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From Soil to Food: Integrated Risk-Based Assessment of Heavy Metals, Radionuclides and Pesticide Residues in Irrigated Agroecosystems of The Syrdarya Region, Uzbekistan

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Abstract: Fragmented contaminant monitoring can miss the point at which a low soil signal becomes a food-chain priority. This study integrated aggregated dissertation datasets on potentially toxic elements, anthropogenic radionuclides and pesticide residues across irrigated agroecosystems of the Syrdarya Region, Uzbekistan. The underlying programme covered 20 control points in Gulistan, Khavast and Mirzaabad during 2020–2025; observation windows differed among datasets. Soil metals were measured by atomic absorption methods, 137Cs and 90Sr by gamma- and beta-spectrometric procedures, and selected pesticides by gas–liquid chromatography. Because raw replicate-level data, complete detection-limit metadata and measurement uncertainties were unavailable, the analysis was descriptive. Ratios to the dissertation's analyte–matrix working criteria were used only for within-pair prioritisation, not as universal regulatory compliance or health-risk metrics. Soil Cu, Zn, Cd and Pb remained low relative to those criteria (maximum ratio 20.7%). By contrast, the highest vegetable signals reached 95% for Pb, 62.5% for Cd, 100% for As and 90% for Hg. Regional mean criterion fractions in beef were 60.8% for Pb, 46.0% for Cd, 43.0% for As and 20.0% for Hg; milk values were 42.0%, 46.7%, 36.0% and 40.0%, respectively. Soil radionuclide ratios were low, but maximum 90Sr fractions were 90% in beef, 88% in mutton and 98% in milk. All targeted pesticide observations in vegetables were below 0.001 mg kg−1; this denotes non-detection within a limited panel rather than absence. The resulting tiered framework prioritises confirmatory analysis of milk 90Sr and crop As/Pb/Hg, paired soil–plant sampling, and explicit reporting of n, LOD/LOQ and uncertainty. The study demonstrates that a transparent soil-to-food dashboard is more informative than a single cross-contaminant index when datasets are heterogeneous and regulatory thresholds are commodity-specific.

Keywords: Irrigated agriculture; soil–plant–animal continuum; potentially toxic elements; caesium-137; strontium-90; pesticide residues; food safety; Central Asia.

Highlights

- A 20-point soil-to-food monitoring programme was reanalysed as one integrated evidence chain.
- Low soil ratios did not preclude high crop-specific or animal-product priority signals.
- Milk 90Sr reached 98% of the study-specific working criterion and requires confirmation.
- Non-detect pesticide results were retained as censored observations, not converted to zero.

INTRODUCTION:

Irrigated agriculture links soil quality, water management, crop production and food safety more tightly than rain-fed systems. Salinity, low organic matter, repeated fertilizer and pesticide inputs, atmospheric deposition and irrigation-water quality can alter both contaminant stocks and their accessibility to biota. The FAO–UNEP global assessment identifies agricultural soils as both receptors and secondary sources of contaminants, while emphasising that effects depend on source, persistence, soil properties and land management [2]. For potentially toxic elements, total concentration alone cannot explain transfer: pH, carbonate content, salinity, redox status, texture, organic matter and competing ions jointly control retention and uptake [3,4].

The Syrdarya Region occupies the eastern Mirzacho'l plain and is dominated by irrigated agriculture. Its 427,618 ha soil-resource base includes 232,472 ha of grey-meadow soils (54.3%) and 95,374 ha of meadow soils (22.3%). Of 227,816 ha of cropped land, cereals account for 40.78% and technical crops for 35.36%; together these two groups represent 76.14% of the cropped area [1]. Consequently, even modest environmental signals may be multiplied across a large and concentrated production base. The same landscape is affected by secondary salinisation, shallow groundwater and low humus, factors that can modify the movement of metals and radionuclides.

Regional evidence from irrigated Central Asia reinforces the need for site-specific interpretation. Studies in southern Kazakhstan found strong spatial and depth-related variation in salinity and metals, and work in the Syr Darya watershed showed that enrichment patterns depend on both geography and soil profile [5,6]. These findings argue against transferring a threshold or transfer coefficient from one soil without considering texture, salinity and sampling depth. They also show why a low regional mean should not conceal a commodity-specific maximum.

