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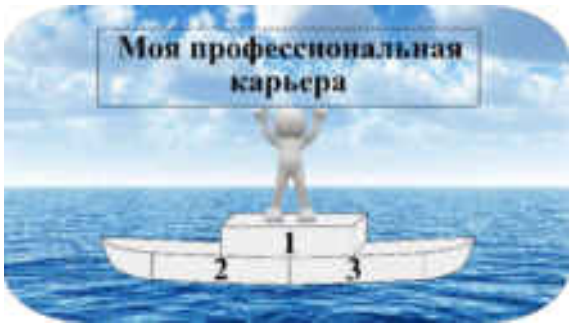
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Международный научно-образовательный электронный журнал «ОБРАЗОВАНИЕ И НАУКА В XXI ВЕКЕ». Выпуск №74-4 (том 3) (май, 2026). Дата выхода в свет: 25.05.2026.

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Название публикации: «POSSIBILITIES FOR THE THERAPEUTIC AND REHABILITATION UTILIZATION OF THERMAL WATER RESOURCES IN THE DASHOGUZ REGION»

Annotation: *Thermal water resources have long been recognized for their therapeutic, preventive, and rehabilitative properties in various regions of the world. The mineral composition, temperature characteristics, and hydrochemical properties of geothermal waters contribute significantly to their medical and wellness applications. This article investigates the possibilities for the therapeutic and rehabilitation utilization of thermal water resources located in the Dashoguz region. The study examines the geological formation of thermal waters, their physicochemical properties, medical applications, rehabilitation potential, and socio-economic significance. Furthermore, the article analyzes the influence of mineralized thermal waters on musculoskeletal disorders, neurological conditions, dermatological diseases, and general human health improvement.*

Keywords: *Anthocyanins, Rubus vulgaris, flavonoids, plant pigments, antioxidant compounds, solvent extraction, phenolic compounds, natural colorants, bioactive substances, phytochemical analysis*

Introduction

Natural therapeutic resources have played an important role in human healthcare for centuries. Among these resources, thermal mineral waters occupy a special position due to their complex chemical composition and physiotherapeutic properties. The therapeutic use of geothermal water resources is widely practiced in many countries for the treatment of chronic diseases, rehabilitation therapy, and preventive healthcare.

Thermal waters are underground waters naturally heated by geothermal processes occurring within the Earth's crust. These waters often contain dissolved minerals, salts, gases, and biologically active components that may positively influence human physiological processes. Depending on their mineral composition and temperature, thermal waters are used in balneology, hydrotherapy, physiotherapy, and wellness medicine. The Dashoguz region possesses natural geothermal resources that may provide valuable opportunities for medical and rehabilitation applications. The presence of thermal water sources in this region creates favorable conditions for the development of health-related infrastructure and therapeutic treatment systems based on natural mineral resources.

In recent decades, growing interest in natural medicine and non-pharmaceutical rehabilitation methods has increased scientific attention toward hydrothermal treatment technologies. Thermal water therapy is increasingly recognized as a complementary approach to conventional medical treatment, particularly in the management of chronic musculoskeletal disorders and rehabilitation following injury or surgery. The therapeutic effectiveness of thermal waters depends on multiple factors including water temperature, mineral concentration, pH level, dissolved gases, and treatment duration. These characteristics influence blood circulation, muscular relaxation, inflammatory processes, and nervous system activity.

Modern rehabilitation medicine increasingly combines traditional hydrotherapy methods with advanced physiotherapeutic technologies. Thermal water treatment is frequently integrated with massage therapy, physical exercise, respiratory therapy, and electrotherapy to improve patient recovery outcomes. The development of therapeutic infrastructure based on thermal resources may also contribute to regional socio-

economic growth. Health tourism and wellness tourism have become important sectors in many countries possessing geothermal resources.

At the same time, sustainable management of thermal water resources remains essential. Excessive extraction, environmental contamination, and inadequate infrastructure may negatively affect geothermal ecosystems and reduce long-term resource availability. This article investigates the therapeutic and rehabilitation possibilities of thermal water resources in the Dashoguz region through three major research perspectives: geological and physicochemical properties of thermal waters, medical and rehabilitation applications, and socio-economic development with future perspectives.

Geological Formation and Physicochemical Properties of Thermal Water Resources

Thermal waters originate through complex geological and hydrothermal processes occurring beneath the Earth's surface. Underground water penetrates deep geological layers where geothermal heat increases water temperature before the heated water rises back toward the surface through fractures and porous rock formations.

The geothermal activity associated with thermal water formation is influenced by tectonic structure, underground heat flow, and hydrogeological conditions. In the Dashoguz region, geological formations may contribute to the natural heating and mineralization of underground water resources.

The chemical composition of thermal waters depends largely on the geological environment through which the water circulates. During underground movement, thermal waters dissolve minerals and trace elements from surrounding rocks, thereby acquiring specific hydrochemical characteristics.

Mineralized thermal waters often contain calcium, magnesium, sodium, potassium, bicarbonates, sulfates, chlorides, and silica compounds. These dissolved components significantly influence the therapeutic value of the water.

Table 1. Common Mineral Components in Thermal Waters

Mineral Component	Physiological Significance
Calcium	Bone and muscle support
Magnesium	Nervous system regulation
Sodium	Electrolyte balance
Sulfates	Skin and digestive benefits
Bicarbonates	Metabolic regulation
Silica	Skin regeneration

Water temperature is one of the most important parameters affecting therapeutic application. Thermal waters are generally classified according to temperature range.

Table 2. Classification of Thermal Waters by Temperature

Temperature Range	Classification
20–37°C	Hypothermal
37–42°C	Thermal
Above 42°C	Hyperthermal

Elevated water temperatures improve blood circulation, relax muscles, and increase metabolic activity in human tissues. Heat transfer from thermal water to the body contributes significantly to rehabilitation processes.

The pH level of thermal waters also affects physiological response. Slightly alkaline mineral waters are often considered beneficial for skin conditions and inflammatory disorders.

Dissolved gases such as carbon dioxide and hydrogen sulfide may further enhance therapeutic effects. Carbon dioxide improves peripheral blood circulation, while sulfur-containing waters are commonly associated with dermatological treatment benefits. Microbiological purity is essential for safe therapeutic utilization. Regular hydrochemical and microbiological monitoring must be conducted to ensure water safety and prevent contamination.

The therapeutic potential of thermal water is influenced not only by individual mineral components but also by the synergistic interaction between temperature, dissolved substances, and hydrostatic pressure. Understanding the geological and physicochemical properties of thermal waters provides the scientific foundation

necessary for developing effective rehabilitation and healthcare applications in the Dashoguz region.

Therapeutic and Rehabilitation Applications of Thermal Waters

Thermal water therapy has long been used in rehabilitation medicine due to its combined thermal, mechanical, and chemical effects on the human body. These therapeutic mechanisms contribute to pain reduction, muscle relaxation, circulation improvement, and functional recovery.

One of the most common applications of thermal water therapy involves musculoskeletal disorders. Patients suffering from arthritis, osteochondrosis, rheumatism, and chronic joint pain often experience symptomatic improvement following hydrothermal treatment. Warm mineralized water increases local blood circulation and improves oxygen delivery to tissues. Enhanced circulation may accelerate tissue repair processes and reduce muscular tension.

Hydrostatic pressure produced during immersion therapy also contributes to rehabilitation effectiveness. Water pressure supports body weight, reduces stress on joints, and facilitates controlled movement during physical therapy exercises. Thermal hydrotherapy is frequently used in neurological rehabilitation programs. Patients recovering from stroke, spinal injuries, or peripheral nerve disorders may benefit from improved muscle coordination and reduced spasticity.

The buoyancy effect of water significantly improves mobility in rehabilitation environments. Patients with limited movement capacity can perform therapeutic exercises more comfortably in aquatic conditions.

Table 3. Therapeutic Applications of Thermal Waters

Medical Condition	**Potential Therapeutic Effect**
Arthritis	Pain reduction
Muscle disorders	Relaxation and recovery
Neurological conditions	Improved mobility
Skin diseases	Anti-inflammatory effect

Stress disorders	Nervous system relaxation

Dermatological applications also represent an important therapeutic field. Sulfur-containing and mineral-rich waters are frequently used for treating psoriasis, eczema, dermatitis, and chronic skin irritation.

Thermal therapy may positively influence psychological health as well. Warm water immersion contributes to stress reduction, relaxation, improved sleep quality, and emotional stabilization. Rehabilitation centers utilizing thermal waters often combine hydrotherapy with physiotherapy, massage therapy, respiratory exercises, and medical supervision to maximize treatment effectiveness.

The duration and frequency of thermal treatment sessions must be carefully controlled. Excessive exposure to high temperatures may negatively affect cardiovascular function in certain patients. Modern rehabilitation medicine increasingly investigates evidence-based approaches to hydrotherapy. Clinical studies continue to evaluate the physiological mechanisms and long-term effectiveness of thermal treatment programs.

The thermal water resources of the Dashoguz region therefore possess significant potential for integration into multidisciplinary rehabilitation and wellness systems designed to support preventive healthcare and patient recovery.

Socio-Economic Importance and Future Development Perspectives

The therapeutic utilization of thermal water resources may significantly contribute to regional socio-economic development. Countries possessing geothermal resources often establish wellness tourism industries centered around rehabilitation and preventive healthcare services.

The Dashoguz region may benefit economically from the development of thermal rehabilitation centers, wellness resorts, and medical tourism infrastructure. Such projects could create employment opportunities and stimulate local economic activity.

Health tourism has become an increasingly important sector in global tourism markets. Many individuals travel specifically to access natural therapeutic resources and rehabilitation programs unavailable in their local regions. The establishment of

modern hydrotherapy centers requires interdisciplinary cooperation between healthcare specialists, engineers, geologists, environmental scientists, and tourism planners.

Infrastructure development is essential for effective utilization of thermal resources. Transportation systems, accommodation facilities, medical equipment, and water treatment technologies must be carefully planned and implemented. Environmental sustainability remains a major consideration in geothermal resource management. Excessive extraction of underground thermal water may reduce water pressure and negatively affect long-term resource availability.

Table 4. Key Factors for Sustainable Thermal Water Development

Factor	**Importance**
Water monitoring	Resource protection
Environmental regulation	Ecological balance
Medical supervision	Patient safety
Infrastructure quality	Service efficiency
Tourism management	Economic sustainability

Scientific research also plays an important role in the future development of thermal therapy systems. Detailed hydrochemical analysis and clinical studies are necessary for validating therapeutic effectiveness and establishing treatment protocols.

Digital healthcare technologies may further improve rehabilitation management. Remote patient monitoring, electronic medical records, and AI-assisted diagnostic systems could enhance therapeutic efficiency in future wellness centers. Educational institutions may also contribute to the development of balneology and rehabilitation sciences through specialized training programs and interdisciplinary research initiatives.

International cooperation in geothermal medicine and rehabilitation research could accelerate technological development and improve clinical treatment methodologies associated with thermal water therapy. Future investments in sustainable geothermal infrastructure may position the Dashoguz region as an important center for therapeutic

tourism and natural rehabilitation medicine within the broader regional healthcare system.

The combination of natural geothermal resources, modern medical technologies, and sustainable management strategies creates significant opportunities for long-term healthcare and economic development.

Conclusion

The thermal water resources of the Dashoguz region possess considerable potential for therapeutic, rehabilitation, and preventive healthcare applications. Their mineral composition, geothermal characteristics, and hydrochemical properties provide favorable conditions for the development of hydrotherapy and balneological treatment systems.

This study has demonstrated that thermal waters may contribute positively to the treatment and rehabilitation of musculoskeletal, neurological, dermatological, and stress-related conditions. The integration of thermal therapy with physiotherapy and modern rehabilitation methods further enhances treatment effectiveness. The socio-economic significance of thermal water utilization extends beyond healthcare applications. Sustainable development of geothermal rehabilitation infrastructure may stimulate tourism, create employment opportunities, and contribute to regional economic growth.

Future research involving hydrochemical analysis, clinical evaluation, environmental monitoring, and infrastructure planning will be essential for maximizing the therapeutic and economic benefits of thermal water resources in the Dashoguz region.

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