakeholder arguments and scientific data, leading to a group decision.
Resources	• Staff and/or Facilities: Classrooms or virtual collaboration tools. • Technology/Equipment: Computers, projectors, or online data-sharing platforms. • Materials: Access to simulated or real-world data sets, environmental and health case studies.
Reflection Methods	• Individual journals summarizing learning outcomes and challenges. • Whole-class discussions on group dynamics and decision-making processes. • Surveys to evaluate understanding and engagement. • Focus groups to refine ideas and arguments.

PBL EVENT PLANNING CALENDAR
DAY 1: Problem presentation
Duration: 6-7h *Aim:* Introduce the project and set the stage to students *Activities:* • Present the problem. • Facilitate a class discussion to explore initial reactions and perspectives on the issue. • Assign stakeholder roles (community, mining company, insurance companies/mining workers union, environmental activists). • Provide a project overview, including objectives, deliverables, and timelines.
Day 2: Individual group discussion

Duration: 6-7h

Aim: Develop strategic approaches, structure the workflow, and assign tasks to ensure effective progress for the next stages of the PBL.

Activities:

- Online research of similar case-studies (focus on mine contamination sites).
- Identify strategies/tools used and examine scientific data supporting risk assessments to inform their approach.
- Design a collaborative plan outlining tasks, deadlines, and responsibilities.

Optional: summary table outlining tools and strategies used in each case, their effectiveness, and gaps

Day 3: Data Analysis

Duration: 6-7h

Aim: Understanding the environmental and health impacts of mining contamination.

Activities:

- Distribute environmental and human biomonitoring datasets (e.g., contamination levels in dust, water, and vegetables).
- Guide students in analysing and interpreting the data relevant to their stakeholder roles
- Facilitate group discussions to develop preliminary arguments based on evidence.

Day 4: Preparation for Debate

Duration: 6-7h

Aim: Develop stakeholder-specific positions and prepare for the municipal assembly.

Activities:

- Each stakeholder group drafts a position statement addressing the key concerns of their role
- Each stakeholder group should organize arguments and defence positions
- Teacher may provide feedback and suggestions for refining arguments.
- Before the final debate, students participate in practice sessions.

Key Considerations:

- What are the strongest data supporting your position?
- Does your position address public health, economic and environmental concerns?
- What challenges exist in implementing your recommendations?

Presentation may include:

- Overview of the PBL
- Data that support their position
- Proposed strategies for risk mitigation and communication
- Challenges, limitations, and policy implications

Optional: a structured summary of their key points, arguments, and counterarguments

Day 5: Preparation for Debate & Debate

Duration: 6-7h

Aim: Facilitate an interdisciplinary debate where groups present their findings, critically evaluate different perspectives, and refine their recommendations

Activities:

- **Debate Structure and Rules Explanation** (max 15 min). *The role of the Moderator is to introduce the format and ensure a structured, respectful debate, as well as keep track of time and ensure that all groups participate.*
- **Group Presentations** (max 1h15). *Each group presents their case in 10-12 minutes. Other groups may ask clarifying questions (2 minutes per question).*
- **Open Debate: Evaluating Different Approaches** (max 2h30).

  Possible Debate Topics:

  - Should economic growth outweigh environmental and health concerns?
  - How can communities be more actively involved in risk mitigation?
  - What are the biggest policy gaps in addressing mine contamination?

  Debate Format:

  - Groups take turns debating the strengths/weaknesses of different approaches.
  - The moderator encourages evidence-based arguments and real-world implications
- **Closing Statements & Collective Conclusions** (max 2h).

  Each group have a short meeting to discuss the group Final Statement (15 min):
  - What did they learn from the debate?
  - How would they refine their recommendations based on feedback?
  - What policy actions are most urgent?

