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THE INFLUENCE OF TECHNOGENIC FACTORS ON THE POLLUTION OF LANDSCAPES OF THE AKHANGARAN RIVER BASIN

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Abstract. This article discusses the features of technogenic pollution of landscape complexes of the Akhangaran River basin, their sources, mechanisms of impact on natural ecosystems and possible measures to mitigate negative consequences. Particular attention is paid to the analysis of the impact of industrial, agricultural and transport activities on the quality of soils, water resources and biodiversity of the region. Recommendations for monitoring and restoration of disturbed ecosystems are provided.

Keywords: Akhangaran, basin, technogenic pollution, landscape complexes, Almalyk Mining and Metallurgical Combine (AMMC).

Texnogen omillarning Ohangaron daryo havzasi landshaftlari ifloslanishiga ta'siri

Annotatsiya. Ushbu maqolada Ohangaron daryo havzasi landshaft komplekslarining texnogen ifloslanishining xususiyatlari, ularning manbalari, tabiiy ekotizimlarga ta'sir qilish mexanizmlari va salbiy oqibatlarini yumshatish bo'yicha muhim bo'lgan chora-tadbirlar ko'rib chiqiladi. Sanoat, qishloq xo‘jaligi va transport faoliyatining hudud tuproq sifati, suv resurslari va bioxilma-xilligiga ta’sirini tahlil qilishga alohida e’tibor qaratilgan. Buzilgan ekotizimlarni tadqiq qilish va tiklash bo'yicha tavsiyalar berilgan.

Kalit so‘zlar: Ohangaron, havza, texnogen ifloslanish, landshaft komplekslari, Olmaliq kon-metallurgiya kombinati (OKMK).

Влияние техногенных факторов на загрязнение ландшафтов бассейна реки Ахангаран

Аннотация. В данной статье рассматриваются особенности техногенных загрязнений ландшафтных комплексов бассейна реки Ахангаран, их источники, механизмы воздействия на природные экосистемы и возможные меры по смягчению негативных последствий. Особое внимание уделяется анализу воздействия промышленной, сельскохозяйственной и транспортной деятельности на качество почв, водных ресурсов и биоразнообразие региона. Приводятся рекомендации по мониторингу и восстановлению нарушенных экосистем.

Ключевые слова: Ахангаран, бассейн, техногенные загрязнение, ландшафтные комплексы, Алмалыкский горно-металлургический комбинат (АГМК).

Introduction. The Akhangaran river basin in the Tashkent region of Uzbekistan is subject to significant technogenic pollution due to intensive economic activity. Industrial centers such as Angren, Almalyk, and Akhagaran, where chemical, metallurgical, and machine-building enterprises are located, are the main sources of pollution. In addition, mining, agriculture, transport, and household waste have

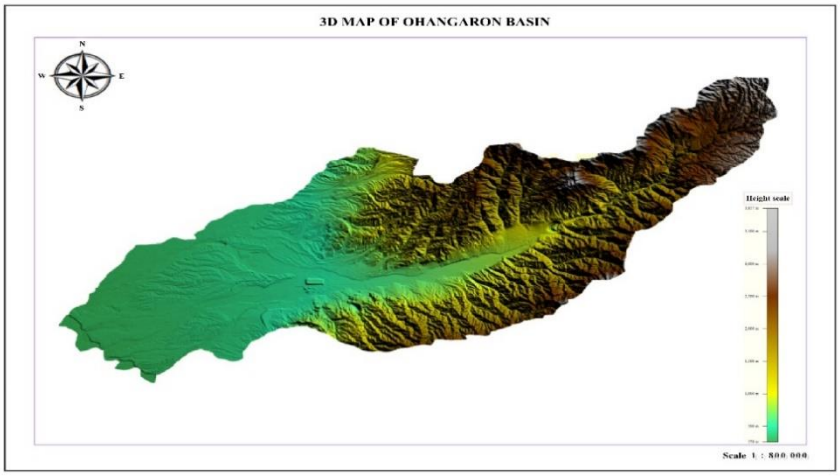
a negative impact on the environment. The main pollutants are heavy metals, nitrogen and sulfur oxides, dust, industrial wastewater, pesticides, mineral fertilizers, and organic waste. These pollutants enter the soil, water, and air, harming the ecosystem and public health. [5; 6; 22].

