**“TOSHKENT IRRIGATSIYA VA QISHLOQ XO‘JALIGINI MEXANIZATSIYALASH MUHANDISLARI INSTITUTI” MILLIY TADQIQOT UNIVERSITETI HUZURIDAGI ILMIY DARAJALAR BERUVCHI DSc.03/30.12.2019.T.10.02 RAQAMLI ILMIY KENGASH ASOSIDAGI BIR MARTALIK ILMIY KENGASH**

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**“TOSHKENT IRRIGATSIYA VA QISHLOQ XO‘JALIGINI MEXANIZATSIYALASH MUHANDISLARI INSTITUTI” MILLIY TADQIQOT UNIVERSITETI**

**SHOERGASHOVA SHOBEGIM SHAROF QIZI**

# IQLIM O‘ZGARISHI SHAROITIDA ZARAFSHON DARYOSI SUV SIFATI SHAKLLANISHIGA ANTROPOGEN AZOT BIRIKMALARINING TA’SIRI

**11.00.05 – Atrof-muhitni muhofaza qilish va tabiiy resurslardan oqilona foydalanish**

**TEXNIKA FANLARI BO‘YICHA FALSAFA DOKTORI (PhD) DISSERTASIYASI AVTOREFERATI**

**Toshkent – 2024**

**UO‘K: 627.152:543.272.37:504.38(575.1)(043)**

**Texnika fanlari bo‘yicha falsafa doktori (PhD) dissertatsiyasi avtoreferati mundarijasi**

**Contents of dissertation abstract of doctor of philosophy (PhD) on technical sciences**

**Оглавление автореферата диссертации доктора философии (PhD) по техническим наукам**

**“TOSHKENT IRRIGATSIYA VA QISHLOQ XO‘JALIGINI MEXANIZATSIYALASH MUHANDISLARI INSTITUTI” MILLIY TADQIQOT UNIVERSITETI HUZURIDAGI ILMIY DARAJALAR BERUVCHI DSc.03/30.12.2019.T.10.02 RAQAMLI ILMIY KENGASH ASOSIDAGI BIR MARTALIK ILMIY KENGASH**

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**Texnika fanlari bo'yicha falsafa doktori (PhD) dissertasiyasi mavzusi O'zbekiston Respublikasi Oliy ta'lim, fan va innovasiyalar vazirligi huzuridagi Oliy attestasiya komissiyasida B2024.3.PhD/T4999 raqam bilan ro'yxatga olingan.**

Dissertatsiya "Toshkent irrigatsiya va qishloq xo'jaligini mexanizatsiyalash muhandislari instituti" Milliy tadqiqot universitetida bajarilgan.

Dissertatsiya avtoreferati uch tilda (o'zbek, ingliz, rus (rezyume)) Ilmiy Kengash veb-sahifasida (www.tiiame.uz) va «ZiyoNet» axborot-ta'lim portalida (www.zivonet.uz) joylashtirilgan.

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## KIRISH (falsafa doktori (PhD) dissertatsiyasi annotatsiyasi)

**Dissertatsiya mavzusining dolzarbligi va zaruriyati.** Jahonda suv resurslari tanqisligi muammosi dolzarblashib bormoqda. Asosiy suv iste'molchisi bo'lgan qishloq xo'jaligida bu muammo ayniqsa yaqqol sezilayotganligi bilan bir qatorda ichimlik va sanoat ehtiyojlarini sifatli suv bilan ta'minlash borasida ham ko'pgina muammolar mavjud. Suvni ifloslantiruvchi asosiy manbalar sanoat korxonalari, qishloq xo'jaligi faoliyati va kommunal-maishiy xo'jalikdir. Qishloq xo'jaligida turli mineral o'g'itlardan foydalanish, kundalik hayotda turli kimyoviy moddalarning roli tobora ortib borishi, kommunal-maishiy va sanoat oqova suvlarining ko'pincha yetarli darajada tozalanmagan holda daryo va kanalizasiyaga oqizilishi suv resurslarining intensiv ifloslanishiga alohida ahamiyat berilmoqda. Hozirgi kunda ekinzorlarda foydalanilayotgan mineral o'g'itlar va o'simliklarni himoya qilish uchun ishlatilayotgan kimyovy zaharli vositalarning ancha qismi kollektor-drenaj suvlari orqali yer usti va yer osti suvlarining ifloslanishiga olib kelmoqda. Shu jihatdan, suvning sifatidagi o'zgarishlarni ekologik tahlil qilish va ta'sir etayotgan antropogen omillarni o'rganishga alohida e'tibor qaratilmoqda.

Jahonda suv sifati va uni boshqarish bo'yicha ilmiy tadqiqotlar olib borilmoqda. Ushbu yo'nalishda, jumladan, Birlashgan Millatlar Tashkiloti tomonidan yanada adolatli, barqaror va farovon dunyo yaratish uchun belgilangan bir qancha Barqaror rivojlanish maqsadlariga (BRM) erishish bilan bevosita bog'liq. Xususan, suv sifati BRM 3: "Yaxshi salomatlik va farovonlik" va BRM 6: "Toza suv va sanitariya" maqsadlariga erishish ustuvor hisoblanmoqda[1]. Shu bilan birga, suv ekotizimlarining tanazzulga uchrashi va resurslarning miqdoriy va sifat jihatidan kamayishi tendentsiyasining davom etishi barcha suv iste'molchilari uchun chuchuk va toza suv tanqisligi xavfini bartaraf etish dolzarb vazifalardan hisoblanmoqda.

Respublikamizda aholi sonining o'sishi 2030 yilga borib yuqori sifatli chuchuk suvga bo'lgan talabning 2,3 milliard $m^3$ dan 2,7-3,0 milliard $m^3$ ga (18-20%) oshishiga olib kelishi kutilmoqda. Bu esa ichki suv resurslariga bo'lgan talabning o'sishiga olib keladi[2]. So'nggi yillarda sanoat va energetika ham faol rivojlanmoqda, bu sohalarning suvga bo'lgan talabi yil sayin ortib bormoqda. Natijada, suv resurslarini ifloslanishdan muhofaza qilish, yer usti va yer osti suvlarining sifatini yaxshilash, suv sifati monitoringini takomillashtirish suv xo'jaligi sohasidagi davlat siyosatining asosiy vazifalaridan biriga aylanmoqda.

Mazkur dissertasiya tadqiqoti O'zbekiston Respublikasi Prezidentining 2019-yil 30-oktyabrdagi "2030-yilgacha bo'lgan davrda O'zbekiston Respublikasining Atrof muhitni muhofaza qilish konsepsiyasini tasdiqlash to'g'risida"gi PF-5863-son Farmonida nazarda tutilgan qishloq va kommunal xo'jaliklarda suv resurslarining kamayishi va ifloslanishidan himoya qilishga qaratilgan vazifalarni hayotga tadbiq etishga ma'lum darajada hissa qo'shadi[3]. O'zbekiston Respublikasi Prezidentining 2021-yil 24-fevraldagi PQ-5005-sonli "O'zbekiston Respublikasida suv resurslarini

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[1] 17 BRM. Birlashgan Millatlar Tashkilotining Barqaror rivojlanish sammiti, 2015 yil.

[2] Oziq-ovqat va qishloq xo'jaligi holati hisoboti. FAO, 2022 yil.

[3] O'zbekiston Respublikasi Prezidentining 2019-yil 30-oktyabrdagi "2030-yilgacha bo'lgan davrda O'zbekiston Respublikasining Atrof muhitni muhofaza qilish konsepsiyasini tasdiqlash to'g'risida"gi PF-5863-son Farmoni.

boshqarish va irrigatsiya sektorini rivojlantirishning 2021-2023-yillarga mo‘ljallangan strategiyasini tasdiqlash to‘g‘risida“gi[4] hamda 2022-yil 1-martdagi PQ-145-sonli “Quyi bo‘g‘inda suv resurslarini boshqarishni takomillashtirish hamda suv iste’molchilari orasidagi munosabatlarni tartibga solish chora-tadbirlari to‘g‘risida”gi[5] qarorlarida belgilangan vazifalar ijrosiga ma’lum darajada xizmat qiladi hamda suv xo‘jaligi sohasidagi faoliyatlarga tegishli boshqa me’yoriy-huquqiy hujjatlarda belgilangan vazifalarni amalga oshirishga ushbu dissertasiya tadqiqoti muayyan darajada xizmat qiladi.

**Tadqiqotning respublika fan va texnologiyalari rivojlanishining ustuvor yo‘nalishlariga mosligi.** Mazkur tadqiqot O‘zbekiston Respublikasi fan va texnologiyalar rivojlantirishning V. “Qishloq xo‘jaligi, biotexnologiya, ekologiya va atrof-muhit muhofazasi” ustuvor yo‘nalishi doirasida amalga oshirildi.

**Muammoning o‘rganilganlik darajasi.** Suv resurslari muammolari va ularning sifat va miqdoriy o‘zgarishlar dinamikasi bo‘yicha ilmiy tadqiqotlar O.Olsson, M.Groll, E. Yilmaz, T. Nasrabadi, X. Sun va boshqalar kabi xorijiy olimlar tomonidan olib borilgan. Yerdan foydalanishning daryolardagi suv sifatiga ta’sirini quyidagi olimlar o‘rganishgan: M. Matysik, Y. Huang, C. Chiang, F. Zhang, N. Shen va boshqalar. Qishloq xo‘jaligi amaliyotlarining daryo suvi sifatiga ta’siri M.Gunawardhana, Bijay-Singh, A.Lobanova, E.Severini va boshqalar tomonidan o‘rganilgan. Sanoat va urbanizatsiyaning daryolar sifatiga ta’siri I.Khan, F.Lemessa, F.Liu, S.Wang va boshqalar tomonidan tahlil qilingan. Bundan tashqari, iqlim o‘zgarishi ta’sirida daryolarning antropogen azot birikmalari bilan ifloslanishini o‘rganish M. Mimikou, P. Whitehead, R. Wilby, M. Astaraie-Imani, B. Pernet-Coudrier, M. Varol, T. Trang, M. Gabriel, N. Akhtar va boshqalar tomonidan amalga oshirilgan.

MDH mamlakatlarida daryolarning azot bilan ifloslanishining vaqt-zamon va fazoviy dinamikasi bo‘yicha tadqiqotlar olimlar A. Kornilov, V. Shesterkin, A. Chaiko, T. Zhuldybina, M. Larionov, E. Morzhakova, Yu. Limonov, N. Murashchenkova, E. Storozhenko va boshqalar tomonidan bajarilgan.

Respublikamizda Orol dengizi havzasi suv resurslari: daryolar, ko‘llar va suv omborlari, jumladan, Zarafshon daryosi suvining ifloslanishi masalalari R.Kulmatov, E. Chembarisov, S.Myagkov, I. Normatov, B. Karimov, R. Razoqov, R. Toryannikova, B. Nishonov, A. Nasrulin va boshqalar tomonidan o‘rganilgan.