The food-chain problem is inherently multi-hazard. Metals such as Pb, Cd, As and Hg are persistent and can accumulate in edible tissues. The fission products 137Cs and 90Sr are relevant because caesium behaves partly as a potassium analogue and strontium as a calcium analogue; nevertheless, their actual transfer is determined by soil mineralogy, exchangeable nutrient status, crop species, animal diet and physiological state [8–10]. Pesticide residues form a different analytical class: a result below a detection limit is censored evidence about a defined target panel, not proof that all active substances or metabolites are absent. These three contaminant classes therefore cannot be defensibly collapsed into a single toxicity score without harmonised toxicological endpoints and exposure data.

International practice increasingly emphasises traceable sampling, method validation, uncertainty and matrix-specific interpretation. Codex contaminant limits are commodity-specific and tied to international trade [22]. IAEA transfer handbooks distinguish environmental concentration ratios from feed-to-animal-product transfer coefficients [8,9,14,15]. Modern pesticide-residue quality control requires explicit LOD/LOQ, recovery, calibration and confirmation criteria [21,23]. A monitoring programme becomes decision-ready only when these concepts are preserved during aggregation.

The dissertation underlying this study contains an unusually broad soil–crop–animal evidence base, but its results were distributed across separate contaminant and matrix tables [1]. The objective of this article was therefore to integrate the aggregated results into a transparent risk-based framework. Specifically, we (i) reconstructed comparable descriptive indicators; (ii) separated means from maxima; (iii) identified pairs approaching the study's own working criteria; (iv) audited transfer-factor and coefficient consistency; and (v) converted the evidence into tiered monitoring actions. The analysis does not estimate dietary dose, cancer risk, hazard quotient or statistical significance because the required individual concentrations, consumption data, body weights, replicate counts and uncertainties were not available.

METHODS

1 Study area and monitoring design

The source investigation was conducted during 2020–2025 in irrigated grey-meadow and meadow agroecosystems of the Syrdarya Region, Uzbekistan. Twenty control points were located in three reference landscapes: Gulistan–Hamid Olimjon, Khavast–Farhod and Mirzaabad–Oqoltin. The network combined eight background-representative points, eight territorially prioritised points and four trophic-chain points. Soil was collected from the 0–30 cm cultivated layer in early spring and at harvest. The dissertation reports cartographic reconnaissance, field observation and laboratory analysis; however, the present article uses only aggregated tables and does not claim access to the individual laboratory records [1].

The monitoring domains were not perfectly synchronous (Table 1). Soil-metal time series covered 2021–2023; soil radionuclides were available for 2021, 2022 and 2025; animal radionuclides and pesticide surveillance extended to 2025. Crop and animal metal tables were multi-year summaries. Each result is therefore interpreted within its own observation window, and apparent cross-domain differences are not treated as simultaneous cause-and-effect observations.

2 Analytical scope

Soil Cu, Zn, Cd and Pb were determined after acid preparation by atomic absorption spectrophotometry and electrothermal atomic absorption procedures. Food-product tables contained Pb, Cd, As and Hg. The source reports 137Cs determination by gamma spectrometry and 90Sr by beta-spectrometric procedures. These method classes are consistent with the measurement principles covered by ISO 18589-3 and ISO 18589-5, but the source tables do not provide detector efficiency curves, chemical yield, blank results, certified reference-material recoveries or expanded uncertainty; international-standard compliance is therefore not claimed [24,25].

Table 1. Evidence structure used in the integrated reanalysis

Domain	Matrices / locations	Analytes	Window	Analytical basis	Resolution used here
Territorial context	Syrdarya Region	Soil and crop-area structure	2023–2024 context	Administrative and cartographic records	Regional totals and shares
Soil metals	0–30 cm; Gulistan, Khavast, Mirzaabad	Cu, Zn, Cd, Pb	2021–2023	AAS and electrothermal AAS	Nine district–year aggregate cells
Crop metals	Grains and vegetables	Pb, Cd, As, Hg	Multi-year aggregate	Atomic-absorption procedures	Reported means/ranges and criterion fractions
Animal-product metals	Beef and milk; three districts	Pb, Cd, As, Hg	Multi-year aggregate	Laboratory concentration measurements	District and regional aggregates
Soil radionuclides	Three irrigated soil groups	137Cs, 90Sr	2021, 2022, 2025	Gamma and beta spectrometry	Nine soil-type–year cells

