ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 10,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

TESTING OF A COMPOSITE CONTAINING SALINITY-REDUCING AND BIO-ADDITIVE COMPONENTS FOR THE FORMATION OF GREEN COVER ON THE DRIED SEABED OF THE ARAL SEA UNDER LABORATORY CONDITIONS

M.B. Jumanazarov, S.D. Yo'ldashev
Tashkent Institute of Chemical Technology, Master's Students

Annotation: This study analyzes the composition, physicochemical properties, and effectiveness of a composite hydrogel containing salinity-reducing and bio-additive components, developed to create green cover on the dried seabed of the Aral Sea. The hydrogel composition included sodium alginate, bentonite, humates, mineral fertilizers (NPK), beneficial microorganisms (Azotobacter, Bacillus subtilis), and calcium chloride. According to research results, the hydrogel demonstrated a water absorption capacity equal to 300–400% of its own weight, maintained a stable pH level (6.5–7.5) in saline solution, and showed an ion absorption efficiency of around 40–70%. Experimental tests demonstrated the hydrogel's stability even under high salinity conditions and its ability to reduce soil salinity by 20–40%. As a result, the composite hydrogel is recommended as an environmentally friendly and effective tool for soil reclamation and the development of green cover in regions such as the Aral Sea basin.

Keywords: Composite hydrogel, salinity-reducing material, bioadditives, sodium alginate, bentonite, kaolin clay, humates, NPK fertilizers, Azotobacter, Bacillus subtilis, calcium chloride, water absorption capacity, swelling ratio, ion absorption index, pH stability, bioactive components, laboratory testing, Aral Sea region, ecological restoration, soil reclamation, green cover formation, hydrogel technology, biopolymer, water-retaining material, drought-resistant system.

Introduction

The main purpose of the composite hydrogel containing salinity-reducing and bio-additive components, developed for the formation of green cover on the dried seabed of the Aral Sea, is to reduce soil salinity, retain moisture, and supply bioactive components that stimulate plant growth. This technology is effective even under conditions of drought and high salinity.

The composite hydrogel is composed of sodium alginate, bentonite or kaolin clay, humates, NPK fertilizers, microorganisms (Azotobacter and Bacillus subtilis), and calcium chloride. Sodium alginate functions as the primary matrix that retains water, while bentonite contributes to salt absorption and structural reinforcement. Humates enhance soil fertility, and microorganisms help form beneficial microflora in the rhizosphere.

Physicochemical analysis of the composite showed that the product has a white-yellow or light brown color and a soft gel-like structure. The hydrogel transitions to gel form within 2–5 minutes, can absorb water up to 200–400% of its own weight, and remains stable in a neutral pH environment (6.5–7.5). When dried, it can be stored for 6–12 months.

Composition and Properties of the Composite Hydrogel

Component	**Function**
Sodium alginate	Main hydrogel matrix, retains water
Bentonite or kaolin clay	Absorbs salt and strengthens structural stability

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 10,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

Component	Function
Humates	Organic substance that increases soil fertility
Nitrogen, phosphorus, potassium fertilizers (NPK)	Bioactive growth-enhancing additives
Microbial inoculants	Form beneficial microflora in the plant rhizosphere

---

Quantitative Composition of Main Components

Substance	Amount (mass %)	Function
Sodium alginate	2–4%	Hydrogel matrix, binds water
Bentonite or kaolin clay	5–10%	Absorbs salts, strengthens structure
Humates	1–2%	Improves soil fertility
NPK fertilizers	0.5–1%	Stimulates plant growth
Azotobacter, Bacillus subtilis	1–3%	Enrich microbial composition of soil
Calcium chloride	2–5%	Crosslinking agent for gel formation

Physicochemical Properties

Indicator	Value / Description
Color	White-yellow or light brown
Structure	Soft or granular gel
Gelation time	2–5 minutes
Water absorption capacity	200–400% of its own weight
pH level	6.5 – 7.5 (neutral)
Storage time	6–12 months (in dried form)

Production Technology

The production process consists of preparing a sodium alginate solution, mixing with bentonite and bioactive components, and then dropping the mixture into a calcium chloride solution for crosslinking. As a result, strong water-absorbing capsules are formed. The final product is packaged in wet or dried granule form.

Laboratory Testing Methods

Laboratory tests were carried out to evaluate the hydrogel’s water absorption capacity, salt absorption index, swelling ratio, pH stability, and reusability.

A. Determination of Water Absorption Capacity (Gravimetric Method):

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 10,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

A dry hydrogel sample was weighed (m_0), then soaked in distilled water for 24 hours. The swollen sample was weighed again (m_1).
If the water absorption value exceeded 300%, the hydrogel was considered effective.

B. Ion Absorption in Saline Solutions:

The hydrogel was placed in 0.1M NaCl, $CaCl_2$, or $MgSO_4$ solutions for 24 hours. Ionic concentrations (Na^+, Cl^-, SO_4^{2-}) were measured using spectrophotometry.
Absorption levels of 40–70% indicated high salt removal efficiency.

C. Swelling Ratio Determination:

The volume of the sample was measured before and after 24 hours in saline solution.
The swelling ratio reflects the hydrogel's water-binding strength and structural stability.

Manufacturing Steps

Primary Stage

Step	Action	Description
1. Material preparation	Grind bentonite/kaolin to 100 microns; Prepare 2–4% sodium alginate solution	Alginic acid dissolves in distilled water
2. Addition of bioactive components	Prepare Azotobacter and Bacillus subtilis cultures; Mix humates and fertilizers	Microorganisms remain active during mixing
3. Composite formation	Mix clay with alginate solution and additives; Drip mixture into $CaCl_2$ solution	Ca^{2+} ions crosslink the gel forming hydrogel capsules
4. Drying (optional)	Hydrogels can be dried under sunlight or stored wet	Dried granules have longer shelf life

Secondary Stage

Stage	Action	Notes
Raw material preparation	Prepare 2–4% sodium alginate solution; grind bentonite	Maintain uniform mixture
Bioactive additives preparation	Ferment Azotobacter and Bacillus subtilis; prepare humates and NPK	Ensure microbial activity
Composite mixing	Add clay, humates, fertilizers, and microorganisms to alginate	Mix for 10–15 minutes
Capsule formation	Drip mixture into $CaCl_2$ solution	Gel structure forms immediately
Drying and storage	Dry or store wet in sealed containers	Prevent dehydration and contamination

During the experiments, modern laboratory equipment such as an analytical balance, graduated cylinders, a pH meter, an electroconductometer, and a spectrophotometer was used. The results showed that the hydrogel preserved its physical properties even in saline environments, maintained a stable pH range of 5.5–7.5, and was considered salt-resistant when its water absorption exceeded 150%.

Field trials conducted in the Aral Sea region demonstrated that the use of the hydrogel reduced soil salinity by **20–40%** and increased water retention capacity by **2–4 times**. Additionally, the

ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 10,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

seed germination rate and green cover formation speed were significantly higher compared to the commercial H-118 hydrogel.

Comparative Table: Composite Hydrogel vs. H-118 Hydrogel

Indicator	**New Composite Hydrogel**	**H-118 Hydrogel**
Composition	Alginate, bentonite, humate, microfertilizer, microorganisms, $CaCl_2$	Alginate, bentonite, $CaCl_2$
Salt absorption ability	High (effective even at 30–40% salinity)	Medium (effective up to ~20% salinity)
Water retention	300–400%	200–250%
Enriched with microorganisms	Yes (Azotobacter, Bacillus subtilis)	No
Effect on plant growth	Positive (rapid germination and development)	Limited (mainly moisture retention)
Contribution to ecological restoration	High – supports microflora and green cover formation	Moderate – functions mainly as a moisture-retaining material
Production complexity	Moderate – includes biotechnological steps	Simple – mainly chemical preparation
Cost (approx.)	1.2–1.5 times higher	Lower
Storage period	6–12 months (dried form)	12–18 months

Economic Efficiency Comparison (Per 1 Hectare)

Indicator	**Composite Hydrogel**	**H-118 Hydrogel**
Production cost	1200 UZS/m²	800 UZS/m²
Average yield after planting	2.5 tons/ha	1.6 tons/ha
Time to form green cover	15–20 days	30–35 days
Soil restoration period	2 years	3–5 years
Annual profit (conditional)	3.2 million UZS/ha	2.0 million UZS/ha

Plant Biomass Productivity Comparison (green mass g/m²)

Month	**Composite Hydrogel**	**H-118 Hydrogel**
1	300	150
2	650	400
3	980	600
4	1250	800

Purpose of Laboratory Testing of the Composite

№	**Indicator**	**Purpose**
1	Water retention capacity	Determines how much water the hydrogel can retain
2	Salt absorption index	Determines the ability to absorb ions in saline solution
3	Swelling ratio	Indicates the degree of hydrogel expansion

ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-5206, Impact Factor: 12,23

American Academic publishers, volume 05, issue 10,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

№	Indicator	Purpose
4	pH stability	Evaluates changes in hydrogel pH in saline solutions
5	Reusability index	Determines how many cycles the hydrogel can be reapplied

Laboratory Testing Procedure

A. Determination of Water Absorption Capacity (Gravimetric Method):

1. The dry hydrogel sample was weighed (m_0).
2. The sample was placed in distilled water or saline solution for 24 hours.
3. The water-saturated sample was weighed again (m_1).

The water absorption coefficient was calculated as:

$$\text{Water Absorption (\%)} = \frac{m_1 - m_0}{m_0} \times 100$$

B. Ion Exchange and Absorption in Saline Solution:

1. The hydrogel samples were kept in 0.1 M NaCl, $CaCl_2$, or $MgSO_4$ solutions for 24 hours.
2. The concentrations of ions (Na^+, Cl^-, SO_4^{2-}) in the solution before and after treatment were measured using spectrophotometric or titrimetric methods.
3. The percentage of absorbed ions was calculated as follows:

$$\text{Ion Absorption (\%)} = \frac{C_0 - C_1}{C_0} \times 100$$

where C_0 is the initial ion concentration and C_1 is the ion concentration after contact with the hydrogel.

C. Determination of Swelling Ratio of the Hydrogel:

1. The initial volume of the dry hydrogel (V_0) was measured.
2. The volume after 24 hours of immersion in solution (V_1) was measured.
3. The swelling coefficient was calculated as:

$$\text{Swelling Ratio} = \frac{V_1}{V_0}$$

Equipment Used for the Experiment (High-Precision Instruments):

1. Analytical balance (accuracy ±0.001 g)
2. Graduated cylinders
3. pH meter
4. Conductivity meter

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 10,2025
Journal: https://www.academicpublishers.org/journals/index.php/ijai

5. Spectrophotometer (for ion analysis)
6. Distilled water and standard saline solutions

Evaluation Criteria for Results:

1. If the hydrogel absorbs ≥300% water — the performance is considered good.
2. If water absorption in saline solution is ≥150% — the hydrogel is considered salt-resistant.
3. If the pH remains within 5.5–7.5 — the hydrogel is considered chemically stable and neutral.
4. If ion absorption is 40–70% — the hydrogel exhibits high desalination capacity.

The results obtained in the laboratory show that the composite hydrogel maintains high water absorption and swelling capacity even in saline media. This indicates that the hydrogel can effectively retain moisture and reduce salt concentration in soils affected by salinity.

Therefore, based on the results of water absorption and ion exchange tests, the composite hydrogel is identified as an **efficient, environmentally friendly material** suitable for **soil reclamation and green cover development in saline regions such as the Aral Sea basin.**

REFERENCES:

1. Mirziyoyev, Sh.M. Green Space — A Symbol of Harmony Between Humans and Nature. Tashkent: "Uzbekistan" Publishing House, 2023. – 352 p.
(The book outlines strategic objectives aimed at restoring ecological balance, establishing green plantations in the Aral Sea region, and protecting the environment.)

2. Usmonov, B.Sh. "Priority Directions of Applying Innovative Technologies in Ensuring Environmental Safety." Scientific Collection of Tashkent Chemical-Technological Institute, 2023, No.2, pp. 14–21.
(The article highlights methods of land reclamation and the creation of green cover on degraded soils using biotechnological approaches.)

3. Usmonov, B.Sh., Rakhimova, D.M., & Khaydarov, A. "Development of Polymer-Based Hydrogels and Their Application as Drought-Resistant Agro-Technological Agents." Science and Innovations Journal, 2022, No.3(18), pp. 57–63.

4. Ismoilov, Sh., & Qodirova, N. "Improving the Physicochemical Properties of Saline Soils Using Hydrogels." Uzbekistan Journal of Chemistry, 2021, No.4, pp. 42–49.

5. G'aniyeva, M., & Karimov, O. Synthesis of Composite Water-Retaining Materials Based on Bentonite Clay and Their Agroecological Significance. Tashkent: "Ilm Ziyo", 2020. – 128 p.

6. Alimov, D., & G'ulomov, S. "The Influence of Bioactive Additives and Microorganisms on Soil Fertility." Agrobiotechnology Journal, 2022, No.1, pp. 23–29.