  Final Collective Reflection:
  - What are the key points of the debate?
  - What would be the next steps?
  - How can interdisciplinary collaboration improve risk evaluation on a real scenario?
- **Student Assessment** (max 1h)**:**
  - What was the most valuable part of the PBL experience?
  - How did this debate challenge or change your perspective on the balance between Public Health Risks and Economic Benefits?
  - What skills did you develop or improve? (e.g., teamwork, research, communication).

POST PROJECT: For Teacher Use
<u>Reflections</u> - **Individual Reflection:** Critical analysis reflecting on what students learned about environmental contamination, health risks, and the importance of evidence-based decision-making. - **Group Reflection:** Conduct a whole-class discussion or survey to evaluate the group dynamics, collaboration, and the impact of the stakeholder role-play on learning outcomes. - **Teacher Reflection:** Analyse the effectiveness of strategies, student engagement, and the authenticity of the project.
<u>Outcomes</u> Did students: ✓ Demonstrate critical thinking by analysing data and forming evidence-based arguments? ✓ Understand the interplay between public perception, environmental health, economics, and policy-making? ✓ Effectively collaborate and communicate in a simulated decision-making process?
<u>Formative Assessment:</u> Guide students' learning by providing continuous feedback before the final assessment. • Review of data analysis and stakeholder position statements • Peer and teacher feedback on practice debates • Encourage self-reflection and revision of arguments Teacher's Role: - Provide feedback on accuracy, logical reasoning, and data driven research. - Encourage students to consider multiple perspectives and strengthen their arguments. - Before the final debate, students participate in practice sessions.
<u>Summative Assessment:</u> Assess students' ability to synthesize their learning and apply it to a real-world context. ✓ Evaluate final presentations at the municipal assembly based on clarity (How well students articulate key points), evidence use (Integration of data and case studies), and persuasiveness (Strength of arguments and engagement with counterpoints). ✓ Assess individual reflections for depth of understanding and personal growth. Teacher's Role:

- Assess how well students balance scientific reasoning, policy implications, and stakeholder concerns
- Provide feedback on their ability to advocate for sustainable solutions

<u>Rubric for Assessment:</u>

A structured rubric ensures clear expectations and consistency in evaluation. Below are suggested assessment categories including categories for critical thinking, collaboration, data analysis, communication, and creativity.

