Available on: https://jnsrr.ep-journals.org/ E-ISSN: 3051-3766 P-ISSN: 3051-3758

# Journal of Natural Science Research and Review

**Volume: 02 Issue: 06 June-2026**

## Improving an Efficient Wastewater Treatment Technology Based on Cation Exchanges and Natural Biopolymers

**Polvon Ruzmatovich Sharipov**
Associate Professor, Tashkent Institute of Chemical Technology

**Muazzamkhon Nazirjon Norbutaeva**
Master's Student, Tashkent Institute of Chemical Technology

**Published Date: June 04, 2026** **Article DOI: 10.65150/EP-jnsrr/V2E6/2026-01**

**ABSTRACT:** This article examines wastewater treatment processes in the Tashkent River using cation exchangers and natural biopolymers. The study examined the key physicochemical parameters of the wastewater composition, including turbidity, total hardness, organic matter, iron ions, nitrates, and phosphates. Chitosan, cellulose, cation exchange resin, amaranth stem, and paulownia charcoal were used as adsorbents and sorbents in the bleaching process.

In each experiment, wastewater from the Tashkent River was mixed with the selected material for 30 minutes, then filtered, and the results were analyzed using charts. The study results showed a significant reduction in suspended particles, organic pollutants, and heavy metal ions in the water. In particular, chitosan and paulownia charcoal demonstrated effective results with high adsorption properties, while the cation exchange resin demonstrated high efficiency in reducing water hardness.

Based on the obtained scientific results, an improved wastewater treatment process flowsheet was developed. The proposed technology is important in terms of environmental safety, cost-effectiveness, and the ability to utilize local raw materials.

**KEYWORDS:** wastewater, cation exchange resin, biopolymer, chitosan, cellulose, adsorption, filtration, paulownia charcoal, amaranth stem, water purification.

### INTRODUCTION

Today, the depletion of water resources and their pollution due to anthropogenic factors is a global environmental problem [1]. Wastewater generated by industrial enterprises, agriculture, and households contains organic matter, heavy metal ions, nitrates, phosphates, and other toxic compounds that negatively impact the ecological state of natural water bodies [2]. Discharge of insufficiently treated wastewater into rivers, canals, and streams degrades water quality, disrupts biological balance, and poses a threat to human health [3]. Therefore, wastewater treatment using effective, environmentally safe, and economically feasible methods is a pressing scientific and practical challenge today [4]. In the Republic of Uzbekistan, special attention is paid to water resource protection, rational use, and effective wastewater treatment [1]. Rivers flowing through Tashkent are polluted by domestic and industrial wastewater, and their physicochemical parameters deviate from established regulatory requirements [5]. Since traditional bleaching methods often require high energy consumption and expensive reagents, the development of alternative, low-cost technologies is of great importance [6].

In recent years, extensive research has been conducted on the use of natural sorbents, biopolymers, and ion-exchange materials in wastewater treatment [3]. In particular, natural materials such as chitosan, cellulose, amaranth stem, and paulownia charcoal are characterized by high adsorption properties, biodegradability, environmental safety, and production from local raw materials [7]. Furthermore, cation exchangers with ion-exchange properties can effectively reduce the content of hardness ions and some heavy metal ions in water [8]. The use of natural sorbents not only reduces the content of organic and inorganic pollutants in water but also prevents secondary environmental hazards [9].

This research study examined the treatment of wastewater from the Tashkent River using chitosan, cellulose, cation exchange resin, amaranth stem, and paulownia charcoal. Changes in water turbidity, total hardness, organic matter content, iron ions, and suspended solids during the bleaching process were analyzed. Based on the obtained results, an improved wastewater treatment process scheme was developed and its environmental and economic efficiency was assessed [4,7,10].

Tashkent River Wastewater Composition. Tashkent river wastewater contains organic and inorganic pollutants that negatively impact the physicochemical parameters of the water. Bleaching, household, and industrial wastewater increases the amount of suspended solids, heavy metal ions, nitrate and phosphate compounds, and microorganisms in the water.

Based on the regulatory document UzDSt 951 "Wastewater. General Specifications," physicochemical analyses of the wastewater were conducted [11], and the following parameters were established.

Main Parameters of River Wastewater

| № | Indicators | Quantity |
|---|---|---|
| 1 | pH | 7,2–7,8 |
| 2 | Turbidity | 18–35 mg/l |
| 3 | Total hardness | 6–9 mg-ekv/l |
| 4 | Chlorides | 120–180 mg/l |
| 5 | Sulfates | 150–240 mg/l |
| 6 | Nitrates | 20–45 mg/l |
| 7 | Phosphates | 3–8 mg/l |
| 8 | Iron ions | 0,4–1,2 mg/l |
| 9 | Organic matter | 15–30 mg/l |
| 10 | Suspended particles | 40–90 mg/l |

Experiment 1. Results of purification using chitosan

Experiment description. Wastewater from the Tashkent River was mixed with chitosan for 30 minutes and then filtered. Chitosan is a natural biopolymer that adsorbs organic matter and heavy metal ions in water. Results.

| Indicators | Before treatment | After treatment |
|---|---|---|
| Turbidity | 32 mg/l | 10 mg/l |
| Organic matter | 28 mg/l | 11 mg/l |
| Iron ions | 1,0 mg/l | 0,3 mg/l |
| Phosphates | 7 mg/l | 2 mg/l |

The use of chitosan significantly reduced turbidity and organic matter content in the water. High bleaching efficiency was noted.

Experiment 2. Results of purification using cellulose

Experiment Description

Wastewater was mixed with cellulose for 30 minutes and filtered. Cellulose was used as a natural fiber adsorbent. Results.

| Indicators | Before treatment | After treatment |
|---|---|---|
| Turbidity | 32 mg/l | 15 mg/l |
| Organic matter | 28 mg/l | 16 mg/l |
| Suspended particles | 85 mg/l | 40 mg/l |

The fiber effectively retained suspended particles in the water.

Experiment 3. Results of purification using a cation exchange resin

Experiment Description

Water was mixed with the cation exchange resin for 30 minutes and then filtered. The cation exchange resin has ion-exchange properties and reduces water hardness. Results.

| Indicators | Before treatment | After treatment |
|---|---|---|
| Total hardness | 8 mg-ekv/l | 3 mg-ekv/l |
| Iron ions | 1,0 mg/l | 0,2 mg/l |
| Chlorides | 170 mg/l | 120 mg/l |

The cation exchange resin demonstrated high efficiency in water softening and metal ion recovery.

Experiment 4. Purification results using amaranth stem

Experiment Description

Crushed amaranth stem was used as an adsorbent. Results

| Indicators | Before treatment | After treatment |
|---|---|---|
| Turbidity | 32 mg/l | 18 mg/l |
| Organic matter | 28 mg/l | 17 mg/l |
| Phosphates | 7 mg/l | 4 mg/l |

Amaranth stems have shown good results as an environmentally friendly and inexpensive adsorbent.
Experiment 5. Results of purification using paulownia carbon
Experiment Description
Carbon obtained from paulownia wood was used as an adsorbent. Results

| **Indicators** | **Before treatment** | **After treatment** |
|---|---|---|
| Turbidity | 32 mg/l | 8 mg/l |
| Organic matter | 28 mg/l | 9 mg/l |
| Iron ions | 1,0 mg/l | 0,1 mg/l |

Pavlov's carbon has been recognized as one of the most effective sorbents due to its high adsorption properties.
Improved Water Purification Technology
Based on the results obtained, the following process flow diagram is recommended:
Proposed Process Steps
1. Mechanical Cleaning – Separation of Large Particles
2. Biopolymer Treatment – Reduction of Organic Matter Using Chitosan or Cellulose
3. Cation Filtration – Reduction of Water Hardness and Metal Ion Content
4. Pavlov's Carbon Adsorption – Absorption of Odors, Color, and Organic Matter
5. Final Filtration and Disinfection – Improving the Quality of Purified Water

**CONCLUSIONS**

The study demonstrated that Tashkent River wastewater can be effectively treated using a cation exchange resin and various natural biopolymers. The study experimentally examined the effects of chitosan, cellulose, a cation exchange resin, amaranth stem, and paulownia charcoal on the physicochemical parameters of the wastewater, and assessed their adsorption and ion-exchange properties. The bleaching process resulted in a significant reduction in turbidity, suspended solids, organic matter, iron ions, and total water hardness.

According to the study, chitosan possesses high adsorption properties and effectively retains organic matter and fine dispersed particles in water. The dramatic reduction in turbidity and organic matter after bleaching demonstrates the high effectiveness of chitosan as a biopolymer. Paulownia charcoal, due to its developed porous structure, demonstrated the best results in adsorbing organic pollutants and certain metal ions in water. This sorbent significantly improved water clarity and reduced the content of odor-causing compounds.

During purification using the cation exchange resin, the overall water hardness decreased, and ion exchange resulted in a reduction in calcium and magnesium ions. This confirmed the important role of cation exchange resins in water softening and producing high-quality water for industrial processes. Natural materials such as cellulose and amaranth stems also demonstrated positive results in retaining suspended particles and improving the physical condition of water. In particular, the availability and low cost of amaranth stems as a local raw material allowed them to be evaluated as an environmentally promising sorbent.

Based on the results obtained, an improved wastewater treatment process flowsheet was recommended. This technology consists of several stages, initially including mechanical filtration, then adsorption purification using biopolymers, and finally ion exchange through cation exchange resins. The final stage involves deep adsorption purification using paulownia carbon. This integrated technology enables efficient wastewater treatment while reducing reagent consumption and ensuring energy efficiency.

The main advantages of the proposed technology are its environmental safety, cost-effectiveness, and the use of local raw materials. The use of natural sorbents reduces the risk of secondary pollution and promotes environmental protection. Furthermore, the application of this technology at local wastewater treatment facilities can expand the potential for wastewater reuse. The research results will have significant scientific and practical implications for the further development of innovative and resource-saving water treatment technologies.

**REFERENCES**

1) Мирзиёев Ш.М. Экологик хавфсизлик ва атроф-муҳит муҳофазаси соҳасидаги ислоҳотлар. – Тошкент: Ўзбекистон, 2023.
2) Арипов Р.А., Исмоилов И.И. Сувни тозалаш технологиялари. – Тошкент: Фан, 2021.
3) Crini G., Lichtfouse E. Advantages and disadvantages of techniques used for wastewater treatment // Environmental Chemistry Letters. – 2019. – Vol. 17. – P. 145–155.
4) Fu F.,Wang Q. Removal of heavy metal ions from wastewaters:A review//Journal of Environmental Management.–2011.–Vol.92.–P. 407–418.
5) O‘zDSt 951:2011. Oqava suvlar. Umumiy texnik shartlar. – Toshkent, 2011.
6) СанПиН №0083-99. Оқова сувларни сув ҳавзаларига ташлаш санитария қоидалари. – Тошкент, 1999.
7) Ahmed S., Ikram S. Chitosan and its derivatives for water treatment applications // Journal of Environmental Chemical Engineering. – 2016. – Vol. 4. – P. 4117–4129.
8) Демидов Н.Н. Ионообменные материалы и их применение. – Москва: Химия, 2018.
9) Маткаримов У.М. Табиий сорбентлар асосида сув тозалаш усуллари // Кимё ва кимё технологияси. – 2022. – №4. – Б. 52–58.
10) Bhattacharya A.K., Mandal S.N., Das S.K. Adsorption of Zn(II) from aqueous solution by using different adsorbents // Chemical Engineering Journal. – 2006. – Vol. 123. – P. 43–51.
11) O’zDSt 951 “Oqava suvlar. Umumiy texnik shartlar”.



Corresponding Author: Polvon Ruzmatovich Sharipov