



Lithological context of source-audited nickel hyperaccumulator and accumulator plant records in Türkiye: A descriptive geobotanical synthesis

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Türkiye’de kaynak denetimli nikel hiperakümülatör ve biriktirici bitki kayıtlarının litolojik bağlamı: Açıklayıcı bir jeobotanik sentez

Abstract: Published records of nickel (Ni) hyperaccumulator and accumulator plants in Türkiye are relevant to serpentine ecology, metallophyte biogeography and future field studies. However, the available records differ markedly in physiological support, taxonomic treatment and spatial precision. This study compiled 66 source-linked candidate evidence entries from accessible literature syntheses and primary research. Each entry links a taxon reported in a source to the available Ni-related evidence and locality information recoverable from that source; it is not equivalent to an independent occurrence record, a unique locality or a newly confirmed Ni-hyperaccumulator observation. An additional 88 GBIF occurrence records were screened separately for occurrence-data quality and possible specimen context and were not used as direct physiological evidence of Ni accumulation. A descriptive lithological-context map was prepared in Google Earth Engine using the MTA 1:500,000 lithological dataset and an attribute-based crosswalk of core Ni-relevant lithologies and broader ophiolitic context units. The map displays 12 unique A-class source-supported localities representing 14 A-class taxon–locality associations, together with one C-class representative locality. At the evidence-entry level, the final spatial-confidence distribution was A=12, B=0, C=1, D=51 and E=2. Rather than proposing a national occurrence model or a revised estimate of Ni-hyperaccumulator richness, the study identifies which published evidence is suitable for descriptive spatial interpretation and which records require further verification.

Key words: Lithological context, nickel hyperaccumulation, source-audited evidence, spatial confidence, ultramafic flora

Özet: Türkiye’de yayımlanmış nikel (Ni) hiperakümülatör ve biriktirici bitki kayıtları, serpantin ekolojisi, metallofit biyocoğrafyası ve gelecekteki saha çalışmalarının planlanması bakımından önem taşımaktadır. Bununla birlikte, mevcut kayıtların fizyolojik kanıt gücü, taksonomik kullanımı ve mekânsal kesinliği belirgin farklılıklar göstermektedir. Bu çalışmada, erişilebilir literatür sentezleri ve birincil araştırmalardan 66 kaynak bağlantılı aday kanıt girdisi derlenmiştir. Her bir girdi, bir kaynaktan bildirilen taksonu, o taksona ilişkin erişilebilen Ni kanıtını ve aynı kaynaktan geri kazanılabilen lokalite bilgisini bir araya getirmektedir; dolayısıyla bağımsız bir yayımlı kaydı, benzersiz bir lokalite veya yeni doğrulanmış bir Ni hiperakümülatör gözlemi olarak değerlendirilmemelidir. Ayrıca, 88 GBIF yayımlı kaydı veri kalitesi ve olası örnek bağlamı bakımından ayrı olarak denetlenmiştir; Ni birikimine doğrudan fizyolojik kanıt olarak kullanılmamıştır. MTA 1:500.000 ölçekli litoloji verisi ile çekirdek Ni ile ilişkili litolojileri ve daha geniş ofiyolitik bağlam birimlerini ayıran öznetelik temelli bir sınıflama kullanılarak Google Earth Engine ortamında açıklayıcı bir litolojik bağlam haritası hazırlanmıştır. Haritada, 14 A-sınıfı takson–lokalite ilişkisini temsil eden 12 benzersiz A-sınıfı kaynak koordinatlı lokalite ile bir C-sınıfı temsili lokalite gösterilmiştir. Girdi düzeyindeki nihai mekânsal güven dağılımı A=12, B=0, C=1, D=51 ve E=2’dir. Çalışma, ulusal bir yayımlı modeli veya Ni hiperakümülatör zenginliğine ilişkin yeni bir tahmin sunmak yerine, hangi yayımlanmış kanıtların açıklayıcı mekânsal yorumlamaya uygun olduğunu ve hangi kayıtların ileri doğrulama gerektirdiğini ortaya koymaktadır.

Anahtar Kelimeler: litolojik bağlam, nikel hiperakümülasyonu, kaynak denetimli kanıt, mekânsal güven, ultramafik flora

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1. Introduction

Nickel (Ni) hyperaccumulation is one of the most distinctive physiological adaptations reported in metallophyte plants. Hyperaccumulator taxa can take up and tolerate unusually high concentrations of particular elements in their aboveground tissues without exhibiting the severe toxicity symptoms expected in most plants. Since the early synthesis of Baker and Brooks (1989), this phenomenon has attracted attention not only as a botanical curiosity, but also because of its relevance to plant adaptation, serpentine ecology, phytoremediation and agromining. Nevertheless, the term “hyperaccumulator” requires careful use. It refers to a physiological condition demonstrated through plant-tissue chemistry and cannot be inferred simply from the occurrence of a taxon on

metalliferous terrain or from its presence in a herbarium or biodiversity database (van der Ent et al., 2013; Krämer, 2010).

Nickel is particularly important in this context because many known Ni hyperaccumulator taxa occur on ultramafic and serpentine-derived soils. Such substrates commonly contain elevated concentrations of Ni, chromium, cobalt and magnesium, while often being deficient in essential nutrients and characterized by low calcium-to-magnesium ratios. These edaphic conditions exert strong ecological filtering on plant communities and may promote local adaptation, endemism and metallophyte specialization (Kruckeberg, 1984; Brady et al., 2005; Harrison and Rajakaruna, 2011). The close relationship between Ni-rich substrates and specialized plant assemblages has made

ultramafic landscapes important natural laboratories for investigating plant–substrate interactions, metal tolerance and the biogeography of metallophytes.

The global literature indicates that Ni is among the elements most frequently associated with metal-hyperaccumulating plants (Reeves et al., 2018; Deng et al., 2018; Reeves et al., 2021). However, the biological interpretation of Ni accumulation depends on several linked sources of evidence: correct taxonomic identification, reliable plant-tissue measurements, an adequately documented sampling context and, where possible, information on the underlying substrate or soil chemistry. A taxon listed as a Ni hyperaccumulator in a review may therefore represent a well-supported physiological record, whereas another may require confirmation through recovery of the primary study, reassessment of voucher material or renewed field sampling. This distinction becomes particularly important when historical records are transferred into spatial databases or national-scale maps.

Türkiye provides an important setting for such an assessment. The country contains extensive ophiolitic belts, ultramafic bodies and serpentinitized terrains associated with its complex tectonic history and distributed across several biogeographical regions (Okay and Tüysüz, 1999; Yiğit, 2009; Adıgüzel and Reeves, 2012). These areas support a distinctive serpentine flora and include numerous endemic, restricted-range and metal-tolerant taxa (Kurt et al., 2013; Adıgüzel and Reeves, 2012). Earlier studies have documented Ni-related plants from several well-known ultramafic landscapes, including Sandras and other southwestern Anatolian localities, Kızıldağ in Konya, Yahyalı in Kayseri, Fındıklı in Mersin, Amanos-related areas and eastern ophiolitic belts. Turkish studies and regional syntheses have reported Ni hyperaccumulator, accumulator and serpentine-associated taxa, particularly within Brassicaceae and, in some cases, Asteraceae and other plant groups (Reeves and Adıgüzel, 2004, 2008; Altınözlü et al., 2012; Aksoy et al., 2015; Çelik et al., 2018; Özbey et al., 2026). A Turkish-language review of hyperaccumulator plants also provides additional contextual background for this literature (Güneş and Bozkurt, 2021).

This literature indicates that Türkiye has a substantial Ni-related botanical evidence base. At the same time, it reveals an important problem of scale and documentation. The evidence available for a given taxon may consist of a precisely georeferenced field study, a locality described only by a mountain name or district, a review-table entry linked to earlier publications, or an occurrence record with incomplete collection metadata. These forms of evidence are not equivalent. A coordinate-bearing specimen record does not by itself demonstrate Ni accumulation, whereas a physiologically well-supported record without a recoverable locality cannot be used confidently in a point-based map. Likewise, a literature-derived locality represented by a village, district or mountain-centre coordinate should not be presented as an exact collection point.

This issue is particularly relevant when botanical records are placed in geological context. Lithological maps can provide meaningful information for interpreting broad ultramafic, serpentinite and ophiolitic environments, but they cannot replace field-scale substrate verification. At the

national scale, a lithological polygon may include several rock types, weathering products, soil units and local contacts that are not resolved by a generalized geological map. The role of lithology in a geobotanical synthesis should therefore remain appropriately limited: it can identify broad geological settings that help organize available evidence and prioritize future investigation, but it cannot provide direct proof of plant occurrence, plant metal status or local soil geochemistry.

Another source of uncertainty concerns the taxonomic history of Ni-related plant records. Many taxa in the Turkish literature have been reported under names that have subsequently changed through taxonomic revision, synonymization or transfer between genera. This is especially evident in taxa historically referred to as *Alyssum* L., *Thlaspi* L. or *Pseudosempervivum* (Boiss.) Grossh. Taxonomic harmonization is therefore necessary when records from different periods and sources are compiled into a common dataset (Chapman, 2005; Grenié et al., 2023). However, harmonization should improve traceability rather than obscure the original literature. The name used in a source remains relevant because physiological evidence, locality information and voucher references are often linked directly to that original taxonomic treatment.

The reliability of occurrence data also requires separate consideration. Biodiversity databases and specimen-derived records can be valuable for locating collection events, documenting taxon occurrence and identifying potentially relevant herbarium material. Yet they may contain incomplete locality descriptions, coordinate uncertainty, duplicate records, swapped coordinates or taxonomic inconsistencies (Beck et al., 2014; Meyer et al., 2016; Heberling et al., 2021). More importantly, occurrence data alone do not constitute evidence of Ni hyperaccumulation. Occurrence metadata and physiological evidence must therefore be treated as separate components of the evidence base, with clear distinction between records that support biological interpretation and those that provide distributional or provenance information only.

Against this background, the present study develops a source-audited synthesis of Ni hyperaccumulator and accumulator plant records reported from Türkiye. Rather than treating all published names and localities as equally precise spatial observations, the study distinguishes candidate evidence entries according to the strength of their physiological support, taxonomic status, source accessibility, locality information and spatial confidence. Records supported by source coordinates are separated from representative localities and from broader regional records that remain useful for the evidence inventory but cannot be mapped as precise points.

The spatial component of the study is deliberately descriptive. MTA 1:500,000 lithological data are used to display the broad distribution of core Ni-relevant ultramafic and serpentinite-peridotite units together with secondary ophiolitic geological context. These lithological layers provide a geobotanical framework for interpreting the mapped subset of records and for identifying areas where herbarium verification, source recovery, targeted field visits and paired soil–plant geochemical sampling may be particularly valuable. Lithology was not used to assign

plant coordinates, and the study does not test a formal national-scale plant–lithology association.