Water pollution in the Akhangaron river leads to a deterioration in its quality and has a negative impact on aquatic organisms. Soil pollution with heavy metals reduces its fertility and disrupts biological processes. Emissions from industrial enterprises and vehicles pollute the air, which leads to a deterioration in air quality and the occurrence of respiratory diseases among the population. [2; 5; 6; 8; 10; 14; 22]. The Akhangaran river basin is one of the industrially developed regions of Uzbekistan, and the presence of the cities of Angren, Almalyk, Akhangaran, as well as the Angren coal mine, the Angren thermal power plant (ATTP), the Almalyk mining and metallurgical complex (AMMC) once again emphasizes the importance of using and high-quality use of groundwater of the Akhangaran River. The basin in the formation of groundwater. [3; 5; 6; 9; 11; 15; 17].

Materials and methods: The complex research methods consist in analyzing scientific and technical data on the geographical and hydrogeological state of groundwater and surface waters of the Almalyk industrial region. Experimental studies were conducted, analytical methods, experimental methods and stationary observations, a method for determining the water level for wells located near the site. [5; 6;12].

Object of study. This study assesses the surface and groundwater of the Akhangaran river basin. The Akhangaran river is located between the Chatkal range and the Kuramin range, with an elevation of 2,710 m, coordinates 41°17′55″ and 70°37′13″, a length of 236 km, a basin area of 7,710 km², and a water consumption of 22,8 m³ per Turk village. [5; 6; 10].

Picture 1: 3D map at Akhangaran river basin.



Analysis results. The Akhangaran basin is a key area for studying man-made pollution due to the high concentration of industrial enterprises, cities, and agricultural activities. The main sources of pollution include the Almalyk Mining and Metallurgical Combine (AMMC), the cities of Angren, Almalyk, Akhangaran, and irrigation systems. Studies conducted over the past 30 years show that the quality of surface and groundwater, soil, and atmosphere has significantly deteriorated due to anthropogenic load. [1; 4; 10; 22].

Main sources of pollution. *Industrial facilities:*

- AMMC: the largest source of pollution with heavy metals (copper, zinc, iron) and nitrogen-containing substances. The plant consumes up to 21 thousand m³/h of water annually, and the discharge of industrial waste into the Akhangaran river leads to exceeding the MAC for copper and nitrites in the middle reaches.

- Cities of Angren and Almalyk: Wastewater from city sewers, storm water from industrial zones and solid waste landfills increase river pollution with organic compounds and heavy metals.

Agriculture:

- The use of mineral fertilizers and pesticides in irrigated agriculture contributes to the accumulation of nitrates and phosphates in soils and groundwater. Secondary salinization of soils due to intensive irrigation affects up to 40% of agricultural land in the basin.

Municipal and domestic wastewater:

- Insufficiently effective treatment of wastewater from settlements (Angren, Almalyk, etc.) leads to the entry of organic matter, biogenic elements (nitrogen, phosphorus), pathogenic microorganisms into the river.

Transport:

- Vehicle exhaust gases, as well as dust from roads (especially dirt roads adjacent to industrial zones) contribute to atmospheric pollution, and indirectly to soil and water pollution.

Power:

- The coal-fired Angren thermal power plant emits significant amounts of ash, sulfur and nitrogen oxides into the atmosphere**.** [22].

Impact on landscapes.

Surface waters:

- Akhangaran river: The most polluted areas are concentrated in the middle reaches, where the copper concentration exceeds the MAC by 5-10 times, and nitrites by 50-100 times.

- Tuyabuguz Reservoir: Accumulates polluted effluents from the Almalyk Mining and Metallurgical Combine, which leads to the accumulation of heavy metals in bottom sediments.

Groundwater:

- Over the past 30 years, groundwater reserves with mineralization <1 g/l have decreased by 40%. Pollution is associated with the infiltration of industrial waste and agricultural chemicals.

Soils:

- Technogenic geochemical anomalies with increased copper, zinc and lead content have been identified near industrial zones. For example, in the soils around the AMMC, copper concentrations reach 350 mg/kg, which is 350 times higher than background values.

Regional features:

- Hydrogeochemical halos: Formed around the AMMC tailings, where the copper pollution contrast coefficients reach 70–175 relative to the MAC.

- Climatic factors: Increased precipitation (up to 580 mm/year) and rising air temperatures (+3–5°C above normal) increase the leaching of pollutants from soils into water systems. [12; 21].

Types of pollutants:

Heavy metals: copper (Cu), zinc (Zn), lead (Pb), cadmium (Cd), arsenic (As), etc. accumulate in soils, bottom sediments, and aquatic organisms, posing a threat to human health.

Sulfates: Formed by the oxidation of sulfide minerals in waste and residues. Leads to acidification of soils and waters.

Pesticides and herbicides: Used in agriculture to control pests and weeds. Have toxic effects, can accumulate in food chains.

Mineral fertilizers: excessive use of nitrogen and phosphorus fertilizers leads to eutrophication of water bodies (excessive growth of algae and consequent oxygen deficiency).

Organic substances: Enter with wastewater, lead to a decrease in the oxygen content in the water and deterioration of the living conditions of aquatic organisms.

Suspended solids: Small particles of rocks, soil, industrial waste. They impair water transparency and make breathing difficult for aquatic organisms. Radionuclides: May be present in mining waste (e.g., uranium mining).

Consequences of pollution:

Deterioration of water quality: The water of the Akhangaran river in many places does not meet quality standards for drinking and domestic water supply. This creates problems in providing the population with clean water. Soil degradation: Soil contamination with heavy metals and other toxic substances reduces its fertility and makes it unsuitable for agriculture.

Biodiversity loss: Pollution leads to the death of aquatic organisms (fish, invertebrates), as well as to a change in the composition of vegetation in the river floodplain.

Damage to public health: Consumption of contaminated water and food grown on contaminated soils can lead to the development of various diseases, including cancer.

Economic damage: reduced agricultural productivity, water treatment and reclamation costs, damage to the fishing industry.

Pollution reduction measures: Improvement of ore mining and processing technologies in mines: introduction of closed water supply technologies, reclamation of degraded lands, use of environmentally friendly natural fertilizers.

Modernization of water treatment facilities: at industrial enterprises and settlements.

Rational use of fertilizers and pesticides in agriculture: use of innovative methods of plant protection, modern biological methods of pest control.

Strengthening environmental control: regular monitoring of the quality of water, soil and atmospheric air and taking necessary measures. [22].

Environmental education of the population: raising awareness of pollution problems and ways to solve them. Develop and implement programs for the reclamation of damaged areas, including waste storage facilities and landfills.

- **Ways to solve the problem.**
- Solving the problem of man-made pollution of the Ahangaron river basin requires an integrated approach, including:
- Modernization of water treatment facilities: for effective wastewater treatment, it is necessary to build and modernize treatment facilities at industrial enterprises and residential areas.
- Introduction of environmentally friendly technologies: The need to introduce environmentally friendly technologies that reduce the emission of pollutants into the atmosphere and water bodies by industrial enterprises is a requirement of the time.
- Control over the use of agrochemicals: It is necessary to strengthen control over the use of pesticides, herbicides and fertilizers in agriculture, as well as develop environmentally friendly methods of farming.
- Land reclamation: It is necessary to recultivate lands contaminated with heavy metals and other toxic substances.
- Environmental education and awareness: It is necessary to increase the environmental literacy of the population, inform about the problem of pollution and the need to treat nature carefully..

Conclusion/Recommendations.

Man-made pollution of landscape complexes of the Akhangaran river basin is a serious environmental problem caused by intensive economic activity in this region. Here are the main aspects of this problem:

The Akhangaran river basin is a classic example of landscape transformation under the influence of man-made factors. The key problems are heavy metal pollution, degradation of water resources and soils. Sustainable development of the region requires the integration of technological innovations, increased monitoring and interdisciplinary research that takes into account climate change and the geochemical features of the basin. To solve the problem of man-made pollution in the Akhangaran river basin, it is necessary to take a number of measures, including the modernization of industrial enterprises, rational use of natural resources, the development of environmentally friendly agriculture, the development of public transport, raising the environmental culture of the population, the introduction of a monitoring and control system, as well as compliance with environmental legislation.

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