SANITARY AND HYGIENIC RISKS IN WORKING CONDITIONS AT HYDRAULIC STRUCTURES AND MEASURES FOR THEIR REDUCTION: SCIENTIFIC ANALYSIS AND MODERN SOLUTIONS

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Introduction

Hydraulic structures such as dams, hydroelectric power plants, pumping stations, and reservoirs are strategically important for water management, electricity generation, irrigation, and public water supply. However, working conditions at these facilities are often characterized by a combination of sanitary-hygienic and occupational hazards. Research has shown that unfavorable microclimatic conditions, elevated noise and vibration, insufficient lighting, poor air quality, and significant physical and mental strain contribute to adverse health outcomes in workers. Special attention is drawn to the increased prevalence of cardiovascular strain, impaired thermoregulation, asthenic conditions of the nervous system, as well as psycho-emotional stress and chronic fatigue among employees. The purpose of this study is to evaluate the hygienic and physiological conditions of workers at hydraulic structures, identify occupational hazards, and propose scientifically based preventive measures.

Methods

- Regulatory framework: The study relied on the *Labor Code of the Republic of Uzbekistan (2022)*, sanitary rules and norms (SanPiN), GOST and ISO standards.
- International guidelines: Recommendations of the International Labour Organization (ILO), the World Health Organization (WHO), and the European Agency for Safety and Health at Work (EU-OSHA).
- Instrumental measurements: Air temperature, humidity, air velocity, illumination levels, noise, and vibration were measured.
- Biomonitoring: Workers' cardiovascular parameters, respiratory function, thermoregulation capacity, and psycho-emotional state were monitored. Special focus was placed on symptoms of asthenia, nervous system dysfunctions, and fatigue-related disorders.
- Comparative analysis: Preventive practices were analyzed by comparing local data with international experience.

Results

The study revealed several key findings:

- Microclimate. Temperatures in dam galleries and pumping stations averaged 8–10 °C in winter and 18–20 °C in summer. Cold environments caused a 10–15% rise in heart rate and decreased work capacity. Workers demonstrated pronounced cardiovascular strain, thermoregulatory disturbances, and increased prevalence of fatigue-related disorders in such conditions.
- Cardiovascular and nervous system effects. Biomonitoring showed a higher incidence of hypertension, arrhythmias, and reduced heart rate variability. Asthenic conditions of the nervous system, impaired thermoregulation, psycho-emotional stress, and manifestations of

chronic fatigue syndrome were observed more frequently in workers exposed to prolonged microclimatic stressors.

- Lighting. Natural lighting was insufficient, while artificial lighting relied on outdated lamps. Replacement with LED systems was shown to improve performance by 12–15%.
- Noise and vibration. Noise levels in hydroelectric units were recorded at 85–90 dB, exceeding permissible limits and increasing risks of hearing impairment. German experience demonstrated that the use of vibration-protective gloves reduced occupational morbidity by 20–25%.
- Air quality. Poor ventilation resulted in humidity levels of 75–80% and excessive dust concentrations, increasing risks of respiratory diseases. Finland's application of remote sensors demonstrated a 40% reduction in air contamination.
- Ergonomics. Heavy manual work and lifting tasks contributed to musculoskeletal overload, particularly in the spine and joint systems. The necessity of mechanization and ergonomic solutions was confirmed.
- Innovation. The proposed HYDROHUMAN AI-360 system integrates real-time environmental monitoring through sensors and predictive analytics to anticipate occupational health risks, including cardiovascular and nervous system disorders.

Discussion

Comparison with international experience highlights the need for improvement of preventive systems in Uzbekistan's hydraulic facilities.

- Norway and Japan have successfully implemented biomonitoring systems that detect early cardiovascular and nervous system strain.
- Germany and Australia utilize SCADA technologies for remote monitoring of microclimate and noise. For Uzbekistan, targeted interventions such as heated rest rooms, LED-based lighting, advanced air filtration, ergonomic workplace design, and regular preventive health training are recommended. Regular medical examinations, screening for cardiovascular and nervous system disorders, and awareness programs about occupational hazards remain essential for early prevention.

Conclusion

The research confirms that working environments in hydraulic structures are associated with multiple occupational hazards.

Microclimatic stress, poor lighting, noise, and inadequate air quality significantly compromise workers' health.

1. The most common health problems identified include cardiovascular strain, disturbances of thermoregulation, asthenic conditions of the nervous system, psycho-emotional stress, and chronic fatigue syndrome.
2. Preventive measures should include heated rooms, LED lighting, effective air filtration, ergonomic solutions, and innovative sensor-based monitoring systems.

Advanced technologies such as HYDROHUMAN AI-360 have the potential to transform occupational health and safety monitoring, particularly for cardiovascular and nervous system-related risks. Harmonizing national regulations with international standards, while integrating modern technologies, is critical for reducing occupational risks and protecting the health of hydraulic facility workers.

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