Accordingly, the objectives of this study were to: (i) compile and audit published Ni-related plant evidence from Türkiye; (ii) harmonize reported taxonomic names while preserving source traceability; (iii) classify records according to physiological support and spatial confidence; and (iv) place the mappable subset within a broad descriptive lithological context. By separating physiological evidence, taxonomic interpretation and locality precision, the study aims to provide a more transparent basis for future research on Turkish serpentine floras, Ni accumulation and geobotanical field verification.

2. Materials and Method

2.1. Study scope and terminology

This study examines plant records from Türkiye that have been reported in connection with nickel (Ni) hyperaccumulation, Ni accumulation, or serpentine- and ultramafic-associated floras. It was designed as a source-audited geobotanical synthesis rather than as a complete national checklist of confirmed Ni hyperaccumulator taxa. The aim was to bring together the available botanical, physiological and spatial information while retaining the differences in evidential strength among sources.

The basic unit of compilation was a source-linked candidate evidence entry. Each entry connected a taxon reported in the literature with a particular source, the available statement or evidence concerning Ni accumulation, and the locality information recoverable from that source. An entry could be associated with no recoverable locality, a single locality, or more than one reported locality. It was therefore not treated as equivalent to an independent occurrence record, a unique locality, an independent population, or a newly confirmed Ni-hyperaccumulator observation.

Where the available evidence allowed a taxon to be linked to an identifiable locality, this linkage was recorded as a taxon–locality association. These associations were used only to describe the connection between a source-audited taxon entry and its reported locality context; they were not interpreted as independent biological observations. Unique mapped localities were counted only after the A-class subset had been consolidated spatially. GBIF occurrence records were maintained as a separate occurrence-metadata dataset and were not included within the 66 candidate evidence entries.

The terms hyperaccumulator, accumulator and Ni-related record were used in accordance with the terminology and evidence available in the original source. A taxon was not assigned a physiological status merely because it occurred on ultramafic terrain or was represented in an occurrence database. Where an accessible source reported plant-tissue Ni concentrations or referred directly to primary analytical evidence, this information was retained in the evidence audit. Records based only on review literature, secondary sources or occurrence databases were kept distinct from directly supported physiological records.

2.2. Literature search and record screening

The evidence dataset was assembled from accessible primary studies, review papers, regional syntheses and additional publications identified through citation

screening. Sources concerned Turkish serpentine floras, ultramafic environments, Ni hyperaccumulation, Ni accumulation and related metallophyte records. Key sources included the regional reviews of Reeves and Adıgüzel (2004, 2008), the serpentine-area synthesis of Adıgüzel and Reeves (2012), and field-based studies from Turkish ultramafic environments, including Altınözlü et al. (2012), Aksoy et al. (2015) and Çelik et al. (2018).

Literature searches were conducted in Google Scholar, DergiPark, TR Dizin, and relevant publisher or journal websites between June 2026 and 27 June 2026. GBIF was consulted separately for occurrence-data quality assessment, while Plants of the World Online and World Flora Online were used for taxonomic checks. Reviewer-specified additional source checks were verified on 28 June 2026. For each retained source, the literature-search log in Appendix A records the search platform or access route, search date, representative query terms, screening decision and role in the present synthesis.

Searches combined taxonomic, geographical and geochemical terms. English-language searches included “nickel hyperaccumulator”, “nickel accumulator”, “serpentine flora”, “ultramafic flora”, “metallophyte”, “Türkiye”, “Turkey”, *Alyssum*, *Odontarrhena* C.A.Mey., *Noccaea* Moench, *Thlaspi*, *Bornmuellera* Hausskn. and *Centaurea* L. Turkish-language searches included combinations of “nikel hiperakümülatör”, “nikel biriktirici”, “serpantin florası”, “ultramafik flora”, “metal biriktiren bitkiler” and relevant taxon names. The complete source list, search routes and screening decisions are provided in the literature-search log in Appendix A.

Records were retained in the evidence inventory when they contained at least one of the following: (i) a reported plant-tissue Ni concentration or explicit statement of Ni hyperaccumulation or accumulation; (ii) a taxon included in a Turkish Ni-related plant synthesis; or (iii) documented locality or occurrence information relevant to evaluating the spatial quality of the record. Records were excluded from the mapped subset when locality information was too broad for point representation, when reported coordinates could not be reconciled with the source locality, or when available information did not allow physiological evidence to be distinguished from general occurrence information.

The inclusion, exclusion and spatial-confidence criteria are summarized in Table 1.

A separately downloaded GBIF occurrence dataset (GBIF.org, 2025) was screened as a provenance and occurrence-quality resource. GBIF records were examined for coordinate availability, locality information, potential duplication, geographic consistency and warning flags. They were not treated as evidence of Ni hyperaccumulation unless an independent physiological source could be linked to the same taxon and locality. This distinction was retained throughout the analysis and in the audit tables in Appendix A.

2.3. Taxonomic harmonization and physiological-evidence classification

Names used in the original literature were retained in the evidence table to preserve traceability to source publications. Accepted or working names were subsequently cross-checked using Plants of the World Online

Table 1. Evidence inclusion, exclusion and spatial-confidence criteria

Criterion	Accepted use in this study	Excluded or restricted use
Candidate evidence entry	Source-linked taxon–evidence unit; may be associated with zero, one, or more reported localities	Not equivalent to an independent occurrence record, unique locality, population, or newly confirmed Ni-hyperaccumulator observation
Physiological Ni evidence	Primary tissue data or source-audited review evidence linked to analytical information	GBIF occurrence data alone were not accepted as physiological evidence
A spatial class	Source-supported coordinate record suitable for descriptive mapping	No independence assumption or formal spatial-association test
B spatial class	Documented non-geological reconstruction of a source-supported locality	Not treated as an exact coordinate; no final B-class point was included in the mapped subset
C spatial class	Explicitly labelled representative locality	Not interpreted as a verified collection or sampling coordinate
Classes D and E	Retained in the evidence inventory and data-gap assessment	Not mapped as points and not assigned inferred coordinates
GBIF occurrence record	Used to assess occurrence metadata, locality quality and possible specimen context	Not treated as direct evidence of Ni accumulation

and World Flora Online (POWO, 2026; WFO, 2026), accessed on 27 June 2026. This procedure was particularly important for taxa historically reported under *Alyssum*, *Thlaspi* and *Pseudosempervivum*, some of which are currently treated under *Odontarrhena* or *Noccaea*.

Taxonomic harmonization was used to standardize the dataset and facilitate comparison among sources; it was not treated as new evidence of Ni accumulation. The source name, accepted or working name, taxonomic reference and synonymy note were retained in the master evidence table so that each entry could be traced back to its published taxonomic treatment. Author citations were checked against Plants of the World Online and World Flora Online and are provided at the first substantive mention in the text and, for nomenclatural clarity, with accepted or working names in Table S2. Source-reported names were retained separately where necessary to preserve traceability to the original literature.

The physiological status of each candidate evidence entry was classified according to the strongest accessible evidence available:

Primary tissue-data evidence: the accessible source reported plant-tissue Ni concentrations or presented direct analytical evidence.

Review evidence supported by primary or later field data: the taxon was listed in a synthesis and could be linked to a primary study or later field-based confirmation.

Review-listed evidence requiring primary-source tracing: the taxon was reported in a review or synthesis, but the underlying primary analytical evidence could not be fully recovered during the present audit.

Secondary, screening-level or verification-needed evidence: the available information was incomplete, indirect, taxonomically uncertain, or insufficient to support a strong physiological interpretation.

These categories describe the traceability and evidential strength of individual entries; they do not replace established physiological thresholds for Ni hyperaccumulation.

2.4. Spatial-confidence classification and georeferencing audit

The spatial reliability of each candidate evidence entry was evaluated separately from its physiological status. This

distinction was essential because evidence of Ni accumulation and confidence in locality position are different attributes. A record may have strong tissue-chemistry evidence but only a broad regional locality, whereas another may have a precise specimen coordinate without direct evidence of Ni accumulation.

Entries were assigned to one of five spatial-confidence classes:

Class A — source-supported coordinate: a coordinate reported directly in the cited source or explicitly linked to a documented sampling locality.

Class B — reconstructable source-supported locality: a locality that could be reconstructed through documented non-geological georeferencing procedures. This category was retained as a methodological class, but no final B-class point was included in the mapped subset.

Class C — representative locality: a gazetteer-derived point representing a named village, district or locality context. Such points were explicitly not interpreted as exact collection or sampling coordinates.

Class D — broad locality information: regional, provincial, mountain, grid-square or similarly broad locality information suitable for the evidence inventory but insufficient for point mapping.

Class E — insufficient or unresolved locality information: records lacking information required for mapping or affected by unresolved geographic or taxonomic uncertainty.

All point coordinates retained for mapping were stored in WGS 84 decimal degrees and assessed against the locality description provided in the corresponding source. Coordinates were not generated from lithology, mapped Ni patterns, MTA polygons or candidate rock units. Where a locality was represented by a gazetteer-derived point, this was explicitly indicated in the evidence table and map legend.

This approach was particularly important for *Noccaea camlikensis* Aytaç, Nordt & Parolly. The point used for the Çamlık–Derebucak–Kızıldağ context represents the named locality and is not interpreted as an exact collection coordinate. To avoid inflating the mapped dataset, candidate evidence entries and unique localities were summarized separately. When several taxa were associated

with the same source-supported coordinate, they were retained as separate entries in the evidence audit but represented by one locality in the descriptive map summary.

2.5. Descriptive lithological-context mapping

The lithological component of the study was designed to provide broad geobotanical context for the spatially mappable subset of Ni-related plant records. Mapping was undertaken in Google Earth Engine (Gorelick et al., 2017) using the MTA 1:500,000-scale geological map dataset (MTA, 2002) and the national boundary of Türkiye as the analysis mask.

The scale of the MTA dataset is appropriate for national and regional screening, but it does not resolve local lithological lenses, plot-scale substrate variability, weathering products or soil chemistry. Lithological units were therefore interpreted as broad geological context rather than as direct representations of the substrate sampled beneath each plant record.

An attribute-based lithological crosswalk was developed from the MTA lithology fields. Two contextual categories were retained for the descriptive lithological map. The first category, core Ni-relevant lithologies, included ultramafic rocks, serpentinite, peridotite, peridotite–pyroxenite, serpentinite–peridotite and other explicitly ultramafic units. The second category, secondary ophiolitic geological context, included ophiolite, ophiolitic assemblages, serpentinite–gabbro, radiolarite–chert and mixed carbonate–ophiolite units. The original MTA attribute values used in the descriptive map, together with their map categories and inclusion rationale, are listed in Table S4.

The lithological-context classes used in the descriptive map are summarized in Table 2.

Only final A-class, source-supported coordinate localities were shown as plant points in the descriptive lithological map. The C-class *Noccaea camlikensis* locality was represented using a separate symbol and labelled as the Çamlık representative locality. D- and E-class entries were retained in the evidence inventory but were not shown as points.

The map was prepared to support visual comparison between source-audited plant records and broad lithological context. Lithological units were not used to assign coordinates, modify record classes, estimate occurrence probability or infer plant–substrate relationships at the

national scale. No buffer-based overlay test, lithological enrichment analysis or inferential spatial statistic was conducted.

2.6. Descriptive summaries and analytical boundaries

The analysis was limited to descriptive summaries of the evidence dataset, spatial-confidence classes and the mappable locality subset. Counts were reported for candidate evidence entries, source-supported coordinate entries, representative localities and inventory-only records. Percentages describing spatial-confidence classes were calculated relative to the total number of candidate evidence entries.

No area-proportion expectation, observed-to-expected ratio, p-value or other inferential spatial statistic was calculated. The map is therefore interpreted as a descriptive and screening-oriented product. It can help identify broad ultramafic and ophiolitic settings where source recovery, herbarium verification, targeted field visits and paired soil–plant geochemical studies may be particularly useful. It does not demonstrate a formal national-scale association between individual plant records and lithological classes.

The overall workflow, from source screening and taxonomic harmonization to spatial-confidence classification and lithological-context mapping, is summarized in Figure 1.

3. Results

3.1. Evidence-search outcome and candidate-record universe

The literature and record-screening process yielded 66 source-linked candidate evidence entries associated with Ni hyperaccumulation, Ni accumulation, or related ultramafic and serpentine environments in Türkiye. Each entry combined a taxon reported in a source, the available Ni-related evidence, and locality information recoverable from that source. The total should therefore not be interpreted as 66 independent occurrence records, 66 unique localities, or 66 confirmed Ni-hyperaccumulator observations. Some entries lack recoverable coordinates, refer only to broad locality contexts, or are linked to more than one reported locality. The physiological status of each entry remains dependent on the strength of the underlying source evidence.

The literature-search log included 16 screened source units, comprising review papers, primary studies, regional syntheses,

Table2. Lithological-context classes used in the descriptive map

Map class	Included MTA lithological context	Purpose in the map	Explicit limitation
Core Ni-relevant lithologies	Ultramafic rocks, serpentinite, peridotite, peridotite–pyroxenite, serpentinite–peridotite and explicitly ultramafic units	Displays the principal broad geological settings relevant to Ni-related metallophyte screening	Not used to assign plant coordinates or demonstrate a formal plant–lithology association
Secondary ophiolitic geological context	Ophiolite, ophiolitic assemblage, serpentinite–gabbro, radiolarite–chert and mixed carbonate–ophiolite units	Provides wider ophiolitic and oceanic–crust context for field verification and source recovery	Contextual layer only; mixed units are not treated as direct ultramafic substrate evidence
A-class plant records	Source-supported coordinate localities retained in the final audited mapping table	Shows the spatially mappable subset of the evidence dataset	Points are descriptive records, not independent observations in a statistical test
C-class <i>Noccaea camlikensis</i> locality	Çamlık locality representative point	Retains the corrected locality context with a separate symbol	Not an exact collection coordinate and not used in formal spatial analysis

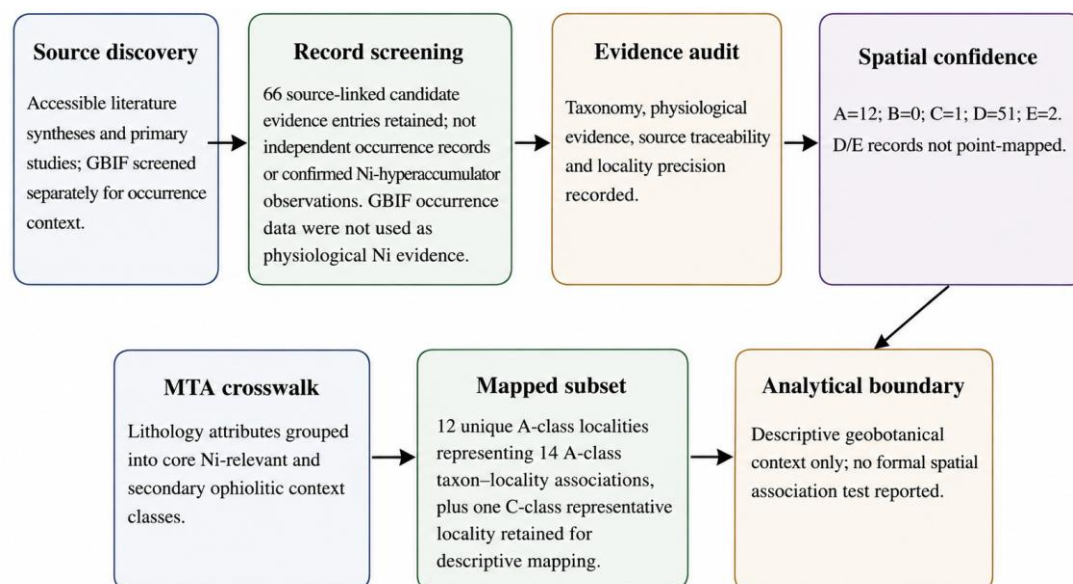


Figure 1. Evidence-screening and mapping workflow for the source-audited Ni-related plant synthesis

taxonomic resources and related publications identified through citation screening. These sources differed in their purpose and level of documentation. Some reported plant-tissue Ni concentrations, sample information and relatively specific field localities, whereas others mainly provided taxonomic or regional syntheses. Consequently, the evidence dataset contains records that differ substantially in both physiological support and spatial precision.

A total of 88 GBIF occurrence records were screened separately from the literature-derived evidence base. Only 11 records (12.5%) contained usable geographic coordinates, whereas 77 records (87.5%) lacked usable coordinates. Within the coordinate-bearing subset, 9 records were retained with spatial caution and 2 carried coordinate-related warning flags. GBIF records were therefore used only to assess occurrence metadata, locality quality and possible specimen context; they were not treated as direct physiological evidence of Ni accumulation.

3.2. Taxonomic and physiological-evidence structure

The audit showed that the Turkish Ni-related plant literature is heterogeneous in both taxonomic treatment and evidential strength. Review tables and regional syntheses form an important part of the available evidence base, whereas a smaller subset of entries can be linked to accessible primary analytical studies or more recent field investigations. This structure is valuable for defining the wider Turkish source-audited candidate-evidence dataset, but it also demonstrates why review-listed names cannot automatically be regarded as mapped, independent or physiologically equivalent records.

Taxonomic harmonization clarified several cases in which historical names differed from accepted or working names. In particular, records originally published under *Alyssum*, *Thlaspi* or *Pseudosempervivum* were retained under their source names in the audit trail while being linked to harmonized names used for synthesis and mapping. This approach preserved source traceability and avoided treating nomenclatural revision as new evidence of Ni accumulation.

The audited dataset structure is summarized in Table 3.

3.3. Spatial-confidence outcomes and mapped locality subset

The spatial-confidence assessment was applied to candidate evidence entries rather than to independent biological observations. Following the georeferencing audit, 12 entries were assigned to class A, 1 to class C, 51 to class D and 2 to class E. Thus, 53 of the 66 candidate evidence entries (80.3%) were retained in the evidence inventory but were not suitable for point mapping.

For map preparation, the A-class subset was consolidated at the locality level. The 12 A-class entries generated 14 taxon–locality associations because C003 and C043 were each linked to two source-supported localities. Where more than one taxon was associated with the same coordinate, the records were represented by a single locality symbol. This consolidation resulted in 12 unique A-class map points.

The separate C-class entry represents *Noccaea camlikensis* in the Çamlık–Derebucak–Kızıldağ context. It was retained as one representative locality symbol to preserve the corrected locality information associated with the taxon, but it was not treated as an exact collection or sampling coordinate and was not combined with the A-class counts.

The locality-symbol subset used in the descriptive map is listed in Table 4.

3.4. Descriptive lithological context

The descriptive map places the spatially mappable subset of Ni-related plant records within the broad lithological framework of Türkiye. Core Ni-relevant lithologies are concentrated in ultramafic, serpentinite and peridotite-bearing belts, whereas the secondary context layer identifies wider ophiolitic, radiolaritic and mixed geological units. These settings provide an appropriate regional framework because they include areas in which serpentine-derived soils, ultramafic parent materials and associated metallophyte floras may occur.

The mapped localities are concentrated in central, southern and southwestern parts of Türkiye, reflecting the regional distribution of source-specific field studies as well as the availability and precision of published locality information.

Table 3. Evidence categories and spatial representation of the audited Ni-related plant dataset

Data component	Count	Interpretation
Source-linked candidate evidence entries	66	Evidence-audit units; not independent occurrence records, unique localities, or newly confirmed Ni-hyperaccumulator observations
Screened source units	16	Primary studies, review papers, regional syntheses, taxonomic resources and related publications
Spatial class A entries	12	Candidate entries with source-supported coordinates
Spatial class B entries	0	No locality met the criteria for documented non-geological reconstruction
Spatial class C entries	1	Representative locality only
Spatial class D entries	51	Broad regional, provincial, mountain or grid-level locality information
Spatial class E entries	2	Insufficient or unresolved locality information
Unique A-class mapped localities	12	Distinct localities retained for descriptive mapping
A-class taxon–locality associations	14	Derived from 12 A-class candidate evidence entries; C003 and C043 are each linked to two source-supported localities
C-class representative locality association	1	Retained separately as a representative locality, not as an exact collection coordinate
Point symbols displayed in Figure 2	13	Twelve unique A-class source-supported localities and one C-class representative locality
GBIF occurrence records screened separately	88	Occurrence metadata only; not treated as physiological Ni evidence