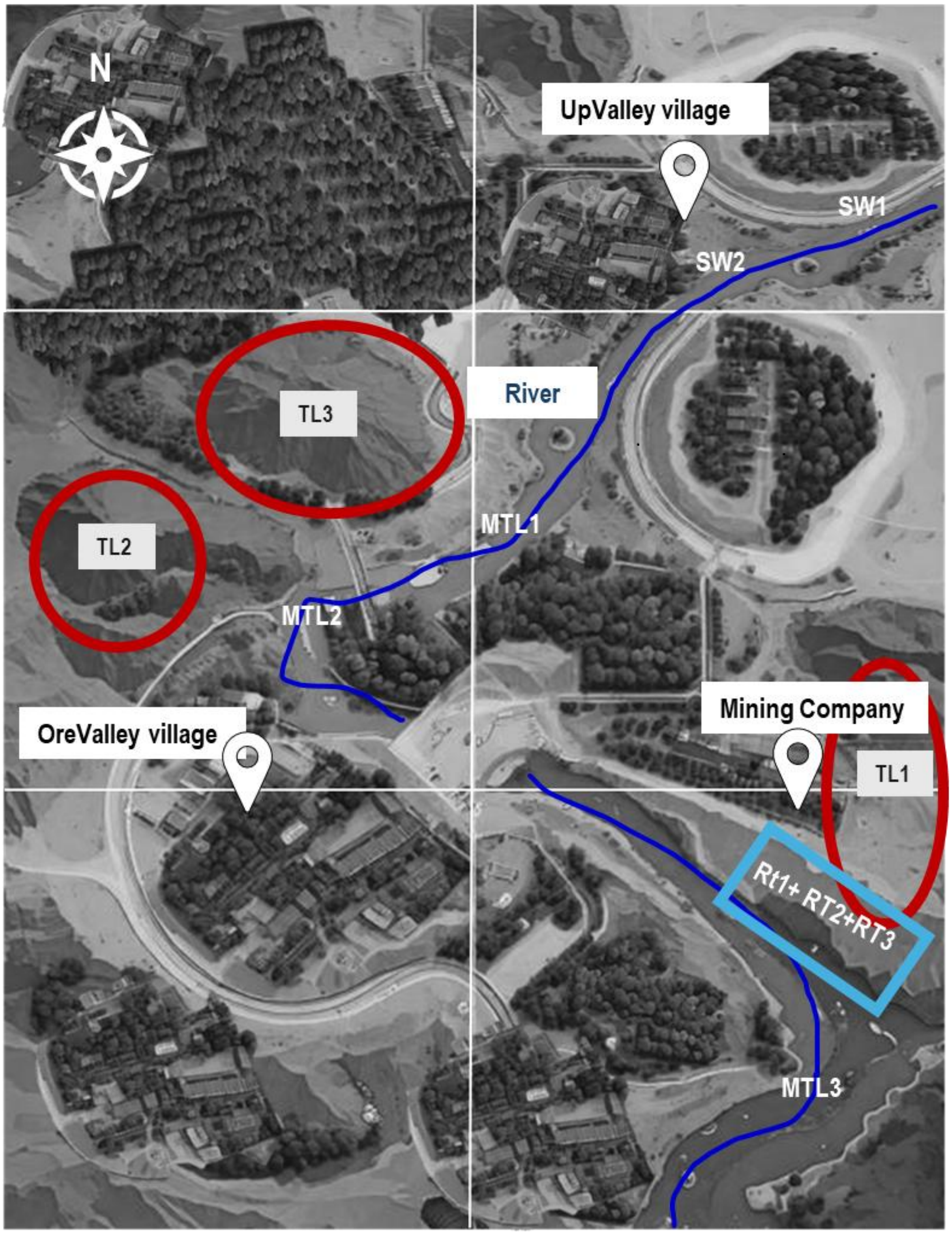
Category	Criteria
Critical Thinking	Demonstrates logical reasoning, problem-solving, and evaluation of evidence.
Collaboration	Effectively works with peers, respects different perspectives, and contributes to group discussions.
Data Analysis	Accurately interprets environmental and health data, integrating findings into arguments.
Communication	Clearly articulates ideas, engages in debate, and uses persuasive techniques.
Creativity	Proposes innovative and sustainable solutions to environmental risks.

THE OREVALLEY DOSSIER

ID_Documents	Source
Facts about OreValley	Municipality
Aerial photo of the region	Municipality
Economic impact of the Mining Company on OreValley	Municipality
Environmental and food contamination report	EcoCypher (analysis performed by an independent and validated Lab)
Surface water analysis report	EcoCypher (analysis performed by an independent and validated Lab)
Human biomonitoring report	EcoCypher (analysis performed by an independent and validated Lab)

Somes facts about OreValley village:

- Total village population: 2 000 residents (~150 are miners)
- Climate: hot and dry conditions during the summer and very cold, rainy and windy conditions in the winter, snow fall is frequent, particularly above the altitude of 700 m. The average annual rain precipitation in the region is 1200–1400 mm. The average annual temperature is around 14ºC/ 57ºF, ranging from 0ºC/ 32ºF during the winter to about 35ºC/95ºF in the summer
- Mine Company history: Established for more than 50 years. Tin–tungsten mineralization also comprises several sulphides, carbonates and silver sulfosalts. Years of mineral extraction and processing produced crushed and milled wastes stored in 4 large tailings and open-air impoundments (TLI1-TL3). One close to the Mining Company Offices and near a river, both are disactivated and stabilized in geotechnical terms, while the other 2 are still being fed with debris from mining operations

AERIAL PHOTO OF THE REGION

Aerial photo showing the location of OreValley in the region. The village is crossed by a river called "River" (blue line). Upstream and north of OreValley there is another village named UpValley. The Mine tailings are identified in the map in red circles, the tailing near the river is identified as a blue square. The river supplies a dam located to the south that is used in the summer for recreational activities by the region's population. SW1-SW2, MTL1-MTL3 and RTL1-RTL3, marks surface water sampling zones.

