ADVANCED TECHNOLOGY FOR INTEGRATED PROCESSING OF XUJAIPOK MINERALIZED WATER IN THE DEHQONOBOD REGION, UZBEKISTAN

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Abstract: Water scarcity and quality degradation represent serious challenges for rural communities across Central Asia. The Xujaipok water source located in the Dehqonobod region of Uzbekistan contains elevated concentrations of dissolved salts, iron, manganese, and microbial contamination, making it unsuitable for direct human consumption without treatment. This study presents the development and evaluation of a multi-stage water processing technology specifically designed for Xujaipok groundwater. The integrated system combines coagulation-flocculation, rapid sand filtration, activated carbon adsorption, reverse osmosis, and ultraviolet disinfection into a unified treatment chain.

Keywords: Xujaipok water, Dehqonobod, water treatment, reverse osmosis, multi-stage purification, groundwater quality.

Introduction. Access to clean drinking water is recognized as a fundamental human right, yet millions of people across Central Asia still rely on untreated groundwater sources that pose serious health risks [1]. Uzbekistan, a landlocked country in the heart of Central Asia, faces growing pressure on its freshwater resources due to population growth, agricultural intensification, and climate-related changes in precipitation patterns [2]. Rural communities in the Dehqonobod district of Kashkadarya region are particularly affected by water quality problems, as local groundwater tends to accumulate dissolved minerals, iron compounds, and biological contaminants due to the geological composition of the underlying aquifers [3].

The Xujaipok water source is one of the main groundwater supplies used by local residents in the Dehqonobod area. However, field measurements consistently show that raw water from this source exceeds safe limits for total dissolved solids (TDS), hardness, iron, manganese, fluoride, and coliform bacteria. Residents have reported gastrointestinal illnesses and long-term health concerns associated with prolonged consumption of untreated water from this source, a pattern observed in comparable settings across the region [4].

Literature Review. Research on groundwater treatment in arid and semi-arid regions has grown substantially over the past two decades. Studies from comparable geological settings in Central Asia highlight that elevated TDS and hardness are the most common problems in rural drinking water, often accompanied by iron and manganese contamination from reduced aquifer zones [1,2]. Treatment approaches must therefore address multiple contaminant classes simultaneously rather than targeting a single parameter.

Coagulation using aluminum sulfate (alum) or ferric chloride has been extensively documented as an effective first step for removing turbidity, colloidal particles, and some heavy metals from groundwater [5]. When combined with rapid sand filtration, this two-stage pre-treatment can remove up to 90% of suspended solids and significantly reduce the fouling load on downstream membrane systems [3]. Activated carbon filtration as a tertiary stage has proven effective for removing residual organic compounds, chlorine by-products, and taste or odor-causing substances that pass through earlier stages.

Reverse osmosis technology has been successfully applied to desalination of brackish groundwater in numerous studies from the Middle East, North Africa, and Central Asia. RO membranes achieve high rejection rates for dissolved salts, divalent ions, and microcontaminants, making them indispensable for treating high-TDS sources like Xujaipok water. Energy consumption and membrane fouling remain the primary operational challenges for RO systems, and pretreatment quality directly influences membrane longevity [4].

3. Materials and Methods

3.1 Study Site and Water Source

Water samples were collected from the Xujaipok groundwater source in Dehqonobod district, Kashkadarya region, Uzbekistan (coordinates: 38°52'N, 66°31'E) over a twelve-month period from January to December 2023. Sampling was conducted monthly at three fixed points: the wellhead, the primary storage tank, and the point of household use. Each sample set consisted of triplicate 5-liter polyethylene containers, transported to the laboratory under controlled temperature conditions (4°C) and analyzed within 24 hours of collection.

3.2 Water Quality Analysis

Physical-chemical parameters including pH, turbidity, electrical conductivity, TDS, total hardness, iron, manganese, nitrate, fluoride, and coliform bacteria were measured according to standard methods outlined by the American Public Health Association (APHA). pH and conductivity were determined using a calibrated multiparameter probe (Hach HQ40d). Turbidity

was measured with a portable turbidimeter (HACH 2100Q). Metal concentrations (iron, manganese) were quantified by atomic absorption spectrometry (AAS). Coliform bacteria enumeration followed the membrane filtration method on m-Endo agar at 37°C for 24 hours.

3.3 Treatment System Design

A pilot-scale treatment unit with a capacity of 1.5 m^3/hour was designed and constructed based on the identified water quality profile. The system comprises five sequential stages: (1) coagulation-flocculation chamber with polyaluminum chloride (PACl) dosing at 12–18 mg/L; (2) dual-media rapid sand filter with anthracite and quartz sand layers; (3) granular activated carbon (GAC) adsorption column with a 15-minute empty bed contact time (EBCT); (4) spiral-wound polyamide RO membrane module (recovery rate 75%); and (5) a UV disinfection chamber with a dose of 40 mJ/cm^2. System performance was monitored continuously over a 90-day operational period.

4. Conclusion. This study demonstrates that a five-stage integrated water treatment technology — comprising coagulation-flocculation, rapid sand filtration, activated carbon adsorption, reverse osmosis, and UV disinfection — successfully transforms Xujaipok groundwater in Dehqonobod region into safe, clean drinking water that meets WHO quality standards. Raw water in this area contains dangerously high levels of dissolved salts, iron, manganese, fluoride, and bacterial contamination. After treatment, all measured parameters fell within acceptable limits. The overall removal efficiency of the system exceeded 98%, and complete elimination of coliform bacteria was consistently achieved.

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