Table 4. Spatially mappable locality-symbol subset used in Figure 2

Locality ID	Linked candidate evidence entry/entries and accepted or working taxon/taxa	Source	Spatial class	Longitude	Latitude
L01	C062 – <i>Isatis cappadocica</i> Desv.	Çelik et al. (2018)	A	35.4634333	37.9137833
L02	C022 – <i>Odontarrhena oxycarpa</i> (Boiss. & Balansa) Španiel, Al-Shehbaz, D.A.German & Marhold	Çelik et al. (2018)	A	35.4566167	37.8965500
L03	C020 – <i>Odontarrhena muralis</i> (Waldst. & Kit.) Endl.	Çelik et al. (2018)	A	35.4370833	37.8695833
L04	C044 – <i>Noccaea perfoliata</i> (L.) Al-Shehbaz	Çelik et al. (2018)	A	35.3934000	37.8858833
L05	C063 – <i>Noccaea triangularis</i> (F.K.Mey.) Al-Shehbaz; C036 – <i>Noccaea sempervivum</i> (Boiss. & Balansa) Özüdoğru & Al-Shehbaz	Çelik et al. (2018)	A	35.4304500	37.7785333
L06	C045 – <i>Noccaea rosularis</i> (Boiss. & Balansa) Al-Shehbaz	Çelik et al. (2018)	A	35.4852500	37.7958833
L07	C023 – <i>Odontarrhena pateri</i> (Nyár.) Španiel, Al-Shehbaz, D.A.German & Marhold	Altınözlü et al. (2012); Dindaroğlu et al. (2019)	A	29.5233333	37.2311833
L08	C003 – <i>Odontarrhena carica</i> (T.R.Dudley & Hub.-Mor.) Španiel, Al-Shehbaz, D.A.German & Marhold	Altınözlü et al. (2012)	A	29.5873000	36.9603333
L09	C043 – <i>Noccaea oxyceras</i> (Boiss.) Al-Shehbaz	Altınözlü et al. (2012)	A	35.9224167	36.3611667
L10	C024 – <i>Odontarrhena peltarioidea</i> subsp. <i>peltarioidea</i> (Boiss.) Španiel, Al-Shehbaz, D.A.German & Marhold	Altınözlü et al. (2012)	A	35.4194333	37.7822000
L11	C025 – <i>Odontarrhena peltarioidea</i> subsp. <i>virgatiformis</i> (Nyár.) Španiel, Al-Shehbaz, D.A.German & Marhold	Altınözlü et al. (2012)	A	28.7851167	39.6296333
L12	C003 – <i>Odontarrhena carica</i> (T.R.Dudley & Hub.-Mor.) Španiel, Al-Shehbaz, D.A.German & Marhold;	Altınözlü et al. (2012)	A	28.6030167	37.1131000
C01	C060 – <i>Noccaea camlikensis</i> Aytaç, Nordt & Parolly	Aytaç et al. (2006) and georeferencing audit	C	31.6389452	37.3510902

Note: Table 4 is organized at the locality-symbol level. It includes 12 unique A-class source-supported localities and one C-class representative locality. These 13 symbols represent 14 A-class taxon–locality associations and one separate C-class representative-locality association. Candidate evidence entries, taxon–locality associations, unique localities and map symbols are therefore not numerically interchangeable. The C-class point is a representative locality, not an exact collection coordinate.

This pattern should not be interpreted as a national occurrence model or as evidence that unmapped lithological areas lack potentially suitable habitats. Instead, it reflects the combined influence of botanical exploration, source accessibility and spatial confidence.

Figure 2 is intended as an evidence-visualization and field-prioritization tool. It shows where source-audited plant records occur relative to broad lithological settings and identifies areas in which herbarium verification, primary-source recovery and paired soil–plant sampling may be particularly informative. No formal relationship between plant occurrence and lithology is inferred from the map.

3.5. Data gaps and implications for spatial interpretation

The clearest outcome of the audit is the contrast between the size of the source-linked candidate-evidence dataset and the much smaller subset suitable for descriptive point representation. The 66 candidate evidence entries do not represent 66 independent occurrence records, unique localities or confirmed Ni-hyperaccumulator observations. At the mapped level, 12 A-class entries produced 14 A-class taxon–locality associations that were consolidated into 12 unique source-supported localities, while one additional C-class entry was retained as a representative locality. The remaining D- and E-class entries remain valuable

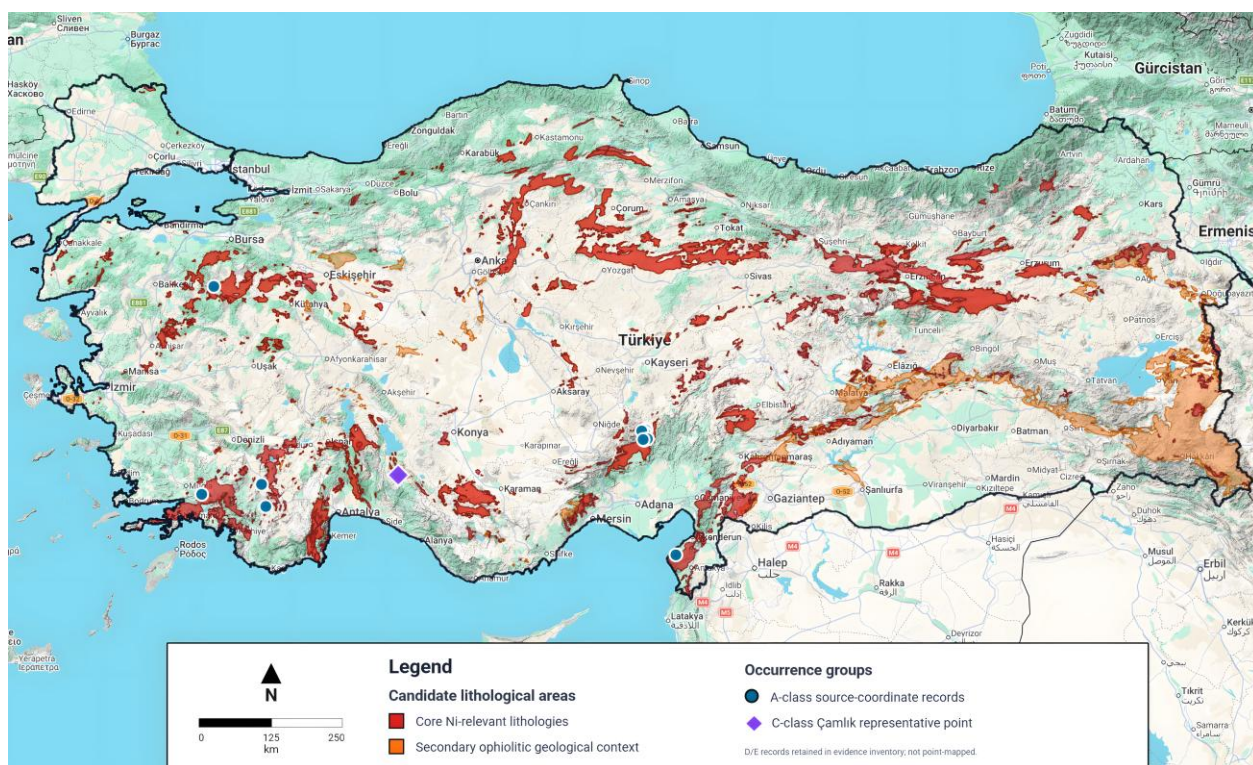


Figure 2. Descriptive lithological context of spatially mappable Ni-related plant records in Türkiye. Core Ni-relevant lithologies are shown in red and secondary ophiolitic geological context in orange. Blue symbols show 12 unique A-class source-supported localities, representing 14 A-class taxon–locality associations after locality-level consolidation. The purple symbol marks the C-class Çamlık representative locality of *Noccaea camlikensis*, which is not an exact collection coordinate.

because they preserve published information on the Turkish Ni-related flora, but their spatial resolution is insufficient for precise geographic mapping.

The audit also separates occurrence metadata from physiological evidence. GBIF records may help locate specimen information, evaluate taxonomic usage and identify potentially relevant herbarium material, but they do not independently demonstrate Ni accumulation. Similarly, broad locality descriptions contained in review literature provide useful regional context without supporting exact point representation.

These evidence gaps indicate the need for future research combining verified vouchers, precise locality information, plant-tissue chemistry and local substrate data. Such work would allow currently broad or inventory-only records to be reassessed and, where justified, incorporated into a more spatially resolved geobotanical framework.

The entry-level spatial-confidence distribution is summarized in Figure 3.

4. Discussions

4.1. What the evidence synthesis establishes

The principal contribution of this study is not the introduction of a new national checklist of confirmed Ni hyperaccumulator taxa. Rather, it provides a transparent framework for distinguishing among source-reported Ni-related plant records according to the strength of their physiological evidence, taxonomic interpretation and locality precision. This distinction is important because hyperaccumulation is a physiological property that must be supported by plant-tissue chemistry and appropriate taxonomic identification; it cannot be inferred solely from

occurrence on ultramafic terrain or from the presence of a specimen record in a biodiversity database (Baker and Brooks, 1989; van der Ent et al., 2013; Krämer, 2010).

The audit therefore retains the scientific value of historical review tables and regional syntheses without treating all records as equivalent. Some entries can be linked to primary analytical studies and are suitable for targeted field reassessment. Others remain important as part of the Turkish Ni-related botanical literature but require recovery of the underlying source, voucher examination or additional field verification before their physiological status or precise location can be treated with greater confidence. This approach does not weaken the existing evidence base; instead, it clarifies how each type of evidence can be used.

A further strength of the present framework is the separation of candidate evidence entries from independent localities. A single taxon may be mentioned in several sources, whereas several taxa may occur at the same ultramafic locality. Treating such records as independent spatial observations would exaggerate the apparent amount of geographic evidence. By retaining source-linked candidate entries in the inventory while summarizing mapped records at the locality level, the study provides a more realistic representation of the available information.

The originality of the present study therefore lies not in proposing an additional national checklist or a new estimate of Turkish Ni-hyperaccumulator richness. Its contribution is to show that the published evidence base contains several distinct layers—physiological support, taxonomic traceability and locality precision—that cannot be inferred directly from a floristic list alone. This distinction is particularly relevant in ultramafic floras, where biologically

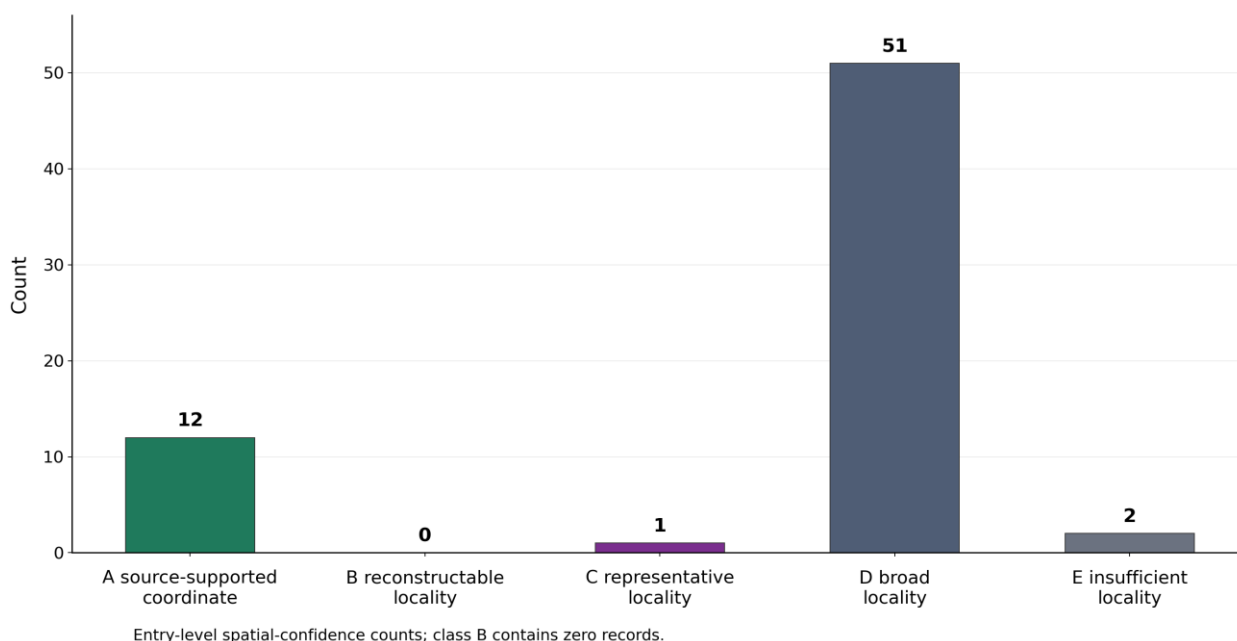


Figure 3. Spatial-confidence and evidence-gap summary for the 66 source-linked candidate evidence entries. Counts refer to evidence-audit units and do not represent independent occurrence records, unique localities, or confirmed Ni-hyperaccumulator observations. A, source-supported coordinate; B, reconstructable locality with zero records; C, representative locality; D, broad locality; E, insufficient locality

important records may remain unsuitable for point-based interpretation because their locality information is incomplete or too broad.