Report _Economic Impact of the Mining Company on OreValley ***(data from the last 20 years)***	
PBL title:	Mining Controversies: Public Health Risks versus Economic Benefits
Disclaimer	*This data is purely fictional and intended for illustrative purposes in the "Mining Controversies: Public Health Risks versus Economic Benefits" problem-based learning scenario*
Employment:	• Total village population: 2 000 residents • Employment before mine: 40% (800 employed) • Employment after mine: 60% (1,200 employed) • Jobs created by the mine: 400
Local Economic Development (goods and services):	• Increase in local business/commerce revenue: 25% • New businesses and commercial activities established related to mining operations: 20 (e.g., supply stores, safety equipment, food services)
Investment in local infrastructure	• Roads: 800.000 € • Railroads: 100.000 € • Schools and education: 200.000 € (including annual university grants for the best students from underprivileged families to support higher education opportunities • Healthcare facilities: 300.000 € • Water and sanitation: 150.000 €
Economic Contributions:	• Annual contribution to local government (taxes, fees): 1.000.000 € • Community development funds: 80.000 € per year
Others	• Construction of OreValley Sports Centre: 90.000 € • Old-Theatre restoration: 39.000 € • Promotion of social activities (Summer Music Festival): 25.000 € per year
Potential economic growth with the mine expansion:	• Projection shows a 50% increase in employment and economic benefits
Potential future investments	• Shopping centre • Nursing homes and day centres • Nurseries

Report _Environmental and food contamination

PBL title:	Mining Controversies: Public Health Risks versus Economic Benefits
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OreValley	Date of sampling: last 2 months

Road dusts (n=12)

(mg kg-1)	Mean	Range
As	827	62–3565
Cd	5.5	0.3–19
Cr	20	9–30
Cu	346	52–766
Pb	45	14–128
Zn	462	110–1262

Vegetables: cabbage (n=29) and potatoes (n=11)

Cabbage (roots) (mg kg-1)		
	Mean	Range
As	20	1.6–52
Cd	0.4	0.1–0.7
Cr	56	2.2–244
Cu	23	8.8–43
Pb	6.1	0.9–11.4
Zn	134	62–237

Cabbage (leaves) (mg kg-1)		
	Mean	Range
As	1.4	0.2–2.9
Cd	0.2	0.1–0.4
Cr	2.4	1.6–3.7
Cu	5.1	3.7–7.7
Pb	0.4	0.1–1.5
Zn	64	25–115

Potato (roots) (mg kg-1)		
	Mean	Range
As	15	4.4–22
Cd	2.1	0.3–4.7
Cr	7.1	3.0–15
Cu	20	12–28
Pb	2.4	1.1–3.1
Zn	71	49–92

Potato (tubbers) (mg kg-1)		
	Mean	Range
As	0.8	0.2–1.4
Cd	0.1	0.04–0.13
Cr	1.8	1.4–2.5
Cu	8.9	7.8–9.9
Pb	0.5	0.1–1.5
Zn	23	17–30

Soil Samples (n=4)

(mg kg-1)	Mean
As	118
Cd	4.1
Cr	206
Cu	122
Mn	1169
Ni	41
Pb	24
Zn	388

Soils (guidelines)

(mg kg-1)	*Mean World soils*	*Normal ranges in soils*	*Maximum content in normal soils*	*Median values for the region soils*	*Guideline values for the region soils*
As	5	0.1–40	40	11	22
Cd	0.3	0.01–2	0.7	0.1	0.2
Cr	80	5–1500	150	21	21
Cu	25	2–250	100	16	16
Mn	700	20–10.000	2000	393.5	–
Ni	20	2–750	80	16	16
Pb	17	2–300	100	21	21
Zn	70	1–900	300	54.5	55