Domain	Matrices / locations	Analytes	Window	Analytical basis	Resolution used here
Crop radionuclides	Grain, straw and fodder	137Cs, 90Sr	Multi-year aggregate	Activity concentration and reported TF	Crop-component summaries
Animal radionuclides	Beef, mutton, milk	137Cs, 90Sr	2021–2025	Gamma and beta spectrometry	Regional means and maxima
Pesticides	Potato, beet, carrot, cabbage; animal products	HCH, DDT, Decis, Karate; selected pyrethroids	2021–2025	Gas–liquid chromatography	Detection statements; vegetable LOD <0.001 mg kg−1

AAS, atomic absorption spectrometry; TF, reported soil-to-plant transfer factor; LOD, limit of detection. Observation windows and sample counts were not uniform across domains. “Multi-year aggregate” means that the source table did not support a complete annual raw-data reconstruction.

Selected pesticide residues were analysed by gas–liquid chromatography on a Kristall-2000 system. The vegetable panel included HCH, DDT, Decis and Karate, with a reported detection limit below 0.001 mg kg−1. Additional animal-product text referred to DDT, HCH and pyrethroids such as cypermethrin, permethrin and deltamethrin, but did not specify a common LOD. The original QuEChERS approach and current quality-control guidance illustrate the metadata needed for internationally comparable residue results, including matrix-matched validation, recovery and confirmation [21,23]. We cite these as benchmarks, not as methods retrospectively attributed to the dissertation.

The dissertation discusses acid-extractable and mobile metal fractions. In this reanalysis, acid-extractable concentration is treated as an operationally defined pool and not equated with bioavailability. DTPA or $CaCl_2$ extraction can support agronomic or mobility screening, but no single extractant directly measures human or ecological exposure [7]. The article therefore avoids the term ‘bioavailable concentration’ unless matched uptake evidence exists.

3 Recalculation and prioritisation

For a given analyte i and matrix m, the screening fraction was calculated as $K(i,m) = C(i,m)/L(i,m)$, where C is the reported concentration or activity and L is the corresponding internal working criterion used in the dissertation. K was expressed as a percentage. Because L values were commodity- and analyte-specific, K was compared only within the same analyte–matrix pair. We did not sum metal, radionuclide and pesticide ratios into a universal index. Such a sum would imply toxicological equivalence that the data do not support.

For the nine district–year soil-metal aggregate cells, arithmetic mean, sample standard deviation (SD), range and coefficient of variation ($CV = 100 \times SD/mean$) were recalculated. Descriptive change was computed between the 2021 and 2023 district averages. These statistics quantify variation among table cells; they are not estimates of analytical precision. No p values or confidence intervals were generated because raw replicates and sample n were unavailable.

For radionuclides in crops, the dissertation reported soil-to-plant transfer factors. We recalculated the straw-to-grain contrast $R = TF(straw)/TF(grain)$ for each cereal and radionuclide. Absolute TF should normally use paired soil and plant activities on a documented dry-mass basis [8,9,11]. Because pairing and mass-basis metadata were absent, only the within-table ratio was retained. For pesticide results, below-LOD observations were kept as censored values; zeros, means and residue sums were not imputed.

Monitoring tiers were assigned using a transparent managerial rule: Tier 1 for a confirmed or reported maximum at least 80% of a working criterion, or a material internal inconsistency; Tier 2 for a mean between 25% and 80%, an upward descriptive trend or high trophic relevance; and Tier 3 for a low current signal requiring sentinel surveillance. The 80% trigger is an operational early-warning choice, not a statutory limit.

RESULTS

1 Territorial exposure context

The regional production system is spatially concentrated. Grey-meadow and meadow soils together occupy 76.6% of the recorded soil area, while cereals and technical crops account for 76.14% of cropped land. This concentration supports a stratified rather than uniformly random surveillance design: stable background points characterise long-term conditions, priority points capture industrial, roadside, irrigation or salinity gradients, and trophic-chain points link soil with edible products. The three reference landscapes provide this structure, but the current aggregated tables do not retain point identifiers; site-level hotspots cannot therefore be mapped from the article dataset.