4.2. Lithological context as a geobotanical framework

Ultramafic, serpentinite and ophiolitic terrains are central to the geobotanical interpretation of Ni-related floras. These substrates are commonly associated with elevated concentrations of Ni, chromium, cobalt and magnesium, nutrient imbalance, low calcium-to-magnesium ratios and other soil conditions that can exert strong ecological filtering on plant communities (Kruckeberg, 1984; Brady et al., 2005; Harrison and Rajakaruna, 2011). Their inclusion in the present study is therefore not simply cartographic. Lithological context provides the environmental framework within which the reported plant records can be interpreted and future field work can be planned.

Nevertheless, lithological context should not be confused with direct evidence of plant occurrence or Ni accumulation. The MTA 1:500,000-scale dataset provides an appropriate basis for national and regional screening, but it cannot resolve local lithological contacts, weathered substrate conditions, soil development or geochemical variation at individual sampling sites. A mapped point positioned within, or close to, an ultramafic polygon does not demonstrate that the sampled plant grew directly on a particular lithological unit, nor does it confirm the Ni concentration of that population.

For this reason, Figure 2 should be interpreted as a descriptive geobotanical screening product. It identifies broad ultramafic and ophiolitic settings in which source-supported plant records occur and where future investigations may be particularly informative. These investigations may include recovery of original field notes, herbarium verification, relocation of historical populations and paired sampling of plant tissues, soil and parent material. The figure is not intended to demonstrate a

national-scale statistical relationship between lithology and plant occurrence.

4.3. Biogeographical context and contribution to previous syntheses

Türkiye's ultramafic landscapes are biogeographically important not only because they contain Ni-rich parent materials, but also because they occur as discontinuous massifs and ophiolitic belts across regions with different climatic, tectonic and floristic histories. Serpentine-derived environments impose strong edaphic constraints on plant communities and have contributed to the development of distinctive local floras, including narrow-range and endemic taxa (Kruckeberg, 1984; Brady et al., 2005; Kurt et al., 2013; Adıgüzel and Reeves, 2012; Özbey et al., 2026). However, serpentinite endemism and Ni accumulation should not be treated as interchangeable attributes. A taxon may be restricted to ultramafic terrain without meeting the physiological criterion for Ni hyperaccumulation, whereas a source-reported Ni accumulator may still require renewed chemical, taxonomic or locality verification.

Previous studies have documented Ni accumulation and hyperaccumulation in geographically separated ultramafic settings, including Sandras and other southwestern Anatolian localities, Kızıldağ in Konya, Yahyalı in Kayseri, Fındıkpınarı in Mersin, Amanos-related areas and eastern ultramafic belts (Reeves and Adıgüzel, 2004, 2008; Altınözlü et al., 2012; Aksoy et al., 2015; Çelik et al., 2018; Özbey et al., 2026). The Kızıldağ and Yahyalı studies are especially informative because they combine floristic observations with plant-tissue analyses and provide a clearer connection between metallophyte taxa and ultramafic settings (Reeves et al., 2009; Aksoy et al., 2015; Çelik et al., 2018). Such studies remain central reference points for understanding the biological significance of Turkish Ni-related floras.

Recent syntheses, particularly Özbey et al. (2026), place Turkish ultramafic plants within a broader historical, floristic and biogeographical context. The present study is intended to complement, rather than duplicate, these comprehensive syntheses. It does not propose a revised total number of Turkish Ni hyperaccumulator taxa, nor does it replace floristic inventories of ultramafic areas. Its contribution is more specific: it examines whether published Ni-related records can be traced to source-level physiological evidence and locality information of sufficient quality for descriptive spatial representation.

The audit shows that the available literature contains at least three different information states. Some records are supported by accessible primary or later field evidence and can be linked to source-supported coordinates. Others have meaningful physiological support but retain only broad regional or historical locality descriptions. A third group remains valuable as part of the published Ni-related flora but requires recovery of primary sources, voucher examination or renewed field sampling before its physiological status and spatial position can be evaluated with greater confidence. This distinction provides a practical bridge between broad floristic synthesis and future field-based verification.

The mapped pattern should therefore not be interpreted as a map of the full Turkish Ni-related flora. The concentration of mapped localities in central, southern and southwestern Türkiye reflects the geography of detailed field studies, publication history and coordinate availability as much as the distribution of suitable ultramafic environments. Areas without mapped points may still contain biologically important serpentine floras or Ni-related taxa that remain insufficiently documented. By making this evidence structure explicit, the present study advances previous syntheses not by adding new occurrence claims, but by identifying which published records are ready for spatial interpretation and which should be prioritized for herbarium verification, source recovery and paired soil–plant field studies.

4.4. Limitations and priorities for future research

The study is limited by the heterogeneity of the available evidence. Published sources differ in analytical method, sampled plant organ, reporting units, sample size, taxonomic treatment and locality precision. In many historical studies, the information needed to connect a plant-tissue measurement to a voucher specimen and an exact geographic coordinate is incomplete or dispersed across several publications. These limitations are common in legacy metallophyte datasets and reinforce the need for careful source-level auditing.

A second limitation concerns spatial scale. The lithological dataset is suitable for broad regional interpretation but cannot substitute for direct field verification of soil, regolith or bedrock conditions. Future work should therefore combine precise GNSS-recorded localities with voucher specimens, standardized plant-tissue analyses and local substrate characterization. At a minimum, each new record

should include a voucher identifier, accepted taxon name, original determination, plant organ analysed, analytical method, Ni concentration, coordinate precision and information on the local substrate.

The most useful next step would be a targeted verification programme focused on localities with strong published physiological evidence but incomplete geographic documentation. Priority should be given to populations associated with well-known ultramafic regions, including Kızıldağ, Sandras, Yahyalı, Fındıkpınarı and Amanos-related areas. Such work would improve the spatial quality of the evidence base while also providing an opportunity to reassess taxonomic identity, population persistence and local soil–plant relationships.

5. Conclusion

This study provides a source-audited synthesis of 66 source-linked candidate evidence entries related to Ni hyperaccumulation, Ni accumulation and ultramafic-associated floras in Türkiye. These entries are not a count of independent occurrence records, unique localities or newly confirmed Ni-hyperaccumulator observations. Rather, the study separates physiological evidence, taxonomic interpretation and locality confidence in order to clarify how the available literature can be used in future geobotanical research.

The lithological map restores the geobotanical context of the spatially mappable subset while avoiding unsupported national-scale inference. Ultramafic, serpentinite and ophiolitic terrains remain highly relevant for understanding and investigating Ni-related plant records, but the available evidence is not yet sufficiently uniform for a formal national plant–lithology model. The resulting framework provides a reproducible basis for source recovery, herbarium verification, targeted field surveys and paired soil–plant geochemical studies.

Conflict of Interest

The author declares no conflict of interest.

Ethical Statement

This study did not involve human participants, animal subjects, experimental plant sampling or experimental manipulation of living organisms. The analysis was based on published literature, occurrence metadata and geological spatial data.

Data Availability Statement

The source-screening log, source and physiological-evidence audit, spatial-confidence and georeferencing audit, and MTA lithological values used in the descriptive map are provided in Appendix A. The GBIF occurrence download used for occurrence-data quality assessment is identified by DOI in the References and was not used as direct physiological evidence of Ni accumulation. Additional audit details are available from the corresponding author upon reasonable request.

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Appendix A. Supporting tables

This appendix documents the source and spatial audit underpinning the revised evidence synthesis. Table S1 provides the literature-search and source-screening log; Table S2 contains the source and physiological-evidence audit; Table S3 documents the spatial-confidence and georeferencing decisions; and Table S4 lists the MTA lithological values used in the descriptive map.