UpValley — Date of sampling: last 2 months

Road dusts (n=8)

(mg kg-1)	Mean	Range
As	14	29–1777
Cd	4.8	0.2–15
Cr	13	9–20
Cu	590	62–2379
Pb	15	6–25
Zn	448	45–1028

Vegetables: cabbage (n=29) and potatoes (n=11)

Cabbage (roots) (mg kg-1)		
	Mean	Range
As	0.4	0.01–0.8
Cd	0.1	0.01–0.1
Cr	2.0	1.1–3.9
Cu	32	2.1–264
Pb	2.1	0.03–17.5
Zn	55	17–249

Cabbage (leaves) (mg kg-1)		
	Mean	Range
As	0.2	0.1–0.4
Cd	0.1	0.02–0.1
Cr	1.2	0.8–1.5
Cu	7.4	2.3–41
Pb	0.4	0.1–1.6
Zn	41	16–108

Potato (roots) (mg kg-1)		
	Mean	Range
As	1.7	1.3–2
Cd	0.7	0.4–1.0
Cr	1.9	1.8–1.9
Cu	21	19–23
Pb	1.3	0.9–1.7
Zn	132	778–185

Potato (tubbers) (mg kg-1)		
	Mean	Range
As	0.2	0.1–0.2
Cd	0.1	0.03–0.13
Cr	0.9	0.8–0.9
Cu	6.9	6.8–6.9
Pb	0.001	0.001–0.002
Zn	25	23–26

Soil Samples (n=4)

(mg kg-1)	Mean
As	14
Cd	2
Cr	148
Cu	37
Mn	297
Ni	22
Pb	258
Zn	20

Report_Surface water analysis

PBL title:	Mining Controversies: Public Health Risks versus Economic Benefits
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OreValley surface water analysis

Date of sampling: last 2 months

Table 1: *pH, electrical conductivity, major ions (Cl-, SO42-, Na+, K+, Mg2+ and Ca2+) (mg L-1) and trace elements (µg L-1) in surface waters (n = 8)*

	Upstream the mine tailings (UpValley)		Downstream the mine tailings			"River" tailing seepage water		
	SW1	SW2	MTL1	MTL2	MTL3	RT1	RT2	RT3
pH	6.8	7.1	4.3	5.7	5.7	3.0	2.9	3.2
Conductivity	59	37	350	1,088	851	3,63	4,4	2,02
Si	10	12	18	16	16	103	108	99
Cl	5	4	5	7	6	5	6	4
SO4	4	4	152	605	441	2,991	3,717	1,398
Na	6	4	5	12	10.4	17.8	19.3	11.8
K	1	0.3	1	5	4	6	0.1	1
Mg	1	1	23	73	56	274	357	103
Ca	3	1	22	120	87	287	401	175
Al	13	7	1,5	800	600	149	161	99
As	2	4	5	13	13	2,138	544	146
Ba	4	1	20	17	39	36	29	25
Cd	0.2	0.2	15	58	40	464	393	226
Co	0.3	0.2	6	84	60	2,621	3,33	1,144
Cu	6.3	3	190	600	510	42,7	54,3	20,1
Fe	40	<30	100	100	290	82,5	91	9,4
Li	<4	<4	32	140	101	1,173	1,01	751
Mn	19	4	1,1	7	4,1	88,7	92,6	22,3
Ni	<1	1	110	273	200	2,153	2,827	1,137
Pb	<0.3	<0.3	<22	<22	<22	<22	<22	<22
Rb	2.5	0.6	<18	36	28	76	37	31
Sr	18	9	75	338	256	658	507	380
Zn	18	21	2	6,3	4,8	49,2	44,5	21,9