Biroq shu bilan bir qatorda, yuqorida ko‘rsatilgan ilmiy manbalar tahlili ko‘rsatadiki, antropogen (qishloq xo‘jaligi, sanoat va kommunal-maishiy) ifloslanish manbalarining Zarafshon daryosi suvi sifatiga aynan azotli birikmalari bilan ifloslanishi miqdori bo‘yicha ta’sirini har tomonlama chuqur baholash, shuningdek, iqlim o‘zgarishining bu jarayonga ta’sirini ilmiy asoslash ishlari amalga oshirilmagan. Shu nuqtai-nazardan, azotli birikmalar bilan ifloslanish manbalarining

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[4] O‘zbekiston Respublikasi Prezidentining 2021-yil 24-fevraldagi “O‘zbekiston Respublikasida suv resurslarini boshqarish va irrigatsiya sektorini rivojlantirishning 2021-2023-yillarga mo‘ljallangan strategiyasini tasdiqlash to‘g‘risida“gi PQ-5005-sonli Qarori.

[5] O‘zbekiston Respublikasi Prezidentining 2022-yil 1-martdagi “Quyi bo‘g‘inda suv resurslarini boshqarishni takomillashtirish hamda suv iste’molchilari orasidagi munosabatlarni tartibga solish chora-tadbirlari to‘g‘risida”gi PQ-145-sonli Qarori.

fazoda taqsimlanishi, ularning migratsiyasi va o‘zgarishi, shuningdek, Zarafshon daryosi havzasidagi maishiy chiqindi suvlar, sanoat va qishloq xo‘jaligi faoliyatining azot birikmalari bilan ifloslanish darajasiga ta’sirini baholash hozirgi kunda katta ilmiy va amaliy ahamiyatga ega.

**Dissertasiya tadqiqotining dissertasiya bajarilgan oliy ta’lim muassasasining ilmiy-tadqiqot rejalari bilan bog‘liqligi:** Dissertasiya tadqiqoti 2020-2022 yillardagi “Toshkent irrigatsiya va qishloq xo‘jaligini mexanizatsiyalash muhandislari instituti” Milliy tadqiqot universitetining “Suv resurslarini va atrof-muhitni boshqarishni iqlim o‘zgarishi sharoitiga moslashtirish tadbirlarini takomillashtirish” (Dav. registratsiya №1.7 (2020-2022)); hamda “Suv resurslarini boshqarishda suvdan faydalanishning yopiq tizimlariga o‘tish va ekologik barqarorlikni ta’minlash” (Dav.registratsiya № 1.7 (2023-2024)) mavzularidagi ilmiy tadqiqot ishlari doirasida olib borildi.

**Tadqiqotning maqsadi:** Zarafshon daryosi suv sifati shakllanishiga antropogen azot birikmalarining iqlim o‘zgarishi sharoitida ta’sirini o‘rganishdan iborat.

**Tadqiqotning vazifalari:**

Zarafshon daryosida azot birikmalari (ammiak, nitrit, nitrat) kontsentratsiyalari va suv sifatining fizik va gidrokimyoviy ko‘rsatkichlari o‘rtasidagi bog‘liqlikni ochib berish;

Zarafshon daryosida azot birikmalari kontsentratsiyalarining vaqt-zamon va fazoviy o‘zgarishlarini miqdoriy baholash va mavsumiy va uzoq muddatli tendentsiyalarini ilmiy asoslash;

geografik axborot tizimi (GAT) usullaridan foydalangan holda Zarafshon daryosi havzasidagi azot birikmalari bilan ifloslantiruvchi manbalarning fazoviy taqsimlanishini, suv sifatiga qishloq xo‘jaligi va maishiy chiqindi suvlar va sanoatning ta’sirini baholash;

Zarafshon daryosida azotli birikmalar konsentratsiyasiga iqlim o‘zgaruvchilari (havo harorati va yog‘ingarchilik) ta’sirini aniqlash;

Zarafshon daryosining suv sifatini barqaror boshqarish bo‘yicha tavsiyalar ishlab chiqish.

**Tadqiqotning obyekti** sifatida Zarafshon daryosi havzasining O‘zbekiston hududida joylashgan o‘rta va quyi oqimlari olingan.

**Tadqiqotning predmeti** antropogen ifloslanish va iqlim o‘zgarishining Zarafshon daryosi o‘rta va quyi oqimidagi suv sifati ko‘rsatkichlariga (elektr o‘tkazuvchanligi, umumiy muallaq qattiq erigan moddalar, harorat, erigan kislorod, kimyoviy kislorod talabi, azotning ammoniy, nitrit va nitrat shakllari) ta’siri hisoblanadi.

**Tadqiqotning usullari.** Dissertatsiya ishida spektrofotometrik usul, statistik va korrelyatsion tahlillar, shuningdek, GAT va fazoviy tahlil usullaridan foydalanilgan.

**Tadqiqotning ilmiy yangiligi quyidagilardan iborat:**

azot birikmalarining konsentratsiyasi va fizik-gidrokimyoviy ko‘rsatkichlari o‘rtasidagi bog‘liqlik olingan, suv sifati o‘zgarishining vaqt-zamon va fazoviy xususiyatlari ilmiy jihatdan isbotlangan;

azot bilan ifloslanishning turli manbalarini fazoviy taqsimoti baholangan, Zarafshon daryosi havzasining o‘rta va quyi oqimida shahar va qishloq xo‘jaligi manbalariga tegishli azot yuklamalari hisoblab chiqilgan;

agrar manbalardan azotli birikmalar bilan ifloslanishda ammoniy azoti ($N-NH_4$) eng sezgir indikator ekanligi ilmiy asoslangan va azotli birikmalar bilan “eng yuqori” ifloslanish xududlari aniqlangan;

Zarafshon daryosi havzasining o‘rta va quyi oqimida 1960-2020 yillarda haroratning biroz o‘sishi (0,02-0,04°C) tendensiyalari topilgan. Lekin, harorat, yog‘ingarchilik va azot birikmalari o‘rtasida sezilarli korrelyatsion bog‘liqlik yo‘qligi aniqlangan.

**Tadqiqotning amaliy natijalari quyidagilardan iborat:**

GAT texnologiyalaridan foydalangan holda antropogen va iqlim omillarini kompleks tahlil qilish asosida Zarafshon daryosida suv sifatini azotli birikmalar bilan ifloslanish darajasini barqaror boshqarish bo‘yicha ilmiy asoslangan amaliy tavsiyalar ishlab chiqilgan;

ko‘p yillik ma’lumotlar asosida daryodagi suv sifati o‘zgarishining uzoq muddatli tendentsiyalari aniqlandi, bu esa mumkin bo‘lgan o‘zgarishlarni bashorat qilishga va suvdan foydalanishda rejalashtirishni takomillashtirish imkonini bergan;

Zarafshon daryosi havzasida shahar va qishloq xo‘jaligi hududlaridan kelib tushadigan azot yuklamalari hisoblab chiqilgan va “Qishloq xo‘jaligidan daryo ekotizimiga tushadigan azot yuklamasini hisoblash” EHM dasturi (№ DGU 43328) yaratilgan;

GAT texnologiyalaridan foydalangan holda Zarafshon daryosining hozirgi ifloslanish darajasining raqamli xaritalari ishlab chiqilgan, azot birikmalari bilan ifloslanishning “eng kuchli” hududiy nuqtalari aniqlangan.

**Tadqiqot natijalarining ishonchliligi.** Tadqiqot natijalarining ishonchliligi uzoq muddatli ma’lumotlarning rasmiy manbalardan olinganligi, tahlillar zamonaviy statistik dasturlardan foydalangan holda olib borilganligi, dala kuzatuvlari belgilangan talablar asosida amalga oshirilganligi, zamonaviy laboratoriya jihozlaridan foydalanilganligi, ilmiy ish natijalari nufuzli xorijiy va milliy ilmiy jurnallarda chop etilganligi, amaliy natijalar esa tegishli davlat organlari tomonidan tan olinganligi va tasdiqlanganligi bilan izohlanadi.

**Tadqiqot natijalarining ilmiy va amaliy ahamiyati.** Tadqiqot natijalarining ilmiy ahamiyati shundan iboratki, daryo suvlari sifatining mavsumiy va uzoq muddatli tendentsiyalari asoslab berilganligi, ifloslanishning asosiy manbalari aniqlanganligi, antropogen ta’sirning azot birikmalari bilan ifloslanish darajasiga katta hissa qo‘shganligini, hamda iqlim o‘zgarishining suvdagi azot birikmalari miqdoriga juda sust ta’sir ko‘rsatishi isbotlanganligi bilan izohlanadi.

Tadqiqot natijalarining amaliy ahamiyati shundan iboratki, Zarafshon daryosidagi suv sifatini baholash bo‘yicha davlat ekologik monitoring tizimini takomillashtirish, ifloslanish xaritalari yordamida suvdan namuna olish tartibi va chastotasi bo‘yicha aniq ko‘rsatmalarni belgilash, boshqaruv strategiyalarini optimallashtirish, gidroekologik va sanitariya sharoitlarini yaxshilash va atrof-muhitni muhofaza qilish maqsadida foydalanishga amaliy tavsiyalar berilganligi bilan izohlanadi. Bundan tashqari, tadqiqotda daryo havzasiga qishloq xo‘jaligidan

kelib tushadigan azot yuklamalarni aniqlash va bashorat qilish uchun EHM dastur yaratilganligi bilan izohlanadi.

**Tadqiqot natijalarining joriy qilinishi.** Iqlim o‘zgarishi sharoitida Zarafshon daryosida suv sifatining shakllanishiga antropogen azot birikmalarining ta’sirini o‘rganish bo‘yicha olingan ilmiy natijalar asosida:

suv sifatini boshqarish bo‘yicha ishlab chiqilgan amaliy tavsiyalar Quyi Zarafshon irrigatsiya tizimlari havza boshqarmasi huzuridagi “Karmana-Konimex” irrigatsiya tizimi boshqarmasi amaliyotiga joriy etilgan (O‘zbekiston Respublikasi Ekologiya, atrof-muhitni muhofaza qilish va iqlim o‘zgarishi vazirligining 2024-yil 25 sentyabrdagi 03-03/3-9385 son ma’lumotnomasi). Natijada, bu ekotizim xizmatlari va aholi salomatligini himoya qilish hamda monitoring tizimini takomillashtirish imkonini bergan;

ishlab chiqilgan EHM dasturi Samarqand viloyati Ekologiya, atrof-muhitni muhofaza qilish va iqlim o‘zgarishi boshqarmasi amaliyotiga joriy etilgan (O‘zbekiston Respublikasi Ekologiya, atrof-muhitni muhofaza qilish va iqlim o‘zgarishi vazirligining 2024-yil 25 sentyabrdagi 03-03/3-9385 son ma’lumotnomasi). Natijada, Zarafshon daryosi havzasining o‘rta va quyi oqimida qishloq xo‘jaligi manbalariga tegishli azot yuklamalarini aniqlash va bashorat qilish imkonini bergan;

ishlab chiqilgan ilmiy va amaliy tavsiyalar Samarqand viloyati Ekologiya, atrof-muhitni muhofaza qilish va iqlim o‘zgarishi boshqarmasi amaliyotiga joriy etilgan (O‘zbekiston Respublikasi Ekologiya, atrof-muhitni muhofaza qilish va iqlim o‘zgarishi vazirligining 2024-yil 25 sentyabrdagi 03-03/3-9385 son ma’lumotnomasi). Natijada, bu suv sifatini yaxshilash va havzada suv ekotizimlarining ekologik barqarorligini ta’minlash imkonini bergan.