Table S1. Source-screening and data-resource log

Source record	Source or data resource	Source type	Role in the present synthesis	Evidence or data used	Main limitation	Search platform / access route	Search date	Representative search query or citation route	Screening decision
S01	Reeves and Adıgüzel (2004)	Regional primary/review context	Early record of rare Turkish serpentine plants and Ni accumulators	Contextual evidence for Turkish Ni-related flora	Not a coordinate-ready inventory	Google Scholar / DergiPark / publisher website / citation screening	June 2026; updated 27 June 2026	Reeves and Adıgüzel (2004) and linked citation route	Retained for source-audited evidence synthesis
S02	Reeves and Adıgüzel (2008)	Foundational review	Overall synthesis of Turkish and adjacent-area Ni hyperaccumulator reports	Foundation for the candidate evidence universe	Taxon-level summaries; not all records contain recoverable coordinates	Google Scholar / DergiPark / publisher website / citation screening	June 2026; updated 27 June 2026	Reeves and Adıgüzel (2008) and linked citation route	Retained for source-audited evidence synthesis
S03	Reeves and Adıgüzel (2008), Table 1	Review-table screening unit	Alyssum sensu lato records	Candidate evidence entries and source taxonomic names	Specimen-level localities not consistently reported	Google Scholar / DergiPark / publisher website / citation screening	June 2026; updated 27 June 2026	Reeves and Adıgüzel (2008), Table 1 and linked citation route	Retained for source-audited evidence synthesis
S04	Reeves and Adıgüzel (2008), Table 2	Review-table screening unit	Brassicaceae records	Candidate evidence entries and source taxonomic names	Several records require primary-source tracing	Google Scholar / DergiPark / publisher website / citation screening	June 2026; updated 27 June 2026	Reeves and Adıgüzel (2008), Table 2 and linked citation route	Retained for source-audited evidence synthesis
S05	Reeves and Adıgüzel (2008), Table 3	Review-table screening unit	Centaurea records	Candidate evidence entries and source taxonomic names	Some entries are based on limited sample information	Google Scholar / DergiPark / publisher website / citation screening	June 2026; updated 27 June 2026	Reeves and Adıgüzel (2008), Table 3 and linked citation route	Retained for source-audited evidence synthesis
S06	Adıgüzel and Reeves (2012)	Regional geobotanical synthesis	Important serpentine areas and distribution context	Geobotanical context and regional prioritization	Not a source of point-level physiological evidence	Google Scholar / DergiPark / publisher website / citation screening	June 2026; updated 27 June 2026	Adıgüzel and Reeves (2012) and linked citation route	Retained for source-audited evidence synthesis
S07	Aytaç et al. (2006)	Primary taxonomic study	Protologue and locality context for Noccaea camlikensis	C-class representative locality context	Protologue locality is not treated as an exact Ni sampling coordinate	Google Scholar / DergiPark / publisher website / citation screening	June 2026; updated 27 June 2026	Aytaç et al. (2006) and linked citation route	Retained for source-audited evidence synthesis
S08	Aksoy et al. (2015)	Primary field study	Metal-accumulating plants from Kızıldağ serpentine habitats	Supporting physiological and regional context	Not all historical records can be linked to exact coordinates	Google Scholar / DergiPark / publisher website / citation screening	June 2026; updated 27 June 2026	Aksoy et al. (2015) and linked citation route	Retained for source-audited evidence synthesis
S09	Altınözlü et al. (2012)	Primary field study	Natural plants from Turkish serpentine soils	Source-supported localities and evidence context	Coordinates are used descriptively, not for inferential spatial analysis	Google Scholar / DergiPark / publisher website / citation screening	June 2026; updated 27 June 2026	Altınözlü et al. (2012) and linked citation route	Retained for source-audited evidence synthesis

S10	Çelik et al. (2018)	Primary field study	Metal-accumulating Brassicaceae from Yahyalı	Source-supported Yahyalı locality records	Represents a limited regional subset of the national inventory	Google Scholar / DergiPark / publisher website / citation screening	June 2026; updated 27 June 2026	Çelik et al. (2018) and linked citation route	Retained for source-audited evidence synthesis
S11	Özbey et al. (2026)	Current review	Turkish ultramafic flora and post-2008 context	Current synthesis and taxonomic/locality context	Does not provide a complete coordinate-ready master inventory	Google Scholar / DergiPark / publisher website / citation screening	June 2026; updated 27 June 2026	Özbey et al. (2026) and linked citation route	Retained for source-audited evidence synthesis
S12	Özdemir and Demir (2010)	Primary regional study	Ni accumulation in Fındıklıpınarı–Erdemli/Mersin	Supporting regional physiological context	Insufficient for inclusion as a precise mapped locality in this synthesis	DergiPark / journal website / citation screening	June 2026; checked 28 June 2026 where reviewer-specified	Özdemir and Demir (2010)	Retained as supporting source; spatial use restricted by audit
S13	Yıldıztekin et al. (2024)	Primary regional study	Heavy-metal accumulation around an old chromium mine site	Supporting recent physiological context for a candidate taxon	Coordinate detail was not retained for the descriptive map	DergiPark / journal website / citation screening	June 2026; checked 28 June 2026 where reviewer-specified	Yıldıztekin et al. (2024)	Retained as supporting source; spatial use restricted by audit
S14	Plants of the World Online (POWO, 2026)	Taxonomic resource	Accepted-name and synonymy cross-check	Taxonomic harmonization	Used as a reference point, not as physiological evidence	Plants of the World Online	27 June 2026	Accepted-name and synonymy checks for candidate taxa	Retained for taxonomic harmonization
S15	World Flora Online (WFO, 2026)	Taxonomic resource	Accepted-name and synonymy cross-check	Taxonomic harmonization	Used as a reference point, not as physiological evidence	World Flora Online	27 June 2026	Accepted-name and synonymy checks for candidate taxa	Retained for taxonomic harmonization
S16	Dindaroğlu et al. (2019)	Primary ecological/heavy-metal tolerance study	Ecology and heavy-metal tolerance of Alyssum pateri Nyár. subsp. pateri in ultramafic soils	Reviewer-specified supporting source for C023 / Odontarrhena pateri	Provides taxon-level ecological and tolerance context; not used to assign the L07 coordinate	DergiPark / TR Dizin / DOI route	28 June 2026	10.33409/tbbbd.668650; reviewer-specified C023 source check	Retained; linked to C023 as supporting source, not as coordinate source

Note. Separate screening records are retained for Tables 1–3 of Reeves and Adıgüzel (2008) because those source tables contributed distinct candidate-entry groups. The MTA lithological classification used in the descriptive map is summarized in Table S4. GBIF occurrence records were used only for occurrence-data quality assessment and are summarized in Results section 3.1 and Table 3.

Table S2. Source and physiological-evidence audit of the candidate evidence dataset

Candidate ID	Source-reported taxon name	Accepted or working name (with author citation)	Main source(s)	Ni-related evidence category
C001	<i>Alyssum anatolicum</i>	<i>Odontarrhena anatolica</i> (Hausskn. ex Nyár.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C002	<i>Alyssum callichroum</i>	<i>Odontarrhena callichroa</i> (Boiss.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C003	<i>Alyssum caricum</i>	<i>Odontarrhena carica</i> (T.R.Dudley & Hub.-Mor.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1; Özbey et al. (2026)	Review-table record with later supporting source
C004	<i>Alyssum cassium</i>	<i>Odontarrhena cassia</i> (Boiss. & Heldr.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1; Özbey et al. (2026), Table 1	Review-table record with reported Ni-related data
C005	<i>Alyssum cilicicum</i>	<i>Odontarrhena cilicica</i> (Boiss. & Balansa) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1; Özbey et al. (2026), Table 1	Review-table record with reported Ni-related data
C006	<i>Alyssum condensatum</i>	<i>Odontarrhena condensata</i> (Boiss. & Hausskn.) Jord. & Fourr.	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C007	<i>Alyssum constellatum</i>	<i>Odontarrhena constellata</i> (Boiss.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C008	<i>Alyssum corsicum</i>	<i>Odontarrhena corsica</i> (Duby) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C009	<i>Alyssum crenulatum</i>	<i>Odontarrhena crenulata</i> (Boiss. & Heldr.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1; Özbey et al. (2026), Table 1	Review-table record with reported Ni-related data
C010	<i>Alyssum cyprium</i> Turkey	<i>Odontarrhena cyprica</i> (Nyár.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C011	<i>Alyssum davisianum</i>	<i>Odontarrhena davisiana</i> (T.R.Dudley) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C012	<i>Alyssum discolor</i>	<i>Odontarrhena discolor</i> (T.R.Dudley & Hub.-Mor.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C013	<i>Alyssum dubertretii</i>	<i>Odontarrhena dubertretii</i> (Gomb.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C014	<i>Alyssum dudleyi</i>	<i>Odontarrhena dudleyi</i> (Adıgüzel & R.D.Reeves) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C015	<i>Alyssum eriophyllum</i>	<i>Odontarrhena eriophylla</i> (Boiss. & Hausskn.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1; Özbey et al. (2026), Table 1	Review-table record with reported Ni-related data
C016	<i>Alyssum floribundum</i>	<i>Odontarrhena floribunda</i> (Boiss.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1; Özbey et al. (2026), Table 1	Review-table record with reported Ni-related data
C017	<i>Alyssum giosnanum</i>	<i>Odontarrhena giosnana</i> (Nyár.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C018	<i>Alyssum huber-morathii</i>	<i>Odontarrhena huber-morathii</i> (T.R.Dudley) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C019	<i>Alyssum masmenaeum</i>	<i>Odontarrhena masmenaea</i> (Boiss.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1; Yıldıztekin et al. (2024)	Review-table record with later primary or recent field support
C020	<i>Alyssum murale</i> subsp <i>murale</i> var <i>murale</i>	<i>Odontarrhena muralis</i> (Waldst. & Kit.) Endl.	Reeves and Adıgüzel (2008), Table 1; Özdemir and Demir (2010); Çelik et al. (2018)	Review-table record with later primary or recent field support
C021	<i>Alyssum murale</i> var <i>haradjianii</i>	<i>Odontarrhena haradjianii</i> (Rech.f.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C022	<i>Alyssum oxycarpum</i>	<i>Odontarrhena oxycarpa</i> (Boiss. & Balansa) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1; Çelik et al. (2018)	Review-table record with later primary or recent field support

C023	<i>Alyssum pateri</i> subsp <i>pateri</i>	<i>Odontarrhena pateri</i> (Nyár.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1; Özbey et al. (2026); Dindaroğlu et al. (2019)	Review-table record with later supporting source; reviewer-specified supporting ecological/tolerance source
C024	<i>Alyssum peltarioides</i> subsp <i>peltarioides</i>	<i>Odontarrhena peltarioidea</i> subsp. <i>peltarioidea</i> (Boiss.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1; Özbey et al. (2026)	Review-table record with later supporting source
C025	<i>Alyssum peltarioides</i> subsp <i>virgatiforme</i>	<i>Odontarrhena peltarioidea</i> subsp. <i>virgatiformis</i> (Nyár.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C026	<i>Alyssum pinifolium</i>	<i>Odontarrhena pinifolia</i> (Nyár.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1; Özbey et al. (2026), Table 1	Review-table record with reported Ni-related data
C027	<i>Alyssum pterocarpum</i>	<i>Odontarrhena pterocarpa</i> (T.R.Dudley) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1; Özbey et al. (2026), Table 1	Review-table record with reported Ni-related data
C028	<i>Alyssum samariferum</i>	<i>Odontarrhena samarifera</i> (Boiss. & Hausskn.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1; Özbey et al. (2026), Table 1	Review-table record with reported Ni-related data
C029	<i>Alyssum sibiricum</i>	<i>Odontarrhena sibirica</i> (Willd.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C030	<i>Alyssum syriacum</i>	<i>Odontarrhena syriaca</i> (Nyár.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-listed record; Turkish status unresolved
C031	<i>Alyssum trapeziforme</i>	<i>Odontarrhena trapeziformis</i> (Bornm. ex Nyár.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1; Özbey et al. (2026), Table 1	Review-table record with reported Ni-related data
C032	<i>Alyssum virgatum</i>	<i>Odontarrhena virgata</i> (Nyár.) Španiel, Al-Shehbaz, D.A.German & Marhold	Reeves and Adıgüzel (2008), Table 1	Review-table record with reported Ni-related data
C033	<i>Bornmuellera glabrescens</i>	<i>Bornmuellera glabrescens</i> (Boiss.) Cullen & T.R.Dudley	Reeves and Adıgüzel (2008), Table 2; Özbey et al. (2026), Table 1	Review-table record with reported Ni-related data
C034	<i>Bornmuellera kiyakii</i>	<i>Bornmuellera kiyakii</i> Aytaç & A.Aksoy	Reeves and Adıgüzel (2008), Table 2; Özbey et al. (2026)	Review-table record with later supporting source
C035	<i>Pseudosempervivum aucheri</i>	<i>Noccaea aucheri</i> (Boiss.) Özüdoğru & Al-Shehbaz	Reeves and Adıgüzel (2008), Table 2; Özbey et al. (2026), Table 1	Review-table record with reported Ni-related data
C036	<i>Pseudosempervivum sempervivum</i>	<i>Noccaea sempervivum</i> (Boiss. & Balansa) Özüdoğru & Al-Shehbaz	Reeves and Adıgüzel (2008), Table 2; Çelik et al. (2018)	Review-table record with later primary or recent field support
C037	<i>Thlaspi carienne</i>	<i>Noccaea cariensis</i> (Carlström) Parolly, Nordt & Aytaç	Reeves and Adıgüzel (2008), Table 2	Review-table record with reported Ni-related data
C038	<i>Thlaspi eigii</i> subsp <i>eigii</i>	<i>Noccaea eigii</i> (Zohary) Al-Shehbaz	Reeves and Adıgüzel (2008), Table 2	Review-table record with reported Ni-related data
C039	<i>Thlaspi eigii</i> subsp <i>samuelssonii</i>	<i>Noccaea eigii</i> (Zohary) Al-Shehbaz	Reeves and Adıgüzel (2008), Table 2	Review-table record with reported Ni-related data
C040	<i>Thlaspi elegans</i>	<i>Noccaea elegans</i> (Boiss.) Al-Shehbaz	Reeves and Adıgüzel (2008), Table 2; Özbey et al. (2026), Table 1	Review-table record with reported Ni-related data
C041	<i>Thlaspi jaubertii</i>	<i>Noccaea jaubertii</i> (Hedge) Al-Shehbaz	Reeves and Adıgüzel (2008), Table 2	Review-table record with reported Ni-related data
C042	<i>Thlaspi ochroleucum</i>	<i>Noccaea ochroleuca</i> (Boiss. & Heldr.) F.K.Mey.	Reeves and Adıgüzel (2008), Table 2; Özbey et al. (2026), Table 1	Review-table record with reported Ni-related data
C043	<i>Thlaspi oxyceras</i>	<i>Noccaea oxyceras</i> (Boiss.) Al-Shehbaz	Reeves and Adıgüzel (2008), Table 2	Review-table record with reported Ni-related data
C044	<i>Thlaspi perfoliatum</i>	<i>Noccaea perfoliata</i> (L.) Al-Shehbaz	Reeves and Adıgüzel (2008), Table 2; Çelik et al. (2018)	Review-table record with later primary or recent field support
C045	<i>Thlaspi rosulare</i>	<i>Noccaea rosularis</i> (Boiss. & Balansa) Al-Shehbaz	Reeves and Adıgüzel (2008), Table 2; Çelik et al. (2018)	Review-table record with later primary or recent field support
C046	<i>Aethionema spicatum</i>	<i>Aethionema spicatum</i> Post	Reeves and Adıgüzel (2008), Table 2	Review-listed record with limited support
C047	<i>Centaurea aladaghensis</i>	<i>Centaurea aladaghensis</i> Wagenitz	Reeves and Adıgüzel (2008), Table 3; Özbey et al. (2026), Table 2	Review-table record with reported Ni-related data
C048	<i>Centaurea amanicola</i>	<i>Centaurea amanicola</i> Hub.-Mor.	Reeves and Adıgüzel (2008), Table 3	Review-table record with reported Ni-related data

C049	<i>Centaurea antitauri</i>	<i>Centaurea antitauri</i> Hayek	Reeves and Adıgüzel (2008), Table 3	Review-table record with reported Ni-related data
C050	<i>Centaurea arifolia</i>	<i>Centaurea arifolia</i> Boiss.	Reeves and Adıgüzel (2008), Table 3; Özbey et al. (2026), Table 2	Review-table record with reported Ni-related data
C051	<i>Centaurea cataonica</i>	<i>Centaurea cataonica</i> Boiss. & Hausskn.	Reeves and Adıgüzel (2008), Table 3	Review-table record with reported Ni-related data
C052	<i>Centaurea cheirolopha</i>	<i>Centaurea cheirolopha</i> (Fenzl) Wagenitz	Reeves and Adıgüzel (2008), Table 3	Review-table record with reported Ni-related data
C053	<i>Centaurea haradjianii</i>	<i>Centaurea haradjianii</i> Wagenitz	Reeves and Adıgüzel (2008), Table 3	Review-table record with reported Ni-related data
C054	<i>Centaurea ensiformis</i>	<i>Centaurea ensiformis</i> P.H.Davis	Reeves and Adıgüzel (2008), Table 3; Özbey et al. (2026), Table 2	Review-table record with reported Ni-related data
C055	<i>Centaurea ptosimopappa</i>	<i>Centaurea ptosimopappa</i> Hayek	Reeves and Adıgüzel (2008), Table 3	Review-table record with reported Ni-related data
C056	<i>Centaurea ptosimopappoides</i>	<i>Centaurea ptosimopappoides</i> Wagenitz	Reeves and Adıgüzel (2008), Table 3; Özbey et al. (2026), Table 2	Review-table record with reported Ni-related data
C057	<i>Centaurea sericea</i>	<i>Centaurea sericea</i> Wagenitz	Reeves and Adıgüzel (2008), Table 3; Özbey et al. (2026), Table 2	Review-table record with reported Ni-related data
C058	<i>Centaurea spicata</i>	<i>Centaurea spicata</i> Boiss.	Reeves and Adıgüzel (2008), Table 3	Review-table record with reported Ni-related data
C059	<i>Centaurea tomentella</i>	<i>Centaurea tomentella</i> Hand.-Mazz.	Reeves and Adıgüzel (2008), Table 3	Review-table record with reported Ni-related data
C060	<i>Noccaea camlikensis</i>	<i>Noccaea camlikensis</i> Aytaç, Nordt & Parolly	Aksoy et al. (2015); Aytaç et al. (2006)	Primary source with separate representative-locality protocol
C061	<i>Isatis pinnatiloba</i>	<i>Isatis pinnatiloba</i> P.H.Davis	Altınözlü et al. (2012)	Primary study identified; detailed extraction incomplete
C062	<i>Isatis cappadocica</i> subsp <i>cappadocica</i>	<i>Isatis cappadocica</i> Desv.	Çelik et al. (2018)	Primary or recent field-study record
C063	<i>Thlaspi triangulare</i>	<i>Noccaea triangularis</i> (F.K.Mey.) Al-Shehbaz	Çelik et al. (2018)	Primary or recent field-study record
C064	<i>Bupleurum croceum</i>	<i>Bupleurum croceum</i> Fenzl	Özbey et al. (2026)	Secondary review record; primary source not recovered
C065	<i>Alyssum desertorum</i>	<i>Alyssum turkestanicum</i> Regel & Schmalh.	Çelik et al. (2018)	Secondary or screening-level record
C066	<i>Arabis sagittata</i>	<i>Arabis sagittata</i> (Bertol.) DC.	Çelik et al. (2018)	Secondary or screening-level record

Note. Source-reported names are transcribed as published to preserve traceability and are not nomenclaturally standardized in that column. Accepted or working names follow the nomenclatural treatment adopted in this synthesis and are given with author citations for nomenclatural clarity. Locality information, spatial-confidence classes and mapping decisions are reported separately in Table S3.

Table S3. Spatial-confidence and georeferencing audit

Candidate ID	Accepted or working taxon	Reported locality	Source coordinate?	Source coordinate string	Audit outcome	Spatial class	Locality ID	In Fig. 2?
C001	<i>Odontarrhena anatolica</i>	Türkiye locality summary; Sipikor Mt. Erzincan exemplar in Özbey et al. (2026), Table 1	No	—	Broad locality retained in the inventory only.	D	—	No
C002	<i>Odontarrhena callichroa</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C003	<i>Odontarrhena carica</i>	Sandras Mountain, Muğla, and related southwestern Türkiye localities	Yes	36°57.620'N; 29°35.238'E; 37°06.786'N; 28°36.181'E	Source-supported coordinate retained for descriptive mapping.	A	L08; L12	Yes
C004	<i>Odontarrhena cassia</i>	Özbey et al. (2026), Table 1 Amanos Mt. Hatay exemplar	No	—	Broad locality retained in the inventory only.	D	—	No
C005	<i>Odontarrhena cilicica</i>	Özbey et al. (2026), Table 1 Guzeldere Mersin exemplar	No	—	Broad locality retained in the inventory only.	D	—	No
C006	<i>Odontarrhena condensata</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C007	<i>Odontarrhena constellata</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C008	<i>Odontarrhena corsica</i>	Türkiye specimens only; exact localities not extracted	No	—	Broad locality retained in the inventory only.	D	—	No
C009	<i>Odontarrhena crenulata</i>	Özbey et al. (2026), Table 1 Samandag Hatay exemplar	No	—	Broad locality retained in the inventory only.	D	—	No
C010	<i>Odontarrhena cyprica</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C011	<i>Odontarrhena davisiana</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C012	<i>Odontarrhena discolor</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C013	<i>Odontarrhena dubertretii</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C014	<i>Odontarrhena dudleyi</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C015	<i>Odontarrhena eriophylla</i>	Özbey et al. (2026), Table 1 Berit Mt. Kahramanmaraş exemplar	No	—	Broad locality retained in the inventory only.	D	—	No
C016	<i>Odontarrhena floribunda</i>	Özbey et al. (2026), Table 1 Guzeldere Mersin exemplar	No	—	Broad locality retained in the inventory only.	D	—	No
C017	<i>Odontarrhena giosnana</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C018	<i>Odontarrhena huber-morathii</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C019	<i>Odontarrhena masmenaea</i>	Sandras Mountain and old-mine ultramafic context; five field locations but no point in accessible text	No	—	Broad locality retained in the inventory only.	D	—	No
C020	<i>Odontarrhena muralis</i>	Beynam or Yahyalı or Mersin contexts in later studies; no exact point	Yes	37°52.175'N; 35°26.225'E; GPS string present but OCR/format malformed in accessible copy	Source-supported coordinate retained for descriptive mapping.	A	L03	Yes
C021	<i>Odontarrhena haradjianii</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C022	<i>Odontarrhena oxycarpa</i>	Yahyalı ultramafic area Kayseri in 2018; broader Türkiye table in 2008	Yes	37°53.793'N; 35°27.397'E	Source-supported coordinate retained for descriptive mapping.	A	L02	Yes

C023	<i>Odontarrhena pateri</i>	Türkiye locality summary only	Yes	37°13.871'N; 29°31.400'E	Source-supported coordinate retained for descriptive mapping. Dindaroğlu et al. (2019) is retained as a supporting ecological/heavy-metal tolerance source for the taxon; the mapped L07 coordinate remains source-supported by the coordinate audit and is not derived from lithology.	A	L07	Yes
C024	<i>Odontarrhena peltarioidea</i> <i>subsp. peltarioidea</i>	Türkiye locality summary only	Yes	37°46.932'N; 35°25.166'E	Source-supported coordinate retained for descriptive mapping.	A	L10	Yes
C025	<i>Odontarrhena peltarioidea</i> <i>subsp. virgatiformis</i>	Türkiye locality summary only	Yes	39°37.778'N; 28°47.107'E	Source-supported coordinate retained for descriptive mapping.	A	L11	Yes
C026	<i>Odontarrhena pinifolia</i>	Özbey et al. (2026), Table 1 Uludag Bursa exemplar	No	—	Broad locality retained in the inventory only.	D	—	No
C027	<i>Odontarrhena pterocarpa</i>	Özbey et al. (2026), Table 1 Cirali Antalya exemplar	No	—	Broad locality retained in the inventory only.	D	—	No
C028	<i>Odontarrhena samarifera</i>	Keldag Türkiye-Syria border	No	—	Broad locality retained in the inventory only.	D	—	No
C029	<i>Odontarrhena sibirica</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C030	<i>Odontarrhena syriaca</i>	Probable Mt. Cassius/Keldag border; Turkish Amanos occurrence Ni unconfirmed	No	—	Insufficient or unresolved locality information; not mapped.	E	—	No
C031	<i>Odontarrhena trapeziformis</i>	Özbey et al. (2026), Table 1 Masmutli Nigde exemplar	No	—	Broad locality retained in the inventory only.	D	—	No
C032	<i>Odontarrhena virgata</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C033	<i>Bornmuellera glabrescens</i>	Özbey et al. (2026), Table 1 Masmutli Nigde exemplar	No	—	Broad locality retained in the inventory only.	D	—	No
C034	<i>Bornmuellera kiyakii</i>	Kızıldağ/Konya/Çamlık area discussed but no source coordinate for this row	Yes - not accepted in final map	GPS string present but OCR/format malformed in accessible copy	Broad locality retained in the inventory only.	D	—	No
C035	<i>Noccaea aucheri</i>	Özbey et al. (2026), Table 1 Sipikor Mt. Erzincan exemplar	No	—	Broad locality retained in the inventory only.	D	—	No
C036	<i>Noccaea sempervivum</i>	Yahyalı ultramafic area Kayseri in 2018; broader Türkiye table in 2008	Yes	37°46.712'N; 35°25.827'E	Source-supported coordinate retained for descriptive mapping.	A	L05	Yes
C037	<i>Noccaea cariensis</i>	Marmaris Lake Koycegiz Sandras Mountain contexts	No	—	Broad locality retained in the inventory only.	D	—	No
C038	<i>Noccaea eigii</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C039	<i>Noccaea eigii</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C040	<i>Noccaea elegans</i>	Özbey et al. (2026), Table 1 Keldag Türkiye-Syria border	No	—	Broad locality retained in the inventory only.	D	—	No
C041	<i>Noccaea jaubertii</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C042	<i>Noccaea ochroleuca</i>	Özbey et al. (2026), Table 1 Erenkoy Canakkale exemplar	No	—	Broad locality retained in the inventory only.	D	—	No
C043	<i>Noccaea oxyceras</i>	Türkiye locality summary only	Yes	36°21.670'N; 35°55.345'E; 37°06.786'N; 28°36.181'E	Source-supported coordinate retained for descriptive mapping.	A	L09; L12	Yes

C044	<i>Noccaea perfoliata</i>	Yahyalı ultramafic area Kayseri in 2018; Beynam noted in Ozbey2026	Yes	37°53.153'N; 35°23.604'E	Source-supported coordinate retained for descriptive mapping.	A	L04	Yes
C045	<i>Noccaea rosularis</i>	Yahyalı ultramafic area Kayseri in 2018; broader Türkiye table in 2008	Yes	37°47.753'N; 35°29.115'E	Source-supported coordinate retained for descriptive mapping.	A	L06	Yes
C046	<i>Aethionema spicatum</i>	Hamidiye-Gerdibi area; Kızıldağ occurrence noted but Ni needs study	No	—	Broad locality retained in the inventory only.	D	—	No
C047	<i>Centaurea aladaghensis</i>	Adana province in Ozbey2026 threatened serpentine endemic table	No	—	Broad locality retained in the inventory only.	D	—	No
C048	<i>Centaurea amanicola</i>	Amanus mountains context; exact locality not extracted	No	—	Broad locality retained in the inventory only.	D	—	No
C049	<i>Centaurea antitauri</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C050	<i>Centaurea arifolia</i>	Hatay province in Ozbey2026 threatened serpentine endemic table	No	—	Broad locality retained in the inventory only.	D	—	No
C051	<i>Centaurea cataonica</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C052	<i>Centaurea cheirollopha</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C053	<i>Centaurea haradjianii</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C054	<i>Centaurea ensiformis</i>	Muğla province; Sandras Mountain context	No	—	Broad locality retained in the inventory only.	D	—	No
C055	<i>Centaurea ptosimopappa</i>	Amanus mountains context; exact locality not extracted	No	—	Broad locality retained in the inventory only.	D	—	No
C056	<i>Centaurea ptosimopappoides</i>	Adana province in Ozbey2026 threatened serpentine endemic table	No	—	Broad locality retained in the inventory only.	D	—	No
C057	<i>Centaurea sericea</i>	Balıkesir province in Ozbey2026 threatened serpentine endemic table	No	—	Broad locality retained in the inventory only.	D	—	No
C058	<i>Centaurea spicata</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C059	<i>Centaurea tomentella</i>	Türkiye locality summary only	No	—	Broad locality retained in the inventory only.	D	—	No
C060	<i>Noccaea camlikensis</i>	Çamlık village, Derebucak, Konya; Kızıldağ, 1,400–1,600 m	Yes	longitude 31.6389452; latitude 37.3510902	Representative locality; not an exact collection coordinate.	C	C01	Yes
C061	<i>Isatis pinnatiloba</i>	locality not extracted from accessible page	No	—	Broad locality retained in the inventory only.	D	—	No
C062	<i>Isatis cappadocica</i>	Yahyalı ultramafic area Kayseri	Yes	37°54.827'N; 35°27.806'E	Source-supported coordinate retained for descriptive mapping.	A	L01	Yes
C063	<i>Noccaea triangularis</i>	Yahyalı ultramafic area Kayseri	Yes	37°46.712'N; 35°25.827'E	Source-supported coordinate retained for descriptive mapping.	A	L05	Yes
C064	<i>Bupleurum croceum</i>	locality not found in accessible sources	No	—	Insufficient or unresolved locality information; not mapped.	E	—	No
C065	<i>Alyssum turkestanicum</i>	Yahyalı ultramafic area Kayseri	No	—	Broad locality retained in the inventory only.	D	—	No
C066	<i>Arabis sagittata</i>	Yahyalı ultramafic area Kayseri	No	—	Broad locality retained in the inventory only.	D	—	No

Class A indicates a source-supported coordinate retained for descriptive mapping; class C indicates a representative locality rather than an exact collection coordinate; classes D and E are retained in the evidence inventory but are not point-mapped. Coordinate strings are reproduced as transcribed in the underlying audit records and are not used for inferential spatial analysis or fine-scale site assignment

Table S4. MTA lithological crosswalk used for the descriptive map

MTA field	Original MTA attribute value	Map category	Purpose in the descriptive map	Explicit limitation
MTA_Lito	Ofiyolit	Secondary ophiolitic geological context (orange)	Displayed as wider ophiolitic context for source recovery and field verification.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.
MTA_Lito	Radyolarit–Çört	Secondary ophiolitic geological context (orange)	Displayed as wider ophiolitic context for source recovery and field verification.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.
MTA_Lito	Ultramafik Kayaç	Core Ni-relevant lithologies (red)	Displayed as the principal broad geological context for Ni-related metallophyte screening.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.
LITHO_L2	Mixed sedimentary–ophiolitic	Secondary ophiolitic geological context (orange)	Displayed as wider ophiolitic context for source recovery and field verification.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.
LITHO_L2	Ultramafic	Core Ni-relevant lithologies (red)	Displayed as the principal broad geological context for Ni-related metallophyte screening.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.
LITHO_L3	Mixed (carbonate + ophiolite)	Secondary ophiolitic geological context (orange)	Displayed as wider ophiolitic context for source recovery and field verification.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.
LITHO_L3	Ophiolite	Secondary ophiolitic geological context (orange)	Displayed as wider ophiolitic context for source recovery and field verification.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.
LITHO_L3	Ophiolitic assemblage	Secondary ophiolitic geological context (orange)	Displayed as wider ophiolitic context for source recovery and field verification.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.
LITHO_L3	Ophiolitic ultramafic	Core Ni-relevant lithologies (red)	Displayed as the principal broad geological context for Ni-related metallophyte screening.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.
LITHO_L3	Peridotite	Core Ni-relevant lithologies (red)	Displayed as the principal broad geological context for Ni-related metallophyte screening.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.
LITHO_L3	Peridotite–pyroxenite	Core Ni-relevant lithologies (red)	Displayed as the principal broad geological context for Ni-related metallophyte screening.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.
LITHO_L3	Radiolarite–chert	Secondary ophiolitic geological context (orange)	Displayed as wider ophiolitic context for source recovery and field verification.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.
LITHO_L3	Serpentinite	Core Ni-relevant lithologies (red)	Displayed as the principal broad geological context for Ni-related metallophyte screening.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.
LITHO_L3	Serpentinite–gabbro	Secondary ophiolitic geological context (orange)	Displayed as wider ophiolitic context for source recovery and field verification.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.
LITHO_L3	Serpentinite–peridotite	Core Ni-relevant lithologies (red)	Displayed as the principal broad geological context for Ni-related metallophyte screening.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.
LITHO_L3	Ultramafic complex	Core Ni-relevant lithologies (red)	Displayed as the principal broad geological context for Ni-related metallophyte screening.	Contextual only; not used to assign coordinates or demonstrate a formal plant–lithology association.

This table lists the 16 MTA attribute values used to define the lithological-context classes displayed in Figure 2.