2 Soil metals

Across nine district–year cells, mean concentrations were 0.527 mg kg−1 Cu, 1.034 mg kg−1 Zn, 0.033 mg kg−1 Cd and 0.734 mg kg−1 Pb (Table 2). Maximum within-pair criterion fractions were 20.7%, 5.1%, 10.0% and 13.7%, respectively. The district-level summed ratios reported in the previous reanalysis were 0.373 for Gulistan, 0.448 for Khavast and 0.408 for Mirzaabad; all were below one under the dissertation's working system. Because the component thresholds are analyte-specific, the sums describe local screening intensity rather than toxicological risk.

Cd had the largest CV (25.98%) and a +22.22% descriptive change between 2021 and 2023, although the absolute concentration remained small. Pb increased 7.04%; Cu was unchanged and Zn declined 0.32%. These are signals for temporal design, not evidence of statistically significant trends. A defensible trend test would require the same georeferenced points, consistent laboratory performance and replicate-level uncertainty across years.

Table 2. Recalculated soil-metal statistics from nine district–year aggregate cells

Element	Mean ± SD (mg kg−1)	Range	CV (%)	Maximum criterion fraction (%)	2021→2023 change (%)
Cu	0.527 ± 0.060	0.45–0.62	11.43	20.7	0.00
Zn	1.034 ± 0.107	0.88–1.18	10.32	5.1	−0.32
Cd	0.033 ± 0.009	0.02–0.05	25.98	10.0	+22.22
Pb	0.734 ± 0.048	0.68–0.82	6.53	13.7	+7.04

SD and CV describe variability among aggregate district–year cells, not analytical replicate uncertainty. The change compares district-averaged 2021 and 2023 values; no significance test was possible.

Table 3. Food-chain metal signals relative to study-specific working criteria

Matrix	Pb (%)	Cd (%)	As (%)	Hg (%)	Interpretation
Vegetables: mean of group-level means	38.1	3.6	42.6	15.4	Central tendency remained below half of the relevant working criteria

Matrix	Pb (%)	Cd (%)	As (%)	Hg (%)	Interpretation
Vegetables: mean of reported maxima	79.4	39.5	85.6	63.3	Upper-tail signal was substantially higher than the mean
Vegetables: highest commodity signal	95.0	62.5	100.0	90.0	Confirm crop identity, units, wet/dry basis and replicate result
Beef: regional mean	60.8	46.0	43.0	20.0	Routine product-specific surveillance
Milk: regional mean	42.0	46.7	36.0	40.0	Routine metal surveillance; retain district stratification

Percentages are ratios to the dissertation's commodity- and analyte-specific working criteria. They must not be compared directly with current Codex maximum levels without reconciling commodity definitions, analytical basis and the legally applicable standard [22].

Table 4. Radionuclide results and diagnostic ratios

Compartment	Indicator	137Cs	90Sr	Key reading
Soil: irrigated grey-meadow	2021–2025 activity (Bq kg−1)	3.6 → 4.8	1.10 → 1.20	Low criterion fractions; Cs increased 33.3%
Soil: meadow	2021–2025 activity (Bq kg−1)	4.9 → 6.2	1.20 → 1.50	Highest combined soil signal among the three groups
Soil: saline grey-meadow	2021–2025 activity (Bq kg−1)	3.1 → 4.0	0.85 → 1.00	Lowest combined soil signal
Crops: straw/grain TF ratio	Wheat; maize; barley	1.23; 2.22; 1.38	1.95; 1.34; 1.10	Reported TF generally favoured straw; barley needs paired-data audit
Animal products: regional mean	Beef; mutton; milk	3.3; 2.8; 2.2	31.0; 33.3; 17.9	Bq kg−1 for meat and Bq L−1 for milk
Animal products: maximum criterion fraction	Beef; mutton; milk	3.75%; 2.88%; 4.10%	90%; 88%; 98%	90Sr, especially milk, drives confirmatory priority

The "TF ratio" compares reported transfer factors for straw and grain. A defensible absolute TF requires paired soil–plant observations on a common mass basis. Working-criterion fractions are screening signals, not dose estimates.

3 Metals in crops and animal products

Vegetable group means were 0.190 mg kg−1 Pb, 0.0072 mg kg−1 Cd, 0.0128 mg kg−1 As and 0.0031 mg kg−1 Hg. When normalised to the internal commodity-specific criteria, the mean signals were 38.1%, 3.6%, 42.6% and 15.4%. The mean of reported maxima was much higher—79.4%, 39.5%, 85.6% and 63.3%—showing why averaging alone is inadequate for food surveillance. The highest commodity-specific signals reached 95% for Pb, 62.5% for Cd, 100% for As and 90% for Hg. These values do not establish a legal exceedance because commodity identity, exact standard, wet/dry basis and uncertainty must first be reconciled. They do justify immediate confirmation.