**Tadqiqot natijalarining aprobatsiyasi.** Mazkur tadqiqot natijalari 2 ta xalqaro va 3 ta respublika ilmiy-amaliy anjumanlarida muhokamadan o‘tkazilgan.

**Tadqiqot natijalarining e’lon qilinganligi.** Dissertatsiya mavzusi bo‘yicha jami 12 ta ilmiy ishlar nashr etilgan, shulardan Scopus jurnallarida 2 ta, OAK ro‘yxatiga kiritilgan jurnallarda 3 ta maqolalar chop etilgan va 1 ta EHM dasturga guvohnoma olingan.

**Dissertatsiyaning tuzilishi va hajmi.** Dissertatsiyaning tuzilishi kirish, beshta bob, xulosa va foydalanilgan adabiyotlar ro‘yxatidan iborat. Dissertatsiyaning hajmi 117 betni tashkil etgan.

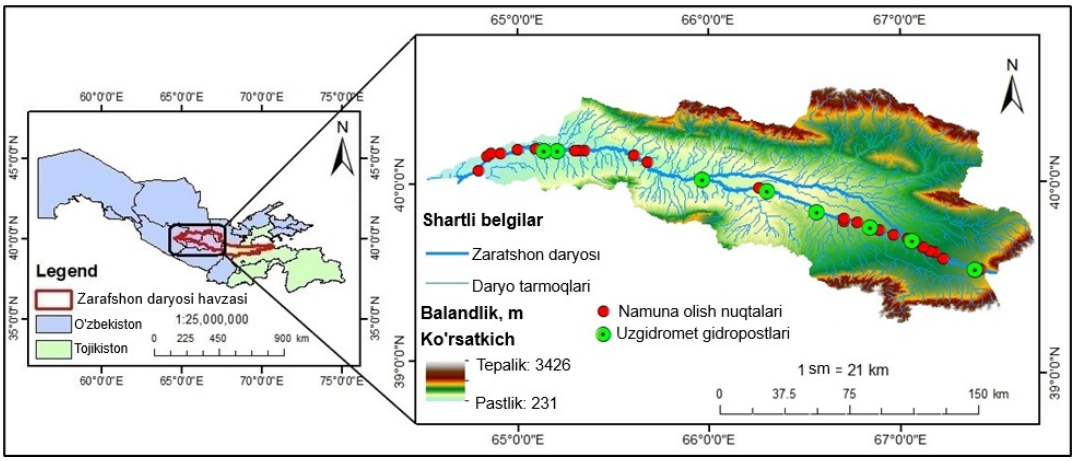
## DISSERTATSIYANING ASOSIY MAZMUNI

Dissertatsiyaning kirish qismida olib borilayotgan tadqiqotning dolzarbligi va unga bo‘lgan talab asoslangan, maqsad va vazifalar shakllantirilgan, tadqiqot obyekti va predmeti keltirilgan. Tadqiqotning O‘zbekiston Respublikasida fan va texnika rivojlantirishning ustuvor yo‘nalishlariga muvofiqligi, shuningdek, dissertatsiya tugatilgan ta’lim muassasasining ilmiy faoliyati bilan bog‘liqligi alohida ta’kidlangan. Tadqiqotning ilmiy yangiligi va amaliy ahamiyati keng yoritilgan, olingan natijalarning nazariy va amaliy ahamiyati ochib berilgan, tadqiqot natijalarini amaliyotga tadbiq etish, aprobatsiyadan o‘tkazish va nashr etish

to‘g‘risidagi shuningdek, dissertatsiyaning tuzilishi va hajmi haqidagi ma’lumotlar berilgan.

Dissertatsiya ishining “Iqlim o‘zgarishi sharoitida Zarafshon daryosi suv sifatining shakllanishiga antropogen azot birikmalarining ta’siri (adabiyot sharhi)” deb nomlangan birinchi bobida daryolar ekotizimlarining azot birikmalari bilan ifloslanishi va uning ekologik oqibatlari masalalari yoritilgan. Ushbu bobda iqlim o‘zgarishining daryolar ekotizimidagi azot birikmalari dinamikasiga ta’siri tahlil qilingan, mahalliy va xalqaro adabiyotlar asosida Zarafshon daryosi havzasidagi suv sifati va ifloslanish muammolari o‘rganilgan. Adabiyotlarni tahlil qilishga ko'ra, daryolarning azot bilan ifloslanishi global miqyosda, ayniqsa qurg‘oqchil va yarim qurg‘oqchil hududlarda keng tarqalgan muammodir. Tadqiqot natijalari shuni ko‘rsatadiki, qishloq xo‘jaligi bilan intensiv faoliyat yuritadigan hududlarda azot birikmalari bilan sezilarli darajada ifloslanish kuzatilgan. Shuningdek, bir qator tadqiqotlarda suv havzalarining azot birikmalari bilan ifloslanish darajasi iqlim o‘zgarishi va yerdan foydalanish ta’siriga e’tibor qaratilgan. Iqlim o‘zgarishi suv havzalarining biogen moddalar bilan ifloslanishining salbiy oqibatlarni kelajakda yanada kuchaytirishi kutilishi xulosa qilingan.

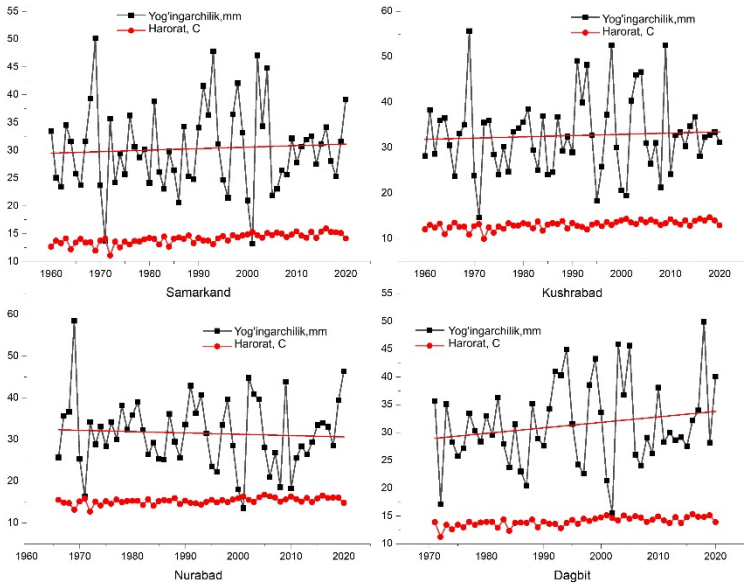
Dissertatsiyaning “Metodika va ma’lumotlar manbalari” deb nomlangan ikkinchi bobida tadqiqot obyekti, o‘rganilayotgan suv sifati parametrlari, ifloslantiruvchi moddalarning ruxsat etilgan kontsentratsiyasi, namuna olish chastotasi va tartibi, namuna olish nuqtalarining nomlari va joylashuvi, gidrokimyoviy va statistik ma’lumotlar, shuningdek, GAT texnologiyalaridan foydalangan holda fazoviy tahlil qilish uchun interpolyatsiya usuli tasvirlab berilgan. Muallif tomonidan tahlil qilingan hududlarning koordinatalar ko‘rsatilgan xaritasi tuzilgan (1-rasm).



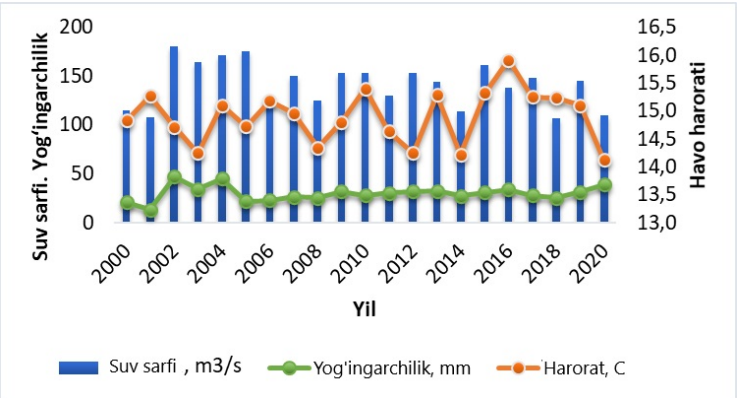

**1-rasm. Tadqiqot hududi – Zarafshon daryosi havzasi**

Dissertatsiyaning “Iqlim o‘zgarishi va uning Zarafshon daryosi havzasining suv sifatiga ta’siri” deb nomlangan uchinchi bobida Zarafshon daryosi havzasidagi so‘nggi bir necha o‘n yillikdagi (1960-2020) iqlim ma’lumotlarini tahlil qilishimiz sezilarli tendentsiya va harorat o‘zgarishlarini aniqladi. To‘rtta meteorologik stansiya – Samarqand, Qushrobod, Nurobod va Dagbit ma’lumotlari 10°C dan 20°C

gacha bo‘lgan oraliqda umumiy barqaror haroratni, ma’lum davrlarda biroz o‘sish tendentsiyasini ko‘rsatdi (2-rasm). Statistik tahlillar, shu jumladan Mann-Kendall testi va Senning nishab baholovchisi yordamida biz birinchi marta 1991–2000 yillar oralig‘idagi o‘n yillikda barcha o‘rganilgan meteorologik stansiyalarda haroratning 0,12–0,15°C gacha ko‘tarilish tendentsiyasi kuzatilganligini aniqladik. Bundan tashqari, butun o‘rganish davrida 0,02-0,04°C gacha bo‘lgan umumiy o‘sish tendentsiyasi kuzatildi. Xususan, Samarqand stansiyasida 2001-2010 yillarda havo harorati 0,07°C ga ko‘tarilganligi aniqlandi.




**2-rasm. Zarafshon daryosi havzasidagi iqlim o‘zgaruvchilarining uzoq muddatli o‘rtacha yillik qiymatlari**

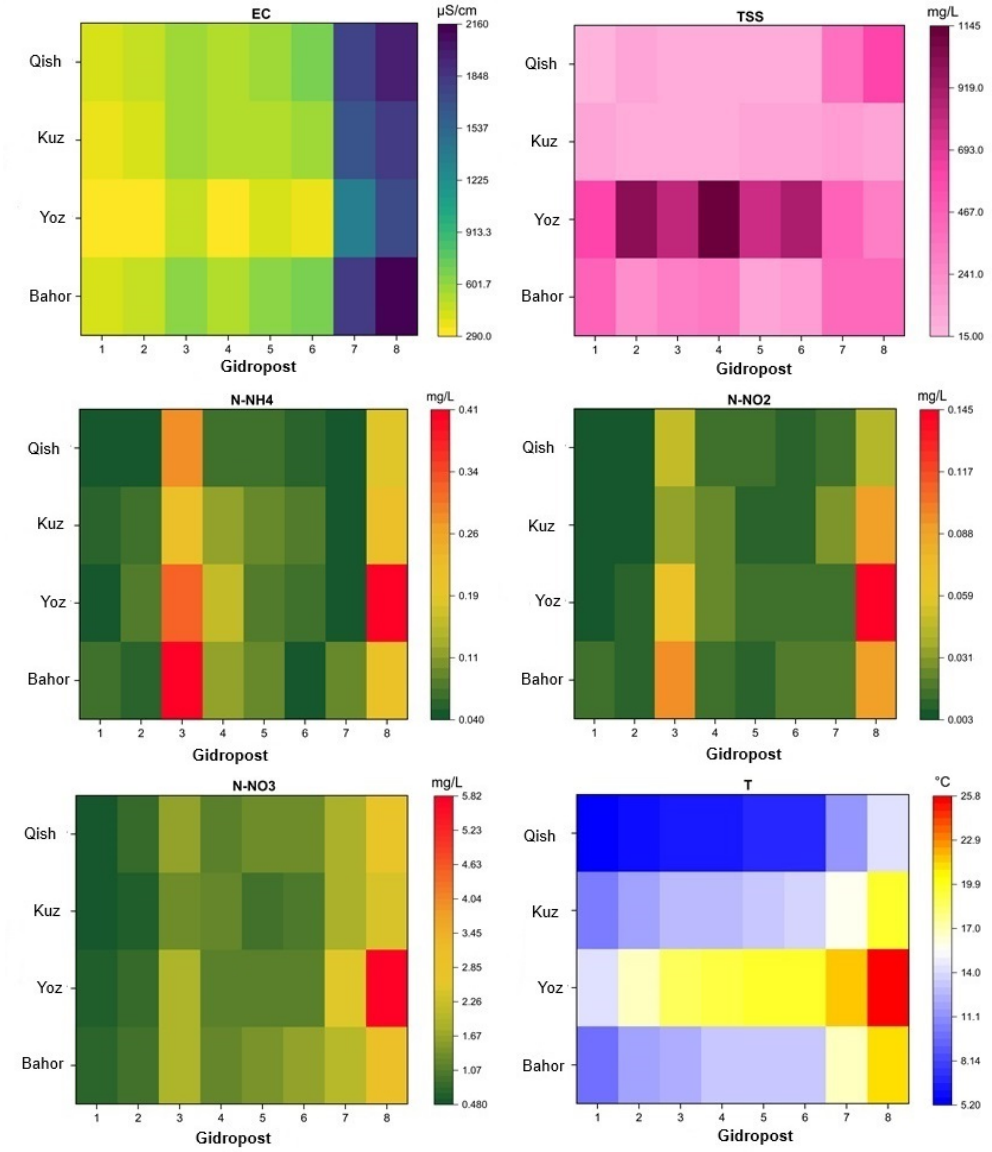



**3-rasm. Zarafshon daryosi havzasida suv sarfi (Ravotxo‘ja – U1), yog‘ingarchilik va havo haroratining (Samarqand) o‘rtacha ko‘p yillik ko‘rsatkichlari**

Yog‘ingarchilik va suv oqimi sarfi haqidagi ma’lumotlar tahlili aniq izchil trendsiz o‘zgaruvchanlik mavjudligini ko‘rsatdi. Sezilarli muhim cho‘qqilar 1969 yilda qayd etildi: Samarqandda 50,16 mm, Qushrobodda 55,67 mm, Nurobodda 58,47 mm. 1970 yildan beri ishlayotgan Dagbit stansiyasi 2020 yilda eng yuqori o‘rtacha yog‘ingarchilik - 52,27 mm ni qayd etdi. Shu bilan birga, suv oqimi 86,5

m³/s dan 163,3 m³/s gacha o‘zgargan. Kuzatishlarga ko‘ra, suvning kam bo‘lgan davri 2021 yilda, ko‘p suvli davr esa 2016 yilda qayd etilgan (3-rasm).

Ravotxo‘ja stansiyasida o‘rganish davrida azot birikmalarining o‘rtacha ko‘p yillik kontsentratsiyasi belgilangan REM me’yorlaridan oshmaganligi aniqlandi. N-$NH_4$, N-$NO_2$, N-$NO_3$ va suv iste’moli o‘rtasidagi korrelyatsiya tahlili mos ravishda -0,43, 0,08 va 0,21 qiymatlarni ko‘rsatdi. Iqlim o‘zgaruvchilari va azot birikmalari o‘rtasidagi korrelyatsiya tahlili hech qanday muhim aloqa mavjud emasligini ko‘rsatdi, bu suvdagi azot birikmalarining kontsentratsiyasiga boshqa antropogen ifloslanish omillari (qishloq xo‘jaligi, sanoat va shahar oqova suvlari) sezilarli ta’sir qilishi mumkinligini ko‘rsatadi.




**4-rasm. Zarafshon daryosi suv sifati ko‘rsatkichlarining vaqt-zamon va fazoviy o‘zgarishlari (EC = elektr o‘tkazuvchanligi, TSS = muallaq moddalarning umumiy miqdori, N-$NH_4$ = ammoniy azoti, N-$NO_2$ = nitrit azoti, N-$NO_3$ =nitrat azoti, T = harorat)**

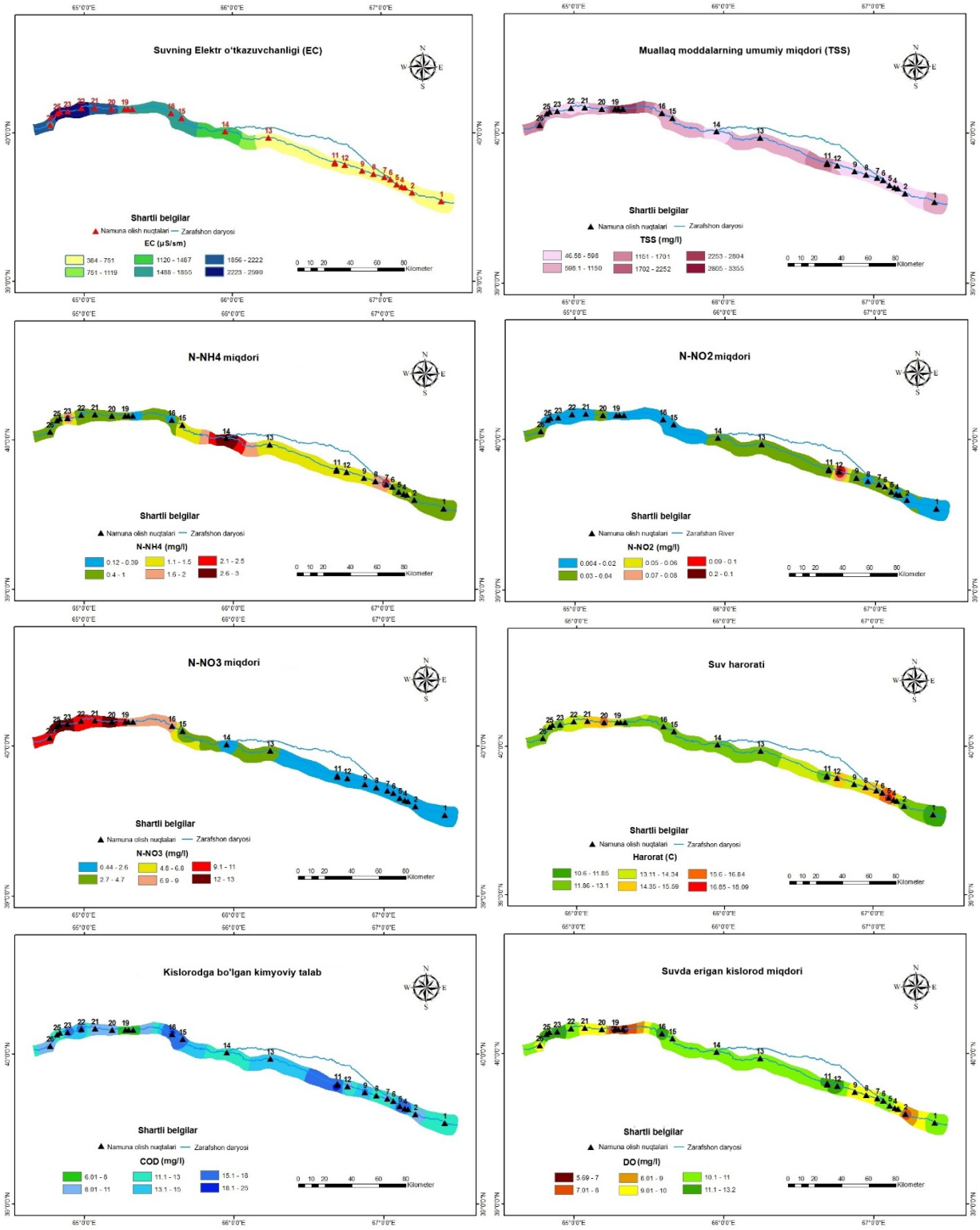
Dissertatsiyaning “Zarafshon daryosi havzasida suv sifati parametrlarining vaqt-zamon va fazoviy o‘zgarishlarini baholash” deb nomlangan to‘rtinchi bobi Zarafshon daryosi suvi ifloslanishining mavsumiy, yillik va fazoviy dinamikasini o‘rganish, shuningdek, o‘rganilayotgan parametrlarning uzoq muddatli trendlarini korrelyatsion tahlil qilish va aniqlashga bag‘ishlangan. Tadqiqot shuni ko‘rsatdiki, muallaq moddalarning umumiy miqdori (TSS), harorat (T) va suvda erigan kislorod miqdori (DO) sezilarli mavsumiy tebranishlarni ko‘rsatgan bo‘lsa, elektr o‘tkazuvchanligi (EC), ammoniy ($N\text{-}NH_4$), nitrit ($N\text{-}NO_2$), nitrat ($N\text{-}NO_3$) kontsentratsiyalari va kislorodga bo‘lgan kimyoviy talab (COD) fazoviy joylashuvga qarab o‘zgardi.

4-rasmda U1 dan U8 gacha bo‘lgan gidropostlarda suvning elektr o‘tkazuvchanlik kattaligi 362 dan 2160 µS/cm gacha oraliqda aniqlanib, U7 va U8 stansiyalarida esa sezilarli o‘sish kuzatilgan. Eng past elektr o‘tkazuvchanlik (362 µS/cm) yozda, eng yuqori elektr o‘tkazuvchanlik (2160 µS/cm) esa bahorda kuzatilgan. Muallaq moddalar (TSS) miqdorining ko‘rsatkichlari yozda eng yuqori darajada (1145 mg/l) aniqlandi va qishda minimal darajaga tushdi (28,8 mg/l). $N\text{-}NH_4$ va $N\text{-}NO_2$ ning yuqori darajasi barcha fasllarda U3 va U8 da qayd etildi, maksimal $N\text{-}NO_3$ (5,81 mg/l) esa yozda U8 da aniqlandi. Suv harorati U7 va U8 (23,7ºC) da doimiy ravishda yuqori bo‘lgan.

Uzoq yillik tahlillar shuni ko‘rsatdiki, Zarafshon daryosining eng yuqori ifloslanish darajasi “Navoiyazot” zavodidan quyi oqimda kuzatilgan. Daryo bo‘ylab fazoviy tahlil natijasida turli xil ifloslanish manbalari aniqlandi (5-rasm).

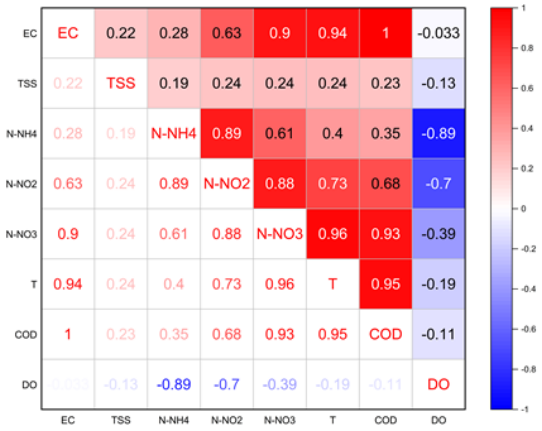
“Navoiyazot” zavodining ta’siridan tashqari, Siyob va Darg‘om kanallaridan qo‘shiluvchi oqova suvlar, xususan, nitrit bilan ifloslanish, va shu bilan bir qatorda, Samarqand shahrining oqova suvlari ta’siri ham sezilarli darajada Zarafshon daryosining ifloslanishga olib keladi, bu esa COD darajasining ortishiga sabab bo‘ladi. Navoiy viloyatining sho‘rlangan tuproqlari ham sezilarli darajada elektr o‘tkazuvchanligi (EC) oshishiga hissa qo‘shgan. Rasmdagi azotli birikmalar o‘rtasidagi ijobiy korrelyatsiya umumiy ifloslanish manbalarini ko‘rsatadi, ko‘tarilgan COD darajasi esa, asosan, turli xil organik moddalar bilan sezilarli darajada ifloslanishini ko‘rsatadi, bu ularning shahar kommunal-maishiy oqovalaridan kelib chiqishini ifodalaydi.

Pearson korrelyatsiya koeffitsienti (r) matritsasi EC ning COD, T, $N\text{-}NO_3$ va $N\text{-}NO_2$ ($r>0,50$) bilan kuchli ijobiy korrelyatsiyaga ega ekanligini ko‘rsatdi. TSS barcha o‘rganilgan parametrlar bilan zaif korrelyatsiyani ko‘rsatdi. $N\text{-}NH_4$ DO bilan manfiy korrelatsiyaga ega (-0,89) va $N\text{-}NO_2$ va $N\text{-}NO_3$ ($r>0,50$) bilan kuchli ijobiy korrelyatsiyalangan, shuningdek, COD (0,35) bilan zaif korrelyatsiyaga ega. Bundan tashqari, $N\text{-}NO_2$ kontsentrasiyasi COD, T, $N\text{-}NO_3$, $N\text{-}NH_4$ va EC bilan ijobiy ($r>0,50$) va DO (-0,7) bilan manfiy korrelyatsiyalangandir. $N\text{-}NO_3$ va T hamda boshqa o‘rganilgan parametrar orasida kuchli va o‘rtacha korrelyatsiya kuzatildi ($r>0,40$), TSS (0,24) va DO (-0,39) dan tashqari. COD esa T, $N\text{-}NO_3$, N-NO2, EC ($r>0,50$), $N\text{-}NH_4$ va TSS ($r<0,50$) bilan ijobiy korrelyatsiyalangan (6-rasm).




**5-rasm. Zarafshon daryosida EC, N-$NH_4$, N-$NO_2$, N-$NO_3$, COD, DO, TSS va T ning fazoviy o‘zgarishlari (2022-yil kuz)**

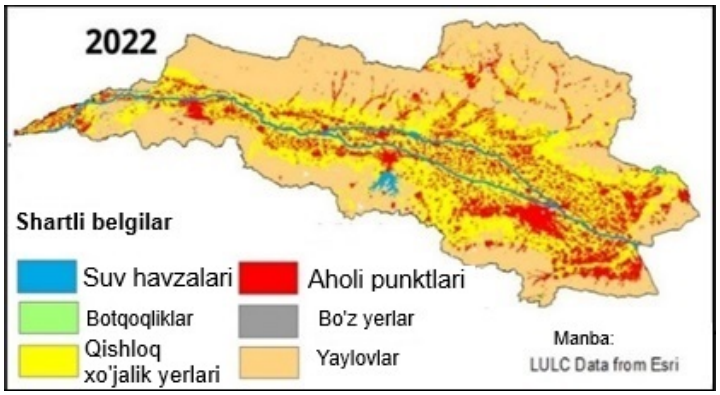
Mann-Kendall testi natijalari ba’zi gidropostlarda (2U va 6U) EC va N-$NH_4$ uchun o‘sib borish trendini aniqladi, TSS, N-$NO_3$, T va COD uchun pasayish trendlari kuzatildi. Suv sifatining boshqa ko‘rsatkichlari esa sezilarli trendlarni ko‘rsatmadi.




**6-rasm. Zarafshon daryosida o‘rganilgan suv sifati turli ko‘rsatkichlarining Pearson korrelyatsiya koeffitsienti (r) matritsasi (har bir gidropost uchun o‘rtacha yillik ko‘rsatkichlar)**

Dissertatsiya ishining “Urbanizatsiya, sanoat va qishloq xo‘jaligining Zarafshon daryosi suv sifatining shakllanishiga ta’siri” nomli beshinchi bobi to‘rt bo‘limni o‘z ichiga oladi. Birinchi bo‘lim yerdan foydalanishning suv sifatiga ta’sirini o‘rganishga bag‘ishlangan. Ikkinchi bo‘lim aholi sonining o‘sishi va sanoat rivojlanishining suv resurslari holatiga bo‘ladigan ta’sirlariga bag‘ishlangan. Uchinchi bo‘limda Zarafshon daryosi havzasidagi suv resurslariga qishloq xo‘jaligi, jumladan mineral o‘g‘itlar va kollektorlardan foydalanishning ta’siri tahlil qilingan.

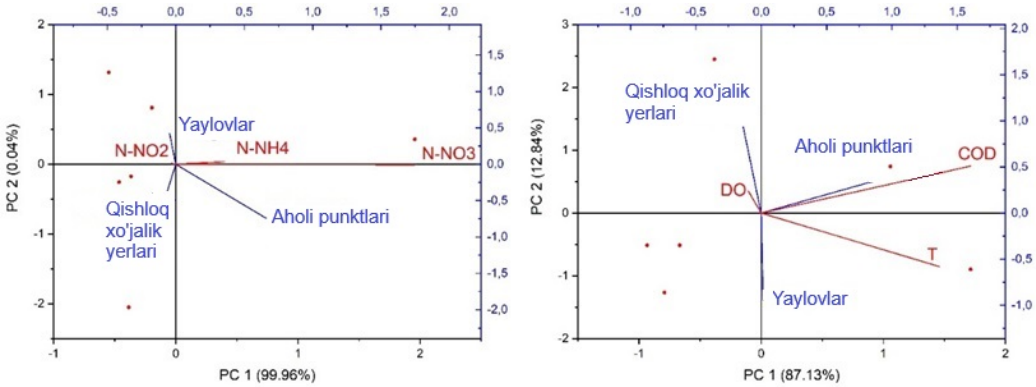
Yerdan foydalanishning suv sifatiga ta’sirini baholash uchun yerdan foydalanishning uchta asosiy turiga e’tibor qaratgan holda RDA tahlili o‘tkazildi: yaylovlar, qishloq xo‘jalik yerlari va aholi punktlari (7, 8-rasmlar). Natijalar aholi punktlari bilan ammoniy va nitrat azoti kontsentratsiyasi (RDA = 0,66) o‘rtasida o‘rtacha ijobiy munosabatni ko‘rsatdi, bu urbanizatsiyalashgan hududlarda ushbu birikmalarning kontsentratsiyasi yuqori darajadaligini anglatadi.




**7-rasm. Zarafshon daryosi havzasining o‘rta va quyi oqimida yer qoplami va yerdan foydalanish xaritasi (2022 yil)**

Bundan tashqari, COD va aholi punktlar hududlari (RDA = 0,89) o‘rtasida kuchli bog‘liqlik qayd etildi, bu urbanizatsiyaning sezilarli ta’sirini ko‘rsatmoqda. Yaylov va qishloq xo‘jalik yerlari azot miqdoriga kam ta’sir ko‘rsatdi, ammo N-$NO_3$

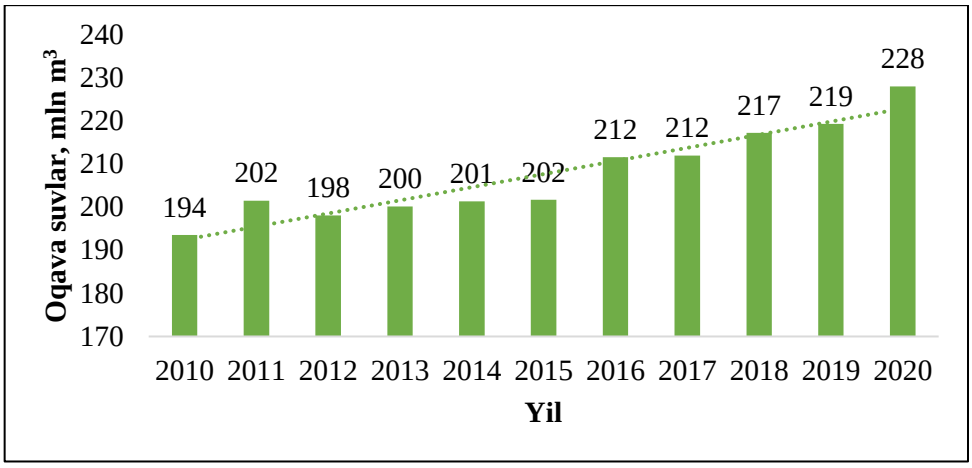
va N-$NH_4$ o‘rtasida sezilarli bog‘liqlik aniqlandi, bu sinergik yoki umumiy ifloslanish manbalarini ko‘rsatishi mumkin.



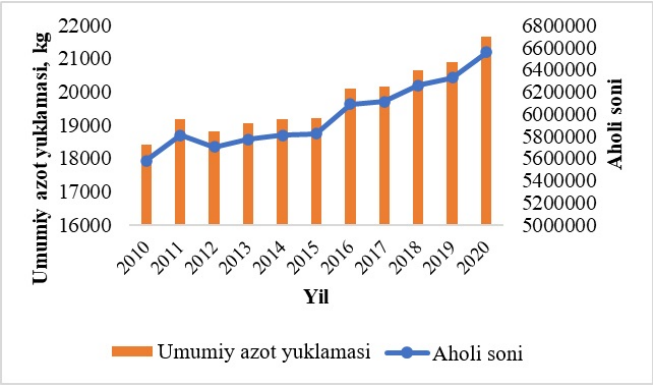

**8-rasm. Yerdan foydalanish turlarining (ko‘k chiziqlar bilan ifodalangan) suv sifatiga ta’sirining (qizil chiziqlar bilan ifodalangan) RDA ordinatsion diagrammasi**

Tahlillarimiz shuni ko‘rsatadiki, havzada aholi soni yildan-yilga oshib, azot kontsentratsiyasining o‘sishiga hissa qo‘shmoqda. Masalan, 2020 yilda aholi soni 2010 yilga nisbatan 1,17 martaga oshgan. Natijada, oqova suvlar hajmining o‘n yil davomida barqaror o‘sish trendi kuzatildi, xususan 2016-yildan (212 million $m^3$) sezilarli darajada o‘sdi. Bu trend urbanizatsiya va sanoat faoliyatining havzadagi suv sifatiga ta’siri kuchayib borayotganini ko‘rsatadi (9-rasm).

Hozirgi kunda O‘zbekiston Respublikasi hududida Zarafshon daryosi havzasida maishiy oqova suvlarni tozalash samaradorligi 70 foizni tashkil etadi. Shu samaradorlikni hisobga olgan holda azot yuklamasi 21648 kg (2020) ni tashkil etdi. Ushbu samaradorlikni 80% gacha oshirish azot yuklamasini (14432 kg/yil) hozirgi darajaga nisbatan 1,5 barobar kamaytirishi mumkin. Samaradorlikni 90% gacha oshirish esa azot yuklamasini (7216 kg/yil) mos ravishda 70% va 80% samaradorlikdagiga nisbatan 2-3 barobarga kamaytirishi mumkin (10-rasm).

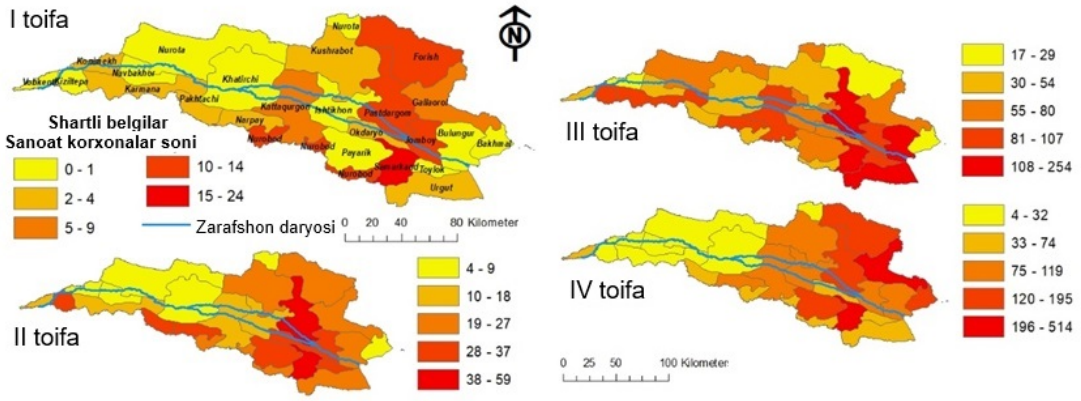



**9-rasm. Yillik oqava suvlarning umumiy hajmi**



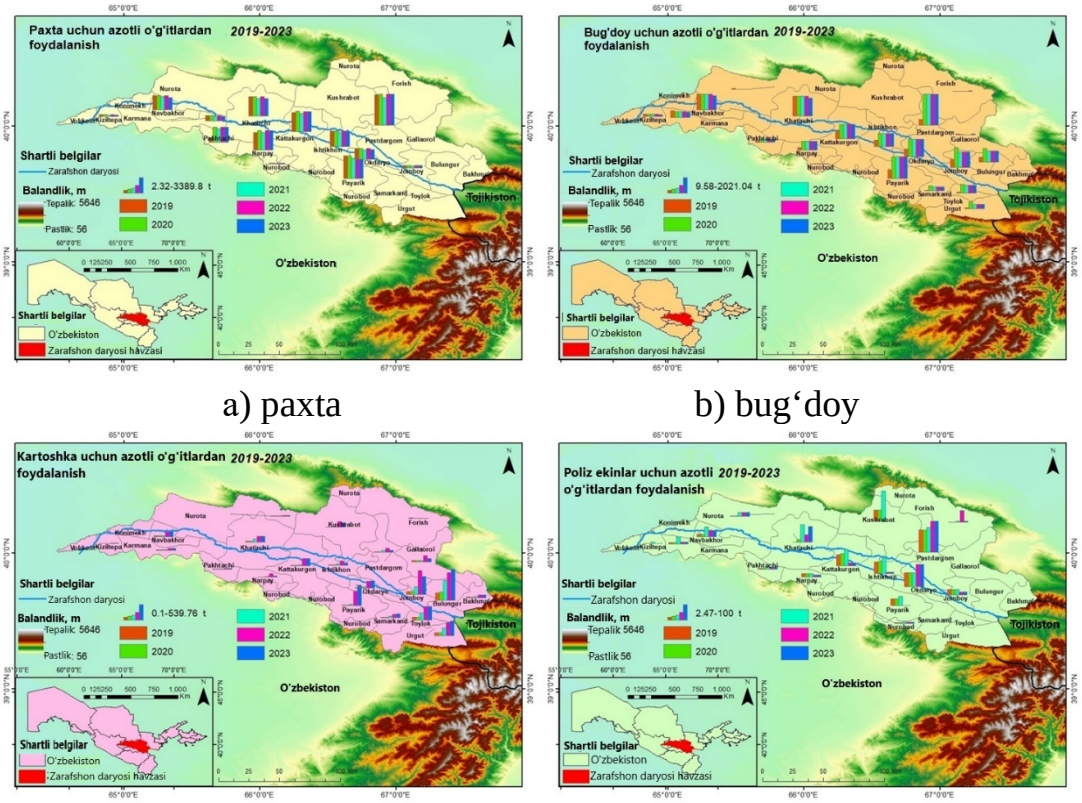

**10-rasm. 70% tozalash samaradorligi bilan shahar oqava suvlaridagi azot yuklamasi**

Zarafshon daryosi havzasidagi sanoat faoliyati tahlili suv sifati va ekotizim salomatligiga sezilarli ta’sir ko‘rsatayotganini ko‘rsatadi. To‘rtta xavfli toifaga bo‘lingan 5353 ta sanoat korxonalari orasidan yuqori xavfli (IV) toifadagi korxonalarning eng katta qismi joylashgan hududlar Forish, Jomboy, Nurobod, Pastdarg‘om tumanlari va Samarqand shahriga to‘g‘ri keladi (11-rasm).




**11-rasm. Zarafshon daryosi havzasidagi sanoat korxonalarining fazoviy taqsimoti (I-IV darajali xavflilik toifalari)**

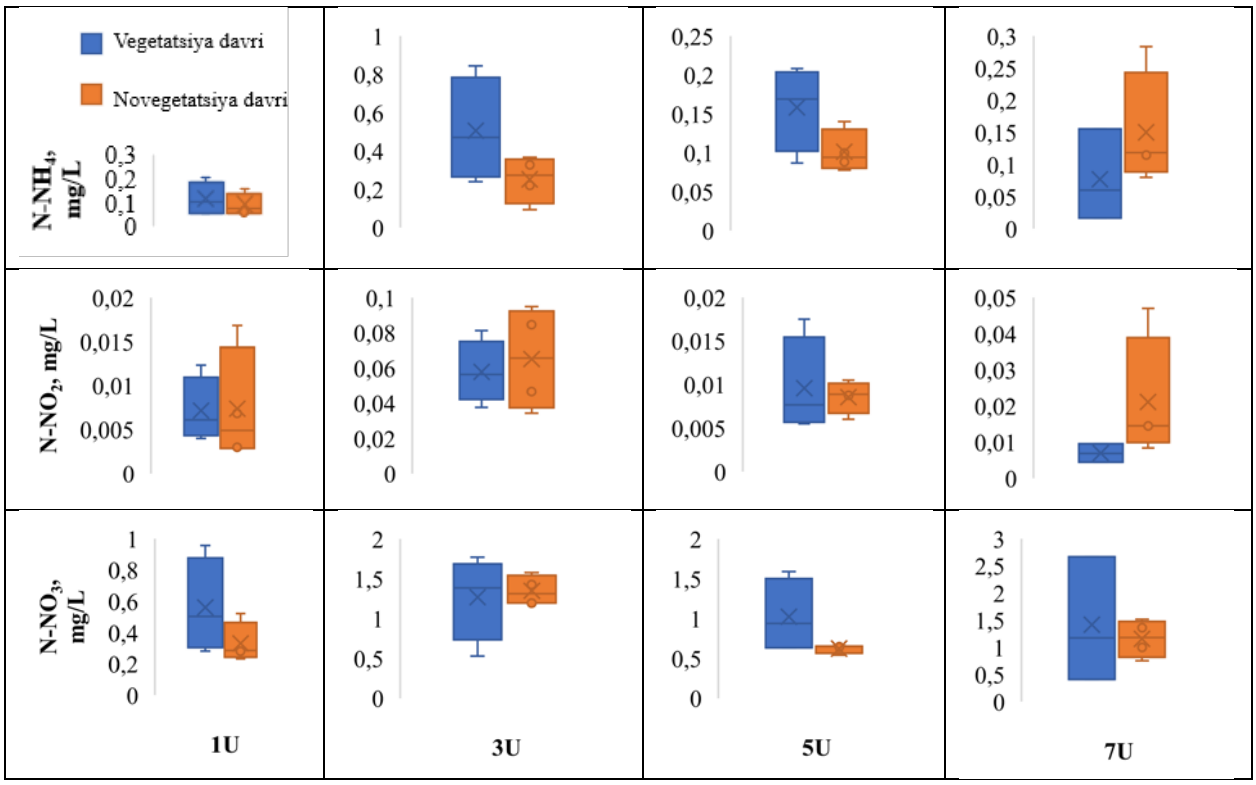
Zarafshon daryosi havzasida o‘g‘itlardan foydalanishni o‘rganish jarayonida Samarqand viloyatining Pastdarg‘om tumani (o‘rta oqim) paxta, bug‘doy va poliz ekinlari yetishtirish uchun azotli o‘g‘itlardan foydalanuvchi asosiy hudud ekanligi aniqlandi. Bundan tashqari, Samarqand viloyatining Bulung‘ur tumani kartoshka yetishtirishda azotli o‘g‘itlardan eng ko‘p foydalanuvchi asosiy hudud sifatida ajralib turadi (12-rasm). Oxirgi besh yil davomida $N\text{-}NH_4$ kontsentratsiyasining tahlili sug‘orish davrida 3U maydonda ushbu modda REM dan sezilarli darajada (1,5-2,1 marta) oshib ketganini ko‘rsatdi. 3U maydonda $N\text{-}NO_2$ kontsentratsiyasi ham yuqori bo‘lgan, ammo vegetatsiya bo‘lmagan davrda qishloq xo‘jaligi bilan bog‘liq bo‘lmagan ifloslanish manbalarini ko‘rsatadi. $N\text{-}NO_2$ darajasi REM dan 1.5-4.5 marta oshib ketdi. N- $NO_3$ kontsentratsiyasi sug‘orish davrida ortdi, lekin REM dan oshmadi, $N\text{-}NO_3$ miqdori quyi oqimda (7U) daryoning yuqori va o‘rta oqimiga nisbatan yuqori qiymatlarini ko‘rsatdi (13-rasm).




a) paxta b) bug‘doy

v) kartoshka g) tarvuz va qovun

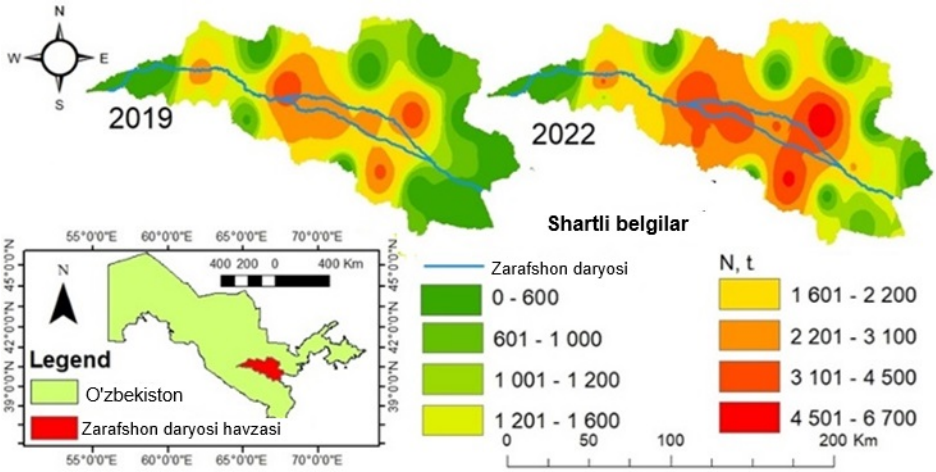
**12-rasm. Zarafshon daryosi havzasida qishloq xo‘jaligi va poliz ekinlarini yetishtirishda azotli o‘g‘itlardan foydalanish (2019-2023-yillar)**



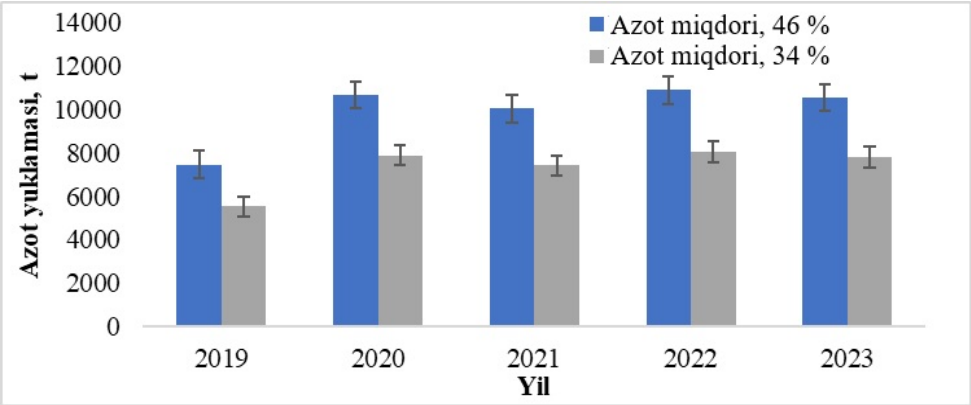

**13-rasm. Azot birikmalarining sug‘oriladigan (vegetatsiya) va sug‘orilmaydigan davrlardagi uzoq muddatli o‘rtacha konsentratsiyasi**

Azotli o‘g‘itlarning fazoviy taqsimoti tahlili shuni ko‘rsatadiki, eng katta ta’sir daryoning o‘rta oqimida kuzatiladi, bu yerda qishloq xo‘jaligi amaliyotlari azot ta’sirini sezilarli darajada oshiradi (14-rasm).

Bu Zarafshon daryosi havzasining azot bilan ifloslanishiga qishloq xo‘jaligining ta’siri yuqoriligini ta’kidlab, qishloq xo‘jaligi faoliyati tufayli 3U (o‘rta oqim) da N-$NH_4$ kontsentratsiyasining ortishi haqidagi oldingi xulosalarimizni tasdiqlaydi.




**14-rasm. 2019-2022 yillarda Zarafshon daryosi havzasida aniqlangan azotli o‘g‘itlarning fazoviy taqsimot xaritalari**

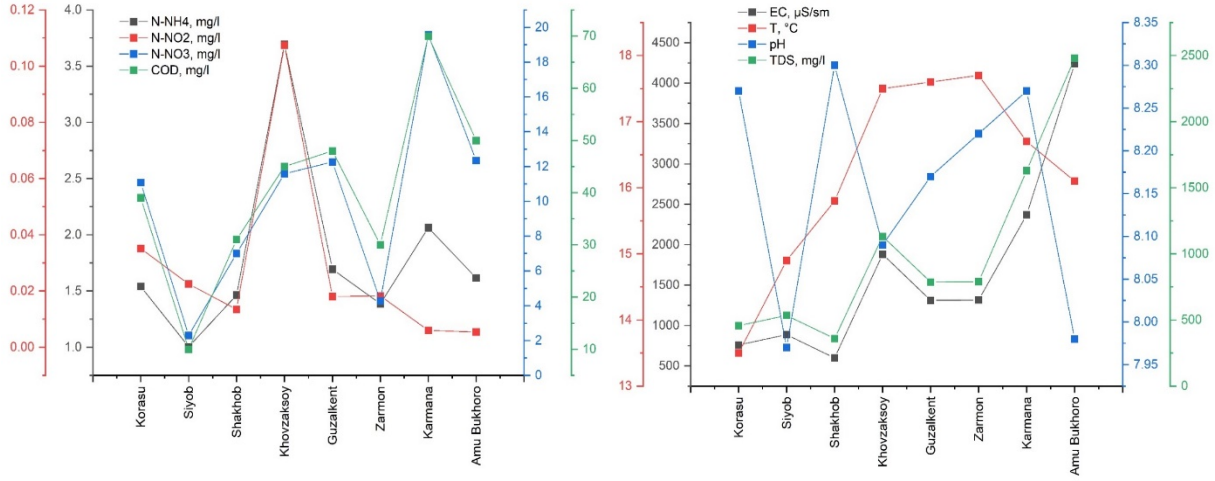



**15-rasm. Azot miqdori 34% va 46% bo‘lgan o‘g‘itlardan foydalanganda azot yuklamasi ko‘rsatkichlari**

Biz o‘g‘itlardan umumiy foydalanish natijasida daryoga tushayotgan azot yuklamalarini hisoblab chiqdik. Azot yuklamasi karbamidli o‘g‘itdan (karbamid) 7472,04-10897,81 t ni, ammoniy selitradan esa 5522,81-8054,9 t ni tashkil qildi (15-rasm).

Zarafshon daryosi havzasida (2022-2023) o‘tkazilgan dala tadqiqotlari davomida bir qancha kollektorlardan (Qorasuv, Siyob, Shaxob, Xovzaksoy, Go‘zalkent, Zarmon, Karmana, Amu-Buxoro – o‘rta oqimdan quyi oqimgacha) suv namunalari olindi va laboratoriyada tahlil qilindi. Natijalar shuni ko‘rsatdiki, Xovzaksoyda N-$NH_4$ (3,7 mg/l) va N-$NO_2$ (0,107 mg/l) ning eng yuqori

kontsentratsiyasi qayd etilgan bo‘lsa, Karmanada eng yuqori ko‘rsatkich N-$NO_3$ (19,58 mg/l) va kislorodga bo‘lgan kimyoviy talab (70 mg/l) kuzatildi. Umuman olganda, eng sezilarli darajada ifloslanish N-$NH_4$ bilan bog‘liq bo‘lib, uning barcha kollektorlardagi kontsentratsiyasi REM dan 2.56-9.49 marta oshdi. N-$NO_2$ miqdori Qorasuv, Siyob va Xovzaksoy kollektorlarida mos ravishda REMdan 1.7, 1.1 va 5.3 martadan oshib ketdi. N-$NO_3$ kontsentratsiyasi esa Qorasuv, Xovzaksoy, Go‘zalkent va Amu-Buxoroda REMdan 1.3 marta, Karmanada 2.2 martadan oshib ketgani aniqlandi (16-rasm).




**16-rasm. Kollektorlardagi suv sifatining hozirgi holati**

## XULOSALAR

Ushbu tadqiqotda Zarafshon daryosidagi antropogen tasirlar natijasida shakllanadigan azot birikmalari va ularning iqlim o‘zgarishi sharoitida suv sifatini shakllanishidagi roli keng qamrovli tahlil qilingan. Dissertatsiya doirasida olib borilgan tadqiqotlar asosida quyidagi xulosalarga kelindi:

1. Suv sifatining TSS, T va DO kabi parametrlari mavsumiy (vaqt-zamonda) o‘zgarishlarga moyilligi aniqlandi, salbiy ta’sirlar ayniqsa yoz mavsumida kuzatildi. Yozda kuzatilgan TSSning keskin o‘sishi (3,355 mg/L) cho‘kindi yuklamasining yuqori ekanligidan dalolat beradi. Boshqa ko‘rsatkichlar (N-$NH_4$, N-$NO_2$, N-$NO_3$, COD, EC) esa fazoviy taqsimot xususiyatlariga bog‘liqligi aniqlandi. Ko‘p yillik tahlillar ifloslanishning asosiy manbalaridan biri “Navoiyazot” zavodi ekanligini ko‘rsatdi.

2. Zarafshon daryosi havzasida birinchi marta Mann-Kendall testi qo‘llanildi va natijalar mos ravishda 2U va 6U da EC ($\tau$ = 0,72) va N-$NH_4$ ($\tau$ = 0,46) ortish trendini ko‘rsatdi, TSS, N-$NO_3$, T va COD kabi boshqa parametrlar esa pasayish trendiga ega. Korrelyatsiya tahlili shuni ko‘rsatdiki, suv oqim sarfi TSS bilan ijobiy korrelyatsiyaga ega ($\tau$ = 0,53), ammo EC ($\tau$ = -0,55), N-$NH_4$ (r = -0,43) va COD ($\tau$ = -0,59) salbiy korrelyatsiya koeffitsientlarini ko‘rsatdi. DO va N-$NH_4$ o‘rtasida kuchli teskari bog‘liqlik aniqlandi ($\tau$ = -0,89).

3. Azotli o‘g‘itlar paxta va bug‘doy yetishtirishda eng yuqori miqdorlarda (mos ravishda 18601,33 t va 18167,50 t) qo‘llanilishi aniqlandi. Poliz ekinlarida

o‘g‘itlar minimal iste’mol qilingan (351,68 t). Umuman olganda, eng ko‘p miqdordagi o‘g‘itlar 2022 yilda (42 305,17 t) ishlatilgan bo‘lib, bu 2019 yilda kuzatilgan eng kam ishlatilganidan (29 006,36 t) 45,85 foizga ko‘pdir. Qo‘llanilgan karbamid o‘g‘itidagi azot yuklamasi 7472,04 t dan 10897,81 t gacha, ammoniyli selitrada azot yuklamasi esa 5522,81 t dan 8054,9 t gacha bo‘lgan.

4. Qishloq xo‘jaligida, xususan, Pastdarg‘om va Bulung‘ur tumanlarida azotli o‘g‘itlardan foydalanishning ko‘payishi daryoda azotli birikmalar miqdorining oshishiga olib kelmoqda. Vegetatsiya va novegetatsiya davrida azot birikmalarining kontsentratsiyasini tahlil qilish qishloq xo‘jaligining Zarafshon daryosi suviga ta’sirini baholash imkonini berdi. Sug‘orish davrida, ayniqsa, azotli o‘g‘itlar eng ko‘p qo‘llaniladigan daryoning o‘rta oqim qismida $N\text{-}NH_4$ kontsentratsiyasi balandligi (1,5-2,1 REM) hamda $N\text{-}NO_3$ ning yuqori konsentratsiyasi (ammo REMdan oshmagan) kuzatildi. Bu shuni ko‘rsatadiki, suv havzalarining mazkur birikmalar bilan ifloslanishi qishloq xo‘jaligi faoliyati natijasida shakllanib, ko‘p jihatdan qishloq xo‘jaligida qo‘llanilayotgan amaliyotlar ta’sirida yuz beradi. Shu bilan birga, novegetatsiya davrida $N\text{-}NO_2$ kontsentratsiyasi REM dan 1,5-4,5 barobar yuqori bo‘lishi aniqlangan, bu uning kelib chiqish manbai qishloq xo‘jaligi emas, balki sanoat yoki shahar oqova suvlaridan ekanligini ko‘rsatadi.

5. Azotli birikmalar orasida qishloq xo‘jaligi tomonidan ifloslanishga eng ko‘proq moyil birikma $N\text{-}NH_4$ ekanligi aniqlandi. Tadqiqotlarimiz natijasida barcha o‘rganilgan kanallarda, xususan, Xovzaksoy (N39.802960, E66.660802) va Karmana (40.159839, 65.173717) kanallarida $N\text{-}NH_4$ kontsentratsiyasi REM dan 2,56 dan 9,49 martaga oshganligi aniqlandi. Bundan tashqari, Karmana va Amu-Buxoro (40.140048, 64.902515) kanallari mineral tuzlar (EC 2370 va 4240 mkS/sm) va TDS (1630 va 2480 mg/L) bilan yuqori darajada ifloslanganligi, bu hududlarda suv sifatining jiddiy muammo ekanligini ko‘rsatmoqda.

6. Daryo suvi azotli birikmalar bilan ifloslanishining quyidagi “eng kuchli” hududiy nuqtalari aniqlandi: $N\text{-}NH_4$ uchun - 14-namuna olish nuqtasida (40,0091927, 65,9526564) REM dan 7,5 marta ortiq, $N\text{-}NO_2$ uchun - S12 nuqtada (39,7848620, 66,7582210) REM dan 4,2 marta oshgan hamda $N\text{-}NO_3$ uchun – S16 (40,1329150, 65,5889920) va S26 (40,16088908, 40,16658908) nuqtalar oralig‘ida yuqori darajada, lekin REM doirasida. Daryodagi COD kontsentratsiyasi S10 (39,7928880, 66,6900640) va S16 nuqtalarda suv ifloslanishining o‘rtacha darajasiga egaligi aniqlandi.

7. Shahar hududlarining kengayishi kommunal-maishiy manbalardan tushadigan organik ifloslanishning ko‘payishidan dalolat beruvchi COD darajasining oshishiga olib kelish tendentsiyasi aniqlandi (RDA = 0,89). Aholi soni yildan-yilga ortib bormoqda, shu sababli umumiy azot yuklamasi (hozirgi davrda azot birikmalaridan tozalash samaradorligi 70% ekanligini hisobga olgan holda) 2010 yildan 2020 yilgacha 17,56% ga oshganligi ochib berildi. Ko‘pincha yetarli darajada tozalanmagan shahar oqava suvlari, bevosita daryo tizimidagi azot birikmalarining miqdori oshuviga hissa qo‘shadi. Mintaqaning sanoat faoliyati, turli xil xavflilik darajasiga ega zavodlar ham suv sifatiga sezilarli ta’sir qiladi. Forish,

Jomboy, Nurobod, Pastdarg‘om tumanlari va Samarqand shahri sanoat tomonidan ifloslanishga eng yuqori hissa qo‘shmoqda.

8. Iqlim o‘zgarishi ta’sirini baholash o‘rganilayotgan davrda (1960-2020) haroratning biroz o‘sishi (0,02-0,04°C) trendini ko‘rsatadi. Biroq, yog‘ingarchilik va suv sarfi ma’lumotlari uzoq muddatli sezilarli trendni namoyon etmaydi. Garchi 1991-2000 yillarda haroratning oshishi tendentsiyasi (0,12-0,15°C) kuzatilgan bo‘lsada, biroq azot birikmalari bilan ifloslanishni o‘rgangan davrimizda (2010-2023) haroratning oshishi trendi kuzatilmadi. Natijada, iqlim o‘zgaruvchilari (yog‘in va harorat) va azot birikmalari o‘rtasidagi korrelyatsiya tahlili sezilarli bog‘liqlikni ko‘rsatmadi, bu esa asosan mavjud boshqa (agrosanoat) omillarning suvdagi azot darajasiga ta’sir qilishini ko‘rsatdi. Ehtimol, azot birikmalarini va ularning keyingi davrdagi iqlim o‘zgarishlari bilan bog‘liqligini o‘rganish ushbu omillar o‘rtasidagi mumkin bo‘lgan o‘zaro bog‘liqlikni to‘g‘ri baholashga imkon beradi.

9. Olingan natijalar va amaliy tavsiyalarning ijtimoiy-iqtisodiy samarasi zararli azot birikmalari bilan ifloslanish darajasini pasaytirish hisobiga ekotizim xizmatlari va biologik xilma-xillikni saqlash, aholi farovonligi va salomatligini yaxshilashga hizmat qilishi orqali ifodalanadi.

**ONE-TIME SCIENTIFIC COUNCIL AT THE SCIENTIFIC COUNCIL AWARDING SCIENTIFIC DEGREES DSc.03/30.12.2019.T.10.02 AT "TASHKENT INSTITUTE OF IRRIGATION AND AGRICULTURAL MECHANIZATION ENGINEERS" NATIONAL RESEARCH UNIVERSITY**

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**"TASHKENT INSTITUTE OF IRRIGATION AND AGRICULTURAL MECHANIZATION ENGINEERS" NATIONAL RESEARCH UNIVERSITY**

**SHOERGASHOVA SHOBEGIM SHAROF KIZI**

# THE INFLUENCE OF ANTHROPOGENIC NITROGEN COMPOUNDS ON THE FORMATION OF WATER QUALITY IN THE ZARAFSHAN RIVER IN THE CONTEXT OF CLIMATE CHANGE

**11.00.05 – Environmental protection and rational use of natural resources**

**DISSERTATION ABSTRACT OF DOCTORAL DISSERTATION (PhD) OF TECHNICAL SCIENCES**

**Tashkent – 2024**

**The theme of doctoral dissertation for a degree of Doctor of Philosophy (PhD) has been registered under No. B2024.3.PhD/T4999 by the Supreme Attestation Commission under the Ministry of Higher education, science and innovation of the republic of Uzbekistan.**

The dissertation has been prepared at the "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University.

The abstract of the dissertation is posted in three languages (Uzbek, English and Russian (resume)) on the website of the Scientific Council (www.tiiame.uz) and information-educational portal "ZiyoNet" (www.ziyonet.uz).

| | |
|---|---|
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| **Leading organization:** | **Research Institute of Environment and Nature Conservation Technologies** |

The defense of the dissertation will take place on «3» Dec 2024 year 12 00 at the meeting of the one-time Scientific Council under the Scientific Council DSc.03/30.12.2019.T.10.02 on awarding scientific degrees at the "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University at the address: 100000, Tashkent city, Kari-Niyaziy st., 39. Tel: (+99871) 237-46-68, e-mail: admin@tiiame.uz.

The dissertation has been registered at the Information-Resource Center of the "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University (Registration No.345) at the address: 100000, Tashkent city, Kari-Niyaziy st., 39. Tel: (+99871) 237-19-34.

The abstract of the dissertation has been distributed on «21» Nov 2024.

(Protocol No.345 dated «21» Nov 2024).

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## INTRODUCTION (abstract of the PhD dissertation)

**Relevance and necessity of the dissertation topic.** The problem of shortage of water resources in the world is becoming urgent. This problem is particularly evident in agriculture, which is the main water consumer, and there are also many problems in providing drinking and industrial needs with quality water. The main sources of water pollution are industrial enterprises, agricultural activities and communal and household economy. The use of various mineral fertilizers in agriculture, the increasingly important role of various chemicals in everyday life, and the often insufficiently treated municipal and industrial wastewaters are discharged into rivers and sewers, are giving special importance to the intensive pollution of water resources. Currently, most of the mineral fertilizers used in the fields and the chemical poisons used to protect the plants lead to surface and underground water pollution through collector-drainage waters. In this respect, the ecological analysis of changes in water quality and the study of influencing anthropogenic factors are of great scientific and practical importance.

Scientific research on water quality and its management is being carried out in the world. In this direction, it is directly related to the achievement of several Sustainable Development Goals (SDGs) set by the United Nations to create a more just, sustainable and prosperous world. In particular, water quality plays a key role in achieving SDG 3: “Good health and well-being” and SDG 6: “Clean water and sanitation”[1]. At the same time, the continuation of the trend of degradation of water ecosystems and reduction of resources in terms of quantity and quality is considered as an urgent task to eliminate the risk of shortage of fresh and clean water for all water consumers.

Population growth in our republic is expected to increase the demand for high-quality fresh water from 2.3 billion $m^3$ to 2.7-3.0 billion $m^3$ (18-20%) by 2030[2]. This leads to an increase in the demand for internal water resources. In recent years, industry and energy are actively developing, and the demand for water in these sectors is increasing year by year. As a result, protection of water resources from pollution, improvement of the quality of surface and underground water, improvement of water quality monitoring are becoming one of the main tasks of the state policy in the field of water management.

This dissertation research to a certain extent contributes to the fulfillment of the tasks provided for by the Decree of the President of the Republic of Uzbekistan No. DP-5863 “On approval of the concept of environmental protection of the Republic of Uzbekistan until 2030” [3] dated October 31, 2019 aimed at protecting against depletion and pollution of water resources in agriculture and public utilities. The study also complies with the Resolution of the President of the Republic of Uzbekistan No. RP-5005 “On approval of the Strategy for water resources management and development of the irrigation sector in the Republic of Uzbekistan

[1] The 17 SDGs. United Nations Sustainable Development Summit, 2015.
[2] State of Food and Agriculture Report. FAO, 2022.
[3] Decree of the President of the Republic of Uzbekistan No. DP-5863 “On approval of the concept of environmental protection of the Republic of Uzbekistan until 2030” dated October 31, 2019.

for 2021-2023" dated February 24, 2021[4], also Resolution No. RP-145 "On measures to improve water resources management and regulate relations between water consumers at the downstream" [5] dated March 1, 2022 and activities in the field of water management This dissertation research serves to a certain extent the implementation of tasks defined in other relevant regulatory legal documents.

**Correspondence of the research with the priorities of the development of science and technology of the republic.** This study was carried out in accordance with the priority areas of development of science and technology of the Republic V. "Agriculture, biotechnology, ecology and environmental protection".

**Level of study of the problem.** Scientific studies on the problems of water resources and the dynamics of their qualitative and quantitative changes were carried out by foreign scientists such as O. Olsson, M. Groll, C. Opp, E. Yilmaz, T. Nasrabadi, X. Sun and others. The impact of land use on water quality in rivers was studied by scientists M. Matysik, Y. Huang, C. Chiang, F. Zhang, N. Shen and others. The impact of agricultural practices on river water quality was studied by M.Gunawardhana, Bijay-Singh, A.Lobanova, E.Severini and others. The impact of industry and urbanization on river quality was analyzed by I.Khan, F.Lemessa, F.Liu, S.Wang and others. In addition, studies of river pollution with anthropogenic nitrogen compounds under the influence of climate change were carried out by such foreign scientists as M. Mimikou, P. Whitehead, R. Wilby, M. Astaraie-Imani, B. Pernet-Coudrier, M. Varol, T. Trang, M. Gabriel, N. Akhtar and others.

In the CIS countries, studies on the temporal and spatial dynamics of nitrogen pollution of rivers were carried out by scientists A. Kornilov, V. Shesterkin, A. Chaiko, T. Zhuldybina, M. Larionov, E. Morzhakova, Yu. Limonov, N. Murashchenkova, E. Storozhenