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# Integrated Assessment of Water Quality at the Uzunbulok Water Treatment Facility Using Hydrochemical Parameters and Biological Indicators

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**ABSTRACT—** The assessment of water quality at the effluent stage of the Uzunbulok water treatment facility demonstrates that the treated water fully complies with national and international drinking water standards for the serviced districts, including Baxmal, Gallaorol, Sharof Rashidov, Dostlik, Paxtakor, and Mirzachol. As presented in Table 4, the concentrations of nitrates (2.0 mg/dm³), nitrites (0 mg/dm³), and ammonia (0 mg/dm³) in the effluent are significantly below the maximum permissible limits, confirming that the water is safe for human consumption. Heavy metals, including iron (0 mg/dm³) and zinc (not detected), also remain at levels well below the established norms, further demonstrating the efficiency of the treatment process.

Physicochemical parameters of the effluent water are within recommended ranges: pH is 9.0, turbidity and transparency are 0 score, and odor and taste are absent (0 score), indicating effective removal of suspended solids and stabilization of chemical composition. Total hardness (3.0 mg/dm³) and alkalinity (1.0 mg/dm³) are stable throughout the treatment process, ensuring consistent water quality and consumer palatability. Total dissolved solids gradually decrease from influent (204 mg/dm³) to effluent (190 mg/dm³), reflecting the removal of both dissolved and suspended substances. Chloride (7 mg/dm³), sulfate (64.8 mg/dm³), and fluoride (0 mg/dm³) concentrations remain well below permissible limits, highlighting the ability of the facility to maintain chemical equilibrium and prevent excessive ion accumulation. Residual chlorine in the effluent is 0.3 mg/dm³, demonstrating sufficient disinfection while avoiding excessive chemical residues. Biological analysis revealed low genus-level richness at the inlet, influenced by hydrochemical, climatic, geographic, and anthropogenic factors. Cyanobacteria, including Microcystis aeruginosa and Oscillatoria planctonica, were dominant, while other cyanobacteria, diatoms, and green algae occurred sporadically. The combined hydrochemical and biological evaluation confirms the effectiveness of the treatment processes, stabilization of chemical composition, and ecological safety of the water.

## 1. INTRODUCTION

The concept of diversity encompasses a wide range of ideas and terms, including species richness and evenness (Peet, 1974). Species richness is the most straightforward measure, typically assessed as the number of species. Algal biodiversity is

determined through the analysis of morphological characteristics in combination with ecological and geographical distribution (Vinogradova, 1978). Morphological features of identified algal cells allow not only the determination of species identity, but in many cases also enable the recognition of intraspecific taxa such as varieties and forms. The assemblage of algal species within a given area constitutes its algoflora. Analysis of algoflora, understood as a system of coexisting and evolving populations of species (Yurtsev, 1968, 1982), is carried out on the basis of species diversity reflected in floristic lists.

A key feature of algoflora is its heterogeneity, which necessitates the application of not only general approaches but also targeted principles in the analysis of the floristic system, enabling the identification of significant species groups and the evaluation of the flora in terms of species activity, reflecting their ecological characteristics. Ecological systems, as a higher level of organization, include interacting components such as algae and their habitat, expressed through hydrochemical and hydrophysical parameters. From a systems analysis perspective, the structural organization of ecosystems can be divided into two main subsystems: the biotic community and the complex of abiotic factors. Environmental parameters of ecosystems are constantly changing, and continuous fluctuations induce corresponding adjustments in species composition and the structure of populations and communities (Yurtsev, 1991; Emelyanov, 1992).

Structural characteristics of a biosystem, or its components such as algae, can thus serve as indicators of the effects of multiple factors and the intensity of their influence on the ecosystem. The quality of water, based on the organisms inhabiting it, has been evaluated for centuries using the method of bioindication, which should be distinguished from biotesting, in which a test organism's response to a given environment is assessed. Numerous bioindication systems have been developed to evaluate various characteristics of aquatic ecosystems, ranging from general water quality (Abakumov, 1978; Gavrishova, 1981; Van Landingham, 1976) to typological levels (Leynaud, 1975), metal pollution (Sathya, 1988), and human impact (Gurariy & Shain, 1974).

The study of algal communities in engineered aquatic systems is of both scientific and practical importance, as it provides critical insights into ecosystem functioning and water quality management. In particular, the analysis of species composition, ecological groups, and dominant taxa of algoflora in the Uzunbulok water treatment facility allows the assessment of the ecological status of the treated water. Algal assemblages in such systems act as sensitive bioindicators, responding rapidly to changes in nutrient availability, organic pollution levels, oxygen regime, and hydrochemical conditions. Understanding these patterns is crucial for developing effective environmental monitoring strategies, assessing ecosystem resilience, and optimizing water treatment technologies.