Grain ranges also varied by crop. Pb ranged from 0.12–0.45 mg kg−1 in wheat, 0.15–0.52 in maize and 0.14–0.48 in barley. Cd ranges were 0.015–0.040, 0.020–0.050 and 0.017–0.045 mg kg−1, respectively. The crop ordering changed by element, supporting element-specific rather than generic ‘accumulator crop’ labels.

In beef, regional mean fractions were highest for Pb (60.8%), followed by Cd (46.0%), As (43.0%) and Hg (20.0%). Milk fractions were more even: Cd 46.7%, Pb 42.0%, Hg 40.0% and As 36.0%. Recalculation also exposed a reporting issue: the source’s published overall coefficient for beef was 0.400, whereas the transparent mean of the four element fractions was 0.425; for milk, 0.450 was published versus 0.412 recalculated. The discrepancy is modest but material for reproducibility and illustrates why formulas and denominator choices should accompany summary coefficients.

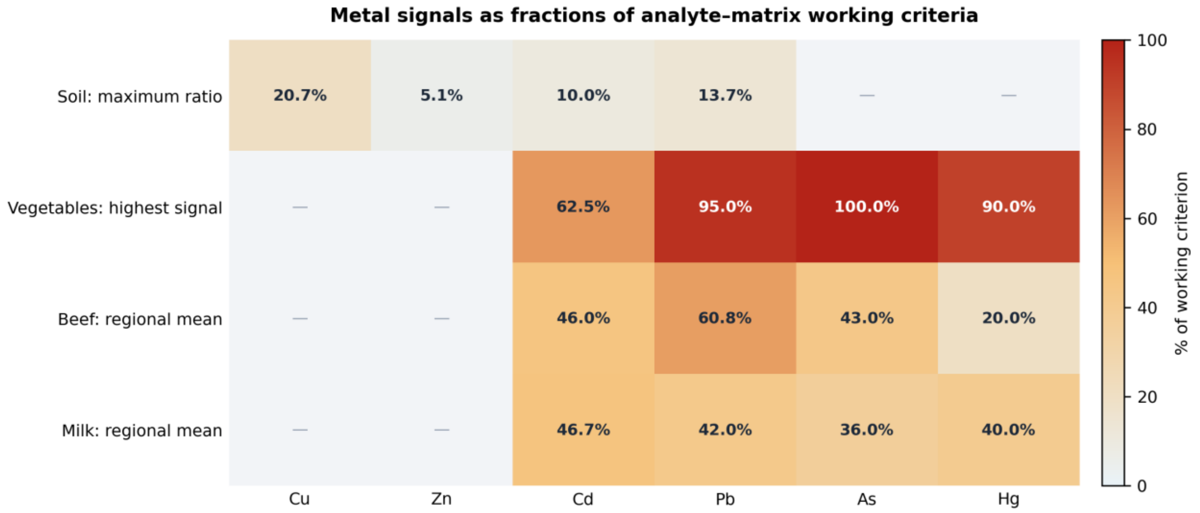

Figure 1. Cross-compartment metal signals expressed as percentages of the dissertation’s analyte–matrix working criteria.

4 Radionuclides in soil, crops and animal products

Soil 137Cs means across the three observation years were 4.20 Bq kg−1 in irrigated grey-meadow soil, 5.57 in meadow soil and 3.63 in saline grey-meadow soil. Corresponding 90Sr means were 1.22, 1.45 and 0.98 Bq kg−1. Meadow soil had the largest combined screening signal, but even its maximum criterion fractions were only 3.44% for 137Cs and 3.00% for 90Sr. Between 2021 and 2025, 137Cs rose 26.5–33.3% across soil groups and 90Sr rose 9.1–25.0%; the sparse three-year sequence cannot distinguish trend from sampling or measurement variability.

Crop activity differed between edible grain and straw. Reported mean 137Cs activities were 2.5 Bq kg−1 in wheat grain and 3.5 in straw, 3.1 and 4.4 in maize, and 3.3 and 3.6 in barley. For 90Sr, the corresponding values were 1.4 and 2.2, 1.9 and 2.6, and 3.5 and 1.9 Bq kg−1. The reported TF table nevertheless yielded straw/grain ratios above one for both radionuclides in all three cereals (Figure 3). The direction for barley 90Sr is inconsistent with the activity-concentration table, suggesting different sample pairing, moisture basis or aggregation. It should be audited before mechanistic interpretation.