SW1	"River" water collected upstream the mine tailings (UpValley)
SW2	"River" water collected upstream the mine tailings (UpValley)
MTL1	"River" water collected downstream the mine tailings (1)
MTL2	"River" water collected downstream the mine tailings (2)
MTL3	"River" water collected downstream the mine tailings (3)
RT1	Seepage waters collected in Rio tailings
RT2	Seepage waters collected in Rio tailings
RT3	Seepage waters collected in Rio tailings

Report _Human biomonitoring

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Results of metal(loid) quantification in different matrices from 3 groups of participants

Group characteristics and Ethical considerations:

- Three groups participated in the study, a group living/working in OreValley (n=20), a group living/working on UpValley (n=20) and a group of Miners (n=10)
- Each village group was comprised by healthy male individuals, never smokers, with an average age of 47 years, not working in the Mine Company. The Miners group consisted of 10 healthy men who were never smokers, with an average age of 42 years, working on similar tasks in the Mining Company for at least 9 years.
- All subjects were fully informed about the procedures and objectives of the study and each of them signed an informed consent prior to the study. Ethical approval was obtained from an independent Ethical Board.
- All participants provided blood (B), fingernails (FN), toenails (TN) and hair (H). Biological samples were quantified by ICP-MS for As, Cd, Cr, Hg, Mn, Mo, Ni, Pb, and Se levels; or by ICP-OES for Ca, Cu, Fe, K, Mg, Na, S, Si and Zn levels.

Main results: Internal Dose Biomarkers

(only statistically significant results are shown)

	Group OreValley (n=20)	Group UpValley (n=20)	Miners (n=10)	Statistical significance
As-FN (µg/g)	0.61 ± 1.04	0.14 ± 0.10	1.31 ± 2.88	*P<0.05
As-TN (µg/g)	0.65 ± 0.56	0.22 ± 0.30	1.01 ± 2.36	*P<0.05
As-H (µg/g)	0.14 ± 0.15	0.12 ± 0.14	0.32 ± 0.52	*P<0.05
Cd-H (µg/g)	0.06 ± 0.08	0.04 ± 0.05	0.15 ± 0.24	*P<0.05
Cr-U (µg/g creat)	1.58 ±0.83	1.23 ±0.98	1.12 ±0.68	*P<0.05
Cr-TN (µg/g)	2.17 ± 2.41	1.19 ± 0.99	0.91 ± 0.92	*P<0.05
Cr-H (µg/g)	0.07 ± 0.08	0.07 ± 0.06	0.18 ± 0.33	*P<0.05
Cu-B (mg/L)	0.02 ± 0.24	1.39 ± 0.59	1.95 ± 0.11	*P<0.05
Mg-B (mg/L)	30.18 ± 4.16	27.62 ± 4.74	28.27 ± 3.44	*P<0.05
Mn-U (µg/g creat)	3.07 ±2.52	1.51 ±2.32	1.45 ±0.91	*P<0.05
Mn-TN (µg/g)	2.84 ± 3.17	1.25 ± 1.29	1.98 ± 3.19	*P<0.05
Mn-H (µg/g)	0.77 ± 0.69 1	0.70 ± 0.84 0	1.50 ± 1.65	*P<0.05
Pb-B (µg/L)	34.08 ± 39.39	36.01 ± 25.81	63.72 ±58.56	*P<0.05
Pb-U (µg/g creat)	2.81 ± 5.3	2.43 ± 2.26	4.59 ± 6.82	*P<0.05
Pb-H (µg/g)	1.45 ± 2 3.02	1.55 ± 2.92	3.02 ± 3.00	*P<0.05
Zn-H (µg/g)	176.47 ± 89.28	158.49 ± 80.4	196.30± 88.48	*P<0.05

Potential confounding variables:

	Group OreValley	Group UpValley
Water consumption:		
Bottled water	7%	5%
Tap water	56%	51%
Spring water	37%	44%
Fish consumption:		
0-2 portions/week	61%	47%
>2 portions/week	39%	53%
Agriculture:		
No	34%	15%
Yes	66%	85%