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Integrating Geo-Health and Thalassotherapy Data: A GIS-Based Model for the Black Sea Region

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Abstract

The Black Sea region, encompassing Bulgaria, Romania, Ukraine, Georgia, and Turkey, contains a unique diversity of marine therapeutic resources — mineralized seawater, peloids, marine aerosols, and coastal microclimates. However, these resources have historically been studied in isolation, without a unified spatial or analytical framework. This study presents a conceptual model for a Geo-Health System integrating GIS-based environmental mapping, biochemical and clinical datasets, and standardized geo-metadata to strengthen preventive medicine, spa management, and sustainable coastal development. Three interrelated components were developed:

1. Thalassotherapy GIS Map – spatial delineation of key therapeutic zones (Pomorie, Techirghiol, Kuyalnik, Balchik Tuzla, Anaklia–Ureki–Grigoleti, Sinop–Rize);
2. Geo-Health Indicators Dashboard – integration of environmental and clinical data through composite indices (HCI, PBI, CCI, TES);
3. Standardized Geo-Metadata Framework – ensuring data interoperability according to INSPIRE Directive and ISO 19115/19139 standards;

Together, these tools offer a foundation for a regional Geo-Health database, promoting evidence-based thalassotherapy, digital transformation, and transnational cooperation in the Blue Health context (Gushcha et al., 2023).

KEYWORDS: Thalassotherapy; Geo-Health; GIS-based mapping; Biochemical indicators; Peloids; Blue Health; Black Sea region; Metadata standardization; Preventive medicine; Sustainable coastal development

1. Introduction

The Black Sea basin possesses a remarkable yet underutilized potential for thalassotherapy and marine health tourism (Babov, Loboda, & Nikipelova, 2007). The region's coastal environments combine rich mineralized waters, organic peloids, marine aerosols, and favorable climatic conditions, which have been traditionally employed in spa medicine across Bulgaria, Romania, and Ukraine, and are emerging areas of research in Georgia and Turkey.

However, scientific knowledge on these natural therapeutic factors remains fragmented. Each country maintains its own datasets, often incompatible and lacking standardized metadata (European Environment Agency [EEA], n.d.). To address this gap, a GIS-based Geo-Health framework is proposed to unify spatial, biochemical, and clinical datasets, ensuring standardization, interoperability, and accessibility under European directives (INSPIRE Directive, 2007).

2. Methods and Conceptual Framework

A spatial database was developed using open geospatial datasets (Sentinel-2, Landsat-8/9, Copernicus DEM, ERA5 climatic data). Key thalassotherapeutic locations were mapped: – Bulgaria: Pomorie, Balchik Tuzla – Romania: Techirghiol Lake – Ukraine: Kuyalnik and Tuzla Estuaries – Georgia: Anaklia, Ureki, Grigoleti – Turkey: Sinop, Rize coastal zonesEach site was evaluated according to salinity, sediment type, organic content, coastal morphology, and climatic comfort, using a multi-criteria GIS analysis (Gushcha et al., 2023).

Figure 1. GIS map of Black Sea Thalassotherapy Zones.

GEO-HEALTH INDICATORS DASHBOARD

The Dashboard integrates laboratory and clinical data into interactive spatial analytics. Four composite indices were defined: – HCI – Hydro-Chemical Index – PBI – Peloid Bioactivity Index – CCI – Climatic Comfort Index – TES – Therapeutic Efficacy ScoreEach index is visualized as an interactive heatmap showing spatial gradients and cross-country comparison.

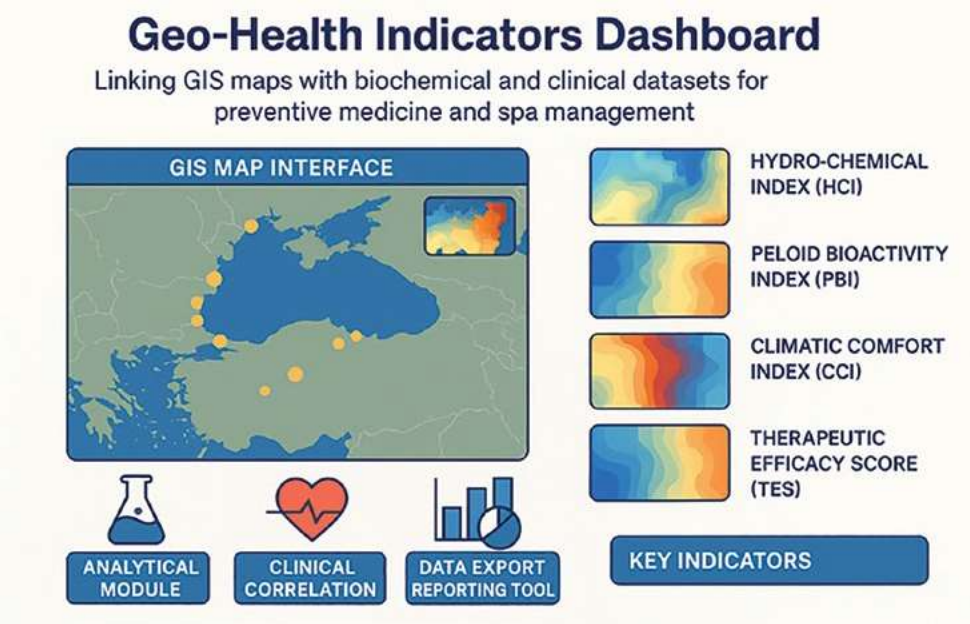

Figure 2. Geo-Health Indicators Dashboard concept.

STANDARDIZED GEO-METADATA

To ensure long-term data interoperability, all datasets follow: – INSPIRE Directive (2007/2/EC) – ISO 19115 & 19139 metadata standards – ISO/IEC 17025 laboratory compliance.A visual metadata schema represents hierarchical data flow from national datasets into a unified Black Sea Geo-Health Metadata Hub (Prodanov et al., 2025; Solodyankina & Vanteeva, 2012, 2015; Zlateva et al., 2024; Nonova et al., 2023).

Figure 3. Standardized Geo-Metadata Framework for data interoperability.

3. Results and Discussion

The GIS mapping identified over 15 distinct coastal zones with active or potential thalassotherapeutic use. Salinity gradients ranged between 5‰ and 250‰, with the highest values in Pomorie and Kuyalnik, indicating strong peloid formation potential (Babov et al., 2007).

The Geo-Health Dashboard visualized correlations between environmental and therapeutic factors. Peloids with higher organic content demonstrated greater anti-inflammatory properties (Gushcha et al., 2023). The metadata harmonization model demonstrated compatibility across national GIS platforms (QGIS, ArcGIS Online, Copernicus) (Vanteeva & Solodyankina, 2018; Doncheva et al., 2020; Vinkovic et al., 2022).

4. Conclusion

The integration of GIS technologies, biochemical analytics, and metadata standardization introduces a new paradigm — the Geo-Health Model for the Black Sea. This framework supports scientific validation of natural marine healing resources, cross-border cooperation, and sustainable “Blue Health” development strategies.

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