Animal-product 137Cs remained a small fraction of the internal working criteria: maxima represented 3.75% in beef, 2.88% in mutton and 4.10% in milk. 90Sr produced the dominant radiological screening signals. Regional means were 31.0 Bq kg−1 in beef, 33.3 Bq kg−1 in mutton and 17.9 Bq L−1 in milk; maxima represented 90%, 88% and 98% of the respective working criteria. No reported value exceeded its criterion, but milk at 98% leaves little analytical margin and should be repeated with chemical-yield recovery, uncertainty and sample identity reported.

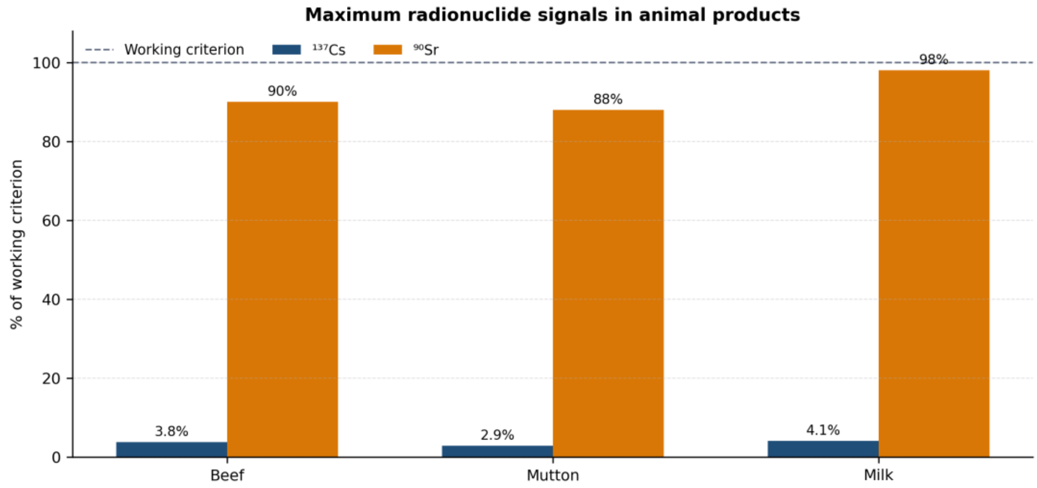

Figure 2. Maximum radionuclide activities in animal products as fractions of the study-specific working criteria.

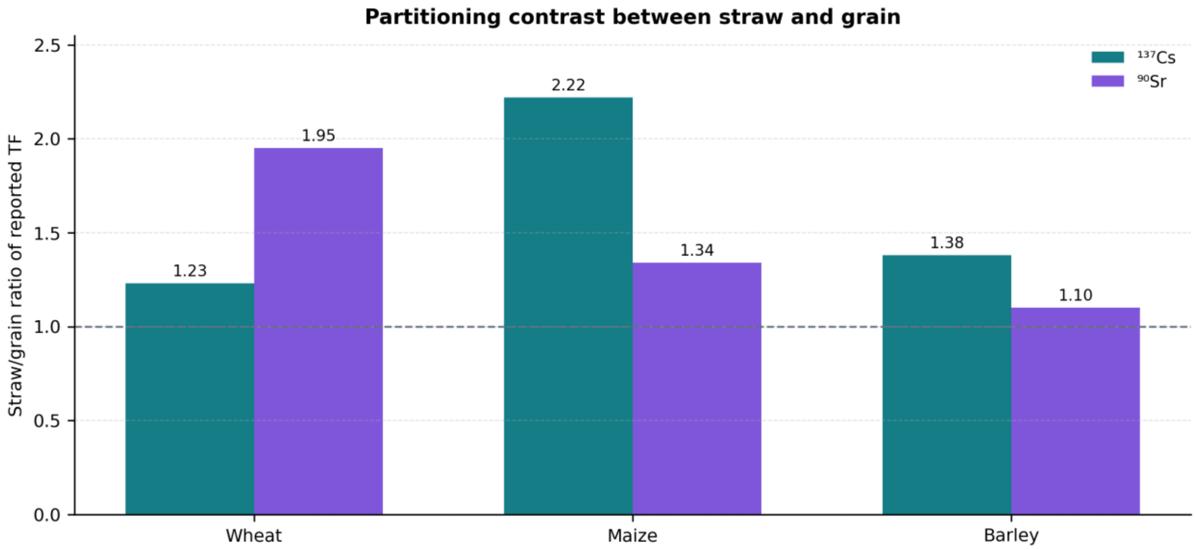

Figure 3. Straw-to-grain ratios calculated from the transfer factors reported in the dissertation.

5 Pesticide residues

During 2021–2025, targeted measurements of HCH, DDT, Decis and Karate in potato, beet, carrot and cabbage from the three reference areas were reported below 0.001 mg kg−1. The source table included different cell counts: for example, Gulistan HCH surveillance included five observations for potato, beet and carrot and four for cabbage, while some Decis and Karate combinations were not tested. Thus, the correct conclusion is zero detections among the tested analyte–commodity cells, not zero pesticide concentration and not full coverage of pesticide use.

The animal-product narrative reported no detections of DDT, HCH or selected pyrethroids in more than 80 meat/fat and approximately 90 milk samples. Because a common LOD, recovery and confirmation protocol was not stated, these results remain qualitative. They support continued sentinel status, while broader parent-compound and metabolite panels are needed if pesticide-use patterns change.

6 Integrated priority structure

The integrated evidence did not support a single cross-contaminant risk score. Instead, priority was concentrated in specific pairs: milk–90Sr, vegetable–As, vegetable–Pb and vegetable–Hg entered Tier 1 because their reported maxima were at or above 80% of the internal criteria. The crop TF inconsistency also entered Tier 1 as a data-quality trigger. Beef metals, milk metals, meat 90Sr and meadow-soil radionuclides formed Tier 2. Soil metals and below-LOD pesticide findings remained Tier 3 sentinel targets (Table 5).

Table 5. Proposed risk-based monitoring tiers for the Syrdarya agroecosystem

Tier	Trigger used in this reanalysis	Priority pairs	Minimum next action	Decision rule
1 — confirm	Maximum ≥80% of a working criterion, or internal inconsistency	Milk–90Sr; vegetables–As/Pb/Hg; crop TF audit	Resample the same source; duplicate preparation; certified reference material; report uncertainty	Escalate only after identity, units, mass basis and result are confirmed
2 — intensified routine	Mean 25–80%, upward descriptive trend, or strong trophic relevance	Beef–Pb/Cd/As; milk–Pb/Cd/Hg; meat–90Sr; meadow soil radionuclides	Seasonal paired soil–feed–product design; retain district and commodity strata	Review annually and move to Tier 1 if a confirmed maximum reaches the trigger
3 — sentinel	Low current ratio but persistent contaminant or incomplete target panel	Soil Cu/Zn/Cd/Pb; soil 137Cs/90Sr; pesticides below LOD	Maintain background points; broaden pesticide parent/metabolite panel; report LOD/LOQ and detection frequency	Do not interpret non-detect as zero; reassess after method or land-use change

Tiers allocate sampling effort; they are not legal classifications. A jurisdictional compliance decision requires the current commodity-specific standard, validated method, sampling plan and measurement uncertainty.

DISCUSSION

The central result is a decoupling between low soil screening ratios and higher product-specific signals. This does not imply that contaminated food arose from uncontaminated soil. It reflects several analytical realities: the soil and food tables covered different elements, observation windows and extraction bases; product maxima can represent local or seasonal conditions hidden by regional means; atmospheric deposition, irrigation water, foliar contact, feed sourcing and processing may intervene; and the working criteria differ by matrix. Therefore, the correct inference is methodological: soil compliance alone is not an adequate substitute for food monitoring.

The soil-metal profile was comparatively stable at the aggregate level, with low maximum criterion fractions. Yet Cd showed the largest relative variability and descriptive increase. In calcareous irrigated soils, pH and carbonates can strongly retain many metals, while salinity, dissolved organic ligands and changing redox or irrigation regimes may alter mobility [3,5–7]. Acid digestion or strong-acid extraction estimates a broad operational pool. Calling that pool ‘mobile’ or ‘bioavailable’ overstates what the method proves. Future work should pair total digestion with a clearly specified extractant such as DTPA or CaCl2, plus pH, electrical conductivity, organic carbon, texture and carbonate content.