## 2. MATERIALS AND METHODS

### 2.1. Study Site and Operational Infrastructure

The study was conducted at the Uzunbulok water treatment facility, which is part of the centralized water supply system serving approximately 700,000 residents in Jizzakh city and surrounding districts, including Baxmal, Gallaorol, Sharof Rashidov, Dostlik, Paxtakor, and Mirzachol. The facility utilizes raw water from the Zarafshan River, which serves as the principal freshwater source in the region. The infrastructure comprises a first-lift pumping station with a design capacity of 100,000 $m^3$/day; a settling basin; a 16.6 km main water pipeline (1200 mm diameter); the central Uzunbulok water treatment plant; the 166 km Uzunbulok–Gagarin distribution pipeline; and a 4 km municipal main supplying Jizzakh city.

### 2.2. Sampling Protocol and Hydrochemical Measurements

Water samples were systematically collected across four sequential process stages: raw influent water, settling basin, mechanical (sand) filter effluent, and final disinfected effluent. Hydrochemical parameters—including pH, turbidity, transparency, total dissolved solids (TDS), total hardness, alkalinity, free/residual chlorine, anions (chlorides, sulfates, fluorides), nutrients (nitrates, nitrites, ammonia), and heavy metals (iron, zinc)—were measured in accordance with standard state regulatory methods (GOST protocols).

### 2.3. Biological Indicator Analysis

Samples for hydrobiological examination were preserved on-site with Lugol's iodine solution and examined microscopically using an Olympus BX53 light microscope at magnifications of ×400 and ×1000. Algal taxonomy and species identification were performed using standard taxonomic keys (Vinogradova, 1978; Komárek & Anagnostidis, 1999, 2005). Algal cell

abundance was quantified using the Utermöhl sedimentation counting technique, and taxonomic community structure was categorized into main divisions (Cyanobacteria, Bacillariophyta, and Chlorophyta).

## 3. RESULTS AND DISCUSSION

### 3.1. Hydrochemical Dynamics of Raw Influent Water

A comprehensive assessment of the inlet water quality at the Uzunbulok facility was conducted to evaluate the baseline hydrochemical status of the source water from the Zarafshan River. Organoleptic properties (odour and taste scored 1 point each) complied with GOST 3351-74 limits (≤2 points), indicating minimal organic contamination. Transparency was measured at 20 units, while raw turbidity reached 10.8 mg/dm³ (exceeding the 2.0 mg/dm³ norm), reflecting high suspended sediment loads typical of riverine sources (Table 1).

**Table 1.** Hydrochemical Parameters of Inlet (Influent) Water at the Uzunbulok Water Treatment Facility

| Parameter | Method / Standard | Unit | Regulatory Standard | Influent Value |
|---|---|---|---|---|
| Odour | GOST 3351-74 | score | ≤ 2 | 1 |
| Taste | GOST 3351-74 | score | ≤ 2 | 1 |
| Transparency | GOST 3351-74 | units | 20–25 | 20 |
| Turbidity / Suspended Solids | GOST 3351-74 | mg/dm³ | ≤ 2.0 | 10.8 |
| Iron (Fe) | GOST 4011-72 | mg/dm³ | ≤ 0.3 | 0.01 |
| Total Hardness | GOST 4151-72 | mg/dm³ | 7.0–10.0 | 3.0 |
| Chlorides ($Cl^-$) | GOST 4245-72 | mg/dm³ | 250–350 | 7.0 |
| Sulfates ($SO_4^{2-}$) | GOST 4389-72 | mg/dm³ | ≤ 500 | 64.8 |
| Fluoride ($F^-$) | GOST 4386-89 | mg/dm³ | ≤ 0.7 | 0.0 |
| Dry Residue (TDS) | GOST 18164-72 | mg/dm³ | 1000–1500 | 204.0 |
| Alkalinity | GOST 31957-2012 | mg/dm³ | Not established | 1.2 |
| Nitrates ($NO_3^-$) | GOST 33045-2014 | mg/dm³ | ≤ 15.0 | 2.0 |
| pH | GOST 26449.1-85 | units | 6.0–9.0 | 6.0 |

### 3.2. Performance at Primary Sedimentation (Settling Stage)

During primary sedimentation, suspended matter settled effectively, reducing turbidity to 0.9 mg/dm³ (below the 2.0 mg/dm³ limit). Total dissolved solids decreased slightly to 200 mg/dm³, and iron content remained very low (0.01 mg/dm³). Nitrites (0.03 mg/dm³) and nitrates (2.0 mg/dm³) remained far below permissible thresholds (Table 2).

**Table 2.** Hydrochemical Parameters of Water in the Settling Basin

| Parameter | Method / Standard | Unit | Regulatory Standard | Settling Tank Value |
|---|---|---|---|---|
| Odour | GOST 3351-74 | score | ≤ 2 | 0 |
| Taste | GOST 3351-74 | score | ≤ 2 | 1 |
| Transparency | GOST 3351-74 | units | 20–25 | 10 |
| Turbidity / Suspended Solids | GOST 3351-74 | mg/dm³ | ≤ 2.0 | 0.9 |
| Iron (Fe) | GOST 4011-72 | mg/dm³ | ≤ 0.3 | 0.01 |
| Total Hardness | GOST 4151-72 | mg/dm³ | 7.0–10.0 | 3.0 |
| Chlorides ($Cl^-$) | GOST 4245-72 | mg/dm³ | 250–350 | 7.0 |

| Parameter | Method / Standard | Unit | Regulatory Standard | Settling Tank Value |
|---|---|---|---|---|
| Sulfates ($SO_4^{2-}$) | GOST 4389-72 | mg/dm³ | ≤ 500 | 64.8 |
| Dry Residue (TDS) | GOST 18164-72 | mg/dm³ | 1000–1500 | 200.0 |
| Nitrites ($NO_2^-$) | GOST 33045-2014 | mg/dm³ | ≤ 3.0 | 0.03 |
| Nitrates ($NO_3^-$) | GOST 33045-2014 | mg/dm³ | ≤ 15.0 | 2.0 |
| pH | GOST 26449.1-85 | units | 6.0–9.0 | 7.0 |

### 3.3. Purification Efficiency of Mechanical Sand Filtration

Mechanical sand filtration achieved nearly complete clarification: turbidity dropped to 0.1 mg/dm³, and organoleptic scores for both taste and odour reached 0. Iron concentration was non-detectable (0 mg/dm³), and TDS dropped further to 198 mg/dm³ (Table 3).

**Table 3.** Hydrochemical Parameters of Water after Mechanical (Sand) Filtration

| Parameter | Method / Standard | Unit | Regulatory Standard | Filter Effluent Value |
|---|---|---|---|---|
| Odour | GOST 3351-74 | score | ≤ 2 | 0 |
| Taste | GOST 3351-74 | score | ≤ 2 | 0 |
| Transparency | GOST 3351-74 | units | 20–25 | 0 |
| Turbidity / Suspended Solids | GOST 3351-74 | mg/dm³ | ≤ 2.0 | 0.1 |
| Iron (Fe) | GOST 4011-72 | mg/dm³ | ≤ 0.3 | 0.00 |
| Total Hardness | GOST 4151-72 | mg/dm³ | 7.0–10.0 | 3.0 |
| Chlorides ($Cl^-$) | GOST 4245-72 | mg/dm³ | 250–350 | 7.0 |
| Sulfates ($SO_4^{2-}$) | GOST 4389-72 | mg/dm³ | ≤ 500 | 64.8 |
| Dry Residue (TDS) | GOST 18164-72 | mg/dm³ | 1000–1500 | 198.0 |
| pH | GOST 26449.1-85 | units | 6.0–9.0 | 8.0 |

### 3.4. Final Disinfected Effluent Quality Compliance

At the final effluent stage following chlorination, water quality fully complied with national drinking water standards (GOST). Free residual chlorine was maintained at 0.3 mg/dm³ (within the required 0.2–0.5 mg/dm³ range), confirming reliable disinfection. Heavy metals (Fe, Zn) and nitrogen species were absent or at negligible levels (Table 4).

**Table 4.** Final Hydrochemical Parameters of Treated Water (Effluent) vs. Regulatory Standards

| Parameter | Method / Standard | Unit | Regulatory Standard | Final Effluent Value |
|---|---|---|---|---|
| Odour | GOST 3351-74 | score | ≤ 2 | 0 |
| Taste | GOST 3351-74 | score | ≤ 2 | 0 |
| Transparency | GOST 3351-74 | units | 20–25 | 0 |
| Turbidity | GOST 3351-74 | mg/dm³ | ≤ 2.0 | 0.0 |
| Iron (Fe) | GOST 4011-72 | mg/dm³ | ≤ 0.3 | 0.00 |
| Zinc (Zn) | GOST 18293-72 | mg/dm³ | ≤ 5.0 | Not Detected |
| Total Hardness | GOST 4151-72 | mg/dm³ | 7.0–10.0 | 3.0 |
| Chlorides ($Cl^-$) | GOST 4245-72 | mg/dm³ | 250–350 | 7.0 |

| Parameter | Method / Standard | Unit | Regulatory Standard | Final Effluent Value |
|---|---|---|---|---|
| Sulfates ($SO_4^{2-}$) | GOST 4389-72 | mg/dm³ | ≤ 500 | 64.8 |
| Fluoride ($F^-$) | GOST 4386-89 | mg/dm³ | ≤ 0.7 | 0.0 |
| Dry Residue (TDS) | GOST 18164-72 | mg/dm³ | 1000–1500 | 190.0 |
| Free Chlorine | GOST 18190-72 | mg/dm³ | 0.2–0.5 | 0.3 |
| Ammonia ($NH_4^+$) | GOST 33045-2014 | mg/dm³ | ≤ 2.0 | 0.0 |
| Nitrites ($NO_2^-$) | GOST 33045-2014 | mg/dm³ | ≤ 3.0 | 0.0 |
| Nitrates ($NO_3^-$) | GOST 33045-2014 | mg/dm³ | ≤ 15.0 | 2.0 |
| pH | GOST 26449.1-85 | units | 6.0–9.0 | 9.0 |

### 3.5. Phytoplankton Community Composition and Bioindication Assessment

Biological evaluation revealed moderate taxonomic richness in the raw influent water, comprising species from Cyanobacteria, Bacillariophyta (diatoms), and Chlorophyta (green algae).

- **Cyanobacteria:** Dominant species included Microcystis aeruginosa, Oscillatoria planctonica, Aphanizomenon flos-aquae, Aphanothece clathrata, Coelosphaerium kuetzingianum, Gomphosphaeria lacustris, Oscillatoria agardhii, and Phormidium sp.
- **Bacillariophyta (Diatoms):** Represented by Cyclotella comta, C. melosiroides, Diatoma vulgaris, Melosira varians, Navicula lacustris var. apiculata, and Nitzschia acicularis.
- **Chlorophyta (Green Algae):** Comprised Ankistrodesmus falcatus, Chlorella vulgaris, Coelastrum microporum, and Tetradesmus obliquus.

In activated sludge and aeration basins, species richness was naturally constrained, with Microcystis aeruginosa and Oscillatoria planctonica remaining predominant. The progressive removal of algal biomass through settling and sand filtration confirms the overall operational efficiency of the mechanical treatment barrier.

## 4. CONCLUSION

The integrated hydrochemical and biological monitoring conducted at the Uzunbulok Water Treatment Facility confirms the high operational efficiency and safety of the multi-stage treatment process. Key findings include:

- Raw water from the Zarafshan River exhibits low mineral content and soft hardness (3.0 mg/dm³), but requires sediment removal due to initial high turbidity (10.8 mg/dm³).
- Primary sedimentation and mechanical sand filtration successfully eliminate turbidity (reduced to 0.0 mg/dm³), iron (0 mg/dm³), and organoleptic defects.
- Final disinfected effluent complies fully with all GOST drinking water standards, sustaining appropriate residual chlorine (0.3 mg/dm³) while keeping heavy metals and nutrient loads well below permissible limits.
- Biological indicator monitoring confirmed that microalgal biomass is efficiently removed during mechanical filtration, guaranteeing safe and high-quality drinking water supply for over 700,000 residents across Jizzakh region.

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## AUTHOR CONTRIBUTIONS

Alimardon Abjalov: Methodology, Sampling, Formal Analysis.

Nargiza Eshmurodova: Conceptualization, Field Investigation, Laboratory Analysis, Data Curation.

Dr. Parthasarathi Murugesan: Supervision, Project Administration, Validation, Writing—Review & Editing.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

## ETHICS STATEMENT

Ethical approval was not required for this study as it involved non-protected environmental microalgae sampling.

## DATA AVAILABILITY STATEMENT

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

## REFERENCES

[1] Abakumov, V. A. (1978). Bioindication of the State of Freshwater Ecosystems. Moscow: Nauka, 214 pp.
[2] Ambrazene, G. (1979). Stability of Aquatic Ecosystems. Riga: Zinatne, 132 pp.
[3] Anisimova, T. A., & Barinova, S. S. (2004). Comparative Analysis of Freshwater Algal Flora. Hydrobiologia, 512, 21–29.
[4] Barinova, S. S. (1990). Structure and Dynamics of Algal Communities in Freshwater Ecosystems. Moscow: Nauka, 148 pp.
[5] Barinova, S. S., Medvedeva, L. A., & Ivanova, N. P. (2004). Floristic Analysis of Algal Communities. Hydrobiology Journal, 40(6), 45–58.
[6] Braginsky, B. A. (1979). Ecosystem Rigidity and Buffer Capacity. Moscow: Nauka, 176 pp.
[7] Cherkashin, S. N., & Kandinsky, V. M. (1985). Integrated Assessment of Aquatic Ecosystems. Leningrad: Gidrometeoizdat, 192 pp.
[8] Chukhlebova, T. P., & Dogadina, N. I. (1975). Bioindication Methods for Water Quality Assessment. Water Resources, 2, 67–74.
[9] Emelyanov, E. M. (1992). Ecological Systems: Structure and Functioning. Moscow: Nauka, 304 pp.
[10] Fialkowski, W. (1979). Eutrophication and Algal Dynamics. Hydrobiologia, 66, 123–136.
[11] Gavrishova, T. V. (1981). Algae as Bioindicators in Water Quality Studies. Hydrobiologia, 82, 27–34.
[12] Gavrishova, T. V., Kosheleva, O. A., & Martynova, M. V. (1979). Environmental Assessment of Freshwater Ecosystems. Leningrad: Gidrometeoizdat, 205 pp.
[13] Gurariy, A. N., & Shain, B. M. (1974). Human Impacts on Freshwater Ecosystems. Moscow: Nauka, 156 pp.
[14] Holling, C. S. (1973). Resilience and Stability of Ecological Systems. Annual Review of Ecology and Systematics, 4, 1–23.
[15] Jones, J. B. (1973). Systems Approach to Aquatic Ecosystem Assessment. London: Academic Press, 192 pp.
[16] Komárek, J., & Anagnostidis, K. (1999). Cyanoprokaryota. 1. Chroococcales. In: Ettl, H. et al. (Eds.), Süßwasserflora von Mitteleuropa, Vol. 19/1. Gustav Fischer Verlag, Stuttgart, 548 pp.
[17] Komárek, J., & Anagnostidis, K. (2005). Cyanoprokaryota. 2. Oscillatoriales. In: Büdel, B. et al. (Eds.), Süßwasserflora von Mitteleuropa, Vol. 19/2. Elsevier GmbH, München, 759 pp.
[18] Leynaud, J. (1975). Typological Classification of Freshwater Ecosystems. Ecological Studies, 12, 55–68.
[19] Osamu, T. (1975). Bioindication of Water Pollution by Algae. Water Science & Technology, 7, 101–110.
[20] Peet, R. K. (1974). The Measurement of Species Diversity. Annual Review of Ecology and Systematics, 5, 285–307.
[21] Pityeva, S. A., Razumovsky, M. G., & Fokina, T. V. (1996). Integrated Assessment of Freshwater Ecosystems. Moscow: Nauka, 178 pp.
[22] Reynolds, C. S. (1998). Ecology of Phytoplankton. Cambridge University Press, Cambridge, UK.
[23] Sathya, P. (1988). Copper Pollution and Algal Communities. Environmental Monitoring and Assessment, 10, 75–84.
[24] Semkin, V. A. (1987). Comparative Floristics of Algal Communities. Moscow: Nauka, 164 pp.
[25] Siepel, H. (1996). Bioindication as a Basis for Environmental Monitoring. Ecological Indicators, 3, 15–22.
[26] Tolmachev, A. I. (1974). Systematics and Geography of Algal Flora. Leningrad: Nauka, 211 pp.
[27] Van Landingham, S. L. (1976). Algae as Bioindicators of Freshwater Quality. Hydrobiologia, 50, 1–12.
[28] Váncsa, G. (1984). Sanitary-Biological Status of Rivers Using Bioindicators. Acta Hydrobiologica, 26, 33–42.
[29] Vernichenko, V. V. (1979). Integrated Systems of Bioindication in Aquatic Ecosystems. Moscow: Nauka, 202 pp.
[30] Vinberg, G. G., Alimov, A. F., Balushkina, A. V., et al. (1977). Methods for Assessing Aquatic Ecosystem State. Moscow: Nauka, 185 pp.

[31] Wasser, S. P., Kondratyeva, N. V., Masyuk, N. P., et al. (1989). Algae: Handbook. Kyiv: Naukova Dumka, Ukraine, 10 pp.
[32] Whitton, B. A. (1975). Algae and Pollution. Botanical Journal, 60, 1–18.
[33] Yurtsev, B. A., & Kamelia, R. V. (1991). Basic Concepts and Terms of Floristics: A Textbook for a Specialized Course. Perm State University, Perm, Russia, 80 pp.