Crop results show the importance of separating central tendency from the upper tail. The mean vegetable signal was moderate or low, while the highest As, Pb and Hg ratios approached the internal criteria. Codex values cannot be substituted mechanically because commodity categories and legal coverage differ [22]. A confirmation protocol should first verify the crop and edible portion, homogenisation, fresh- versus dry-mass basis, method blank, recovery, certified reference material and expanded uncertainty. Only then should the result be compared with the currently applicable national and export-market standard.

The radionuclide pattern is biologically plausible in one respect: 90Sr can show greater plant availability than 137Cs in many semi-arid systems, and nutrient analogues Ca and K influence transfer [8,11–13,18–20]. Central Asian evidence has also demonstrated strong soil-type control of radiostrontium uptake [18]. However, generic transfer factors span orders of magnitude and must not replace local paired measurements. The barley inconsistency in this dataset confirms the need to preserve sample pairing and dry-mass convention. A transfer factor derived from unmatched regional means is an ecological ratio, not a causal coefficient.

The animal-product results further demonstrate why the term 'transfer coefficient' must be used carefully. A feed-to-milk or feed-to-meat coefficient requires daily intake and equilibrium product activity, with units such as d L−1 or d kg−1 [14–17]. The dissertation's Ko values are fractions of working criteria, not biological transfer coefficients. The high milk 90Sr maximum therefore cannot be used to infer a feed-to-milk transfer parameter or radiation dose. It is an early-warning measurement that merits immediate replicate confirmation and a paired feed, water and soil investigation.

Pesticide non-detections are reassuring but bounded. A result <0.001 mg kg−1 indicates that the target analyte was not quantified above that method's detection threshold in the tested sample. It does not cover untested active ingredients, transformation products or dates outside the sampling window. International residue programmes preserve detection frequency, LOD/LOQ, recovery and measurement uncertainty and usually use multiresidue confirmation [21,23]. The Syrdarya programme can be strengthened by linking the analytical panel to actual pesticide-use records and adding metabolites relevant to persistence and toxicity.

The proposed tier system converts these limitations into an operational advantage. It directs expensive confirmatory work to the few pairs with small safety margins while maintaining lower-cost sentinel monitoring elsewhere. The system also avoids an opaque composite score. A universal sum of Pb, 90Sr and pesticide ratios would be dimensionless but scientifically misleading because their toxicological endpoints, time scales, detection processes and regulatory denominators differ. A dashboard of pair-specific signals preserves the information needed for decisions.

This study has important limitations. First, it is a secondary reanalysis of aggregated dissertation tables. The absence of raw concentrations, sample identifiers and uncertainty prevents inferential statistics, geostatistical mapping, dietary exposure assessment and independent outlier verification. Second, sample counts and observation windows differ among domains. Third, several working criteria were internal to the dissertation and may not match current national or export-market requirements. Fourth, non-detect data were available only for a limited pesticide panel. Fifth, transfer-factor mass basis and pairing were incompletely documented. These constraints are explicitly reflected in the cautious interpretation and monitoring recommendations.

Despite these limitations, the integrated approach offers a reproducible contribution. All recalculated indicators can be traced to a stated formula and an aggregated source table. Means and maxima are separated, non-detects are not converted to zero, inconsistencies are disclosed, and no health-risk claim is made without exposure data. This is the level of analytical transparency expected for an international journal submission and provides a clear roadmap for a subsequent raw-data paper.

CONCLUSIONS

An integrated reanalysis of the Syrdarya monitoring programme identified a generally low soil-metal and soil-radionuclide screening profile but a more differentiated food-chain pattern. The highest actionable signals were vegetable As, Pb and Hg and animal-product 90Sr, particularly the milk maximum at 98% of the dissertation's working criterion. These findings do not demonstrate a legal exceedance or health risk; they identify where confirmation and better metadata have the greatest value.

Future monitoring should preserve the 20-point network while pairing soil, irrigation water, plant or feed, and animal product at the same location and time. Tier 1 samples should be repeated with duplicate preparation, certified reference materials, recovery and expanded uncertainty. Crop results should report edible portion and moisture basis; radionuclide TF should use matched dry-mass data; pesticide reports should retain LOD, LOQ, detection frequency and target-panel coverage. This design will allow subsequent statistical trend analysis and dietary exposure assessment without overstating the present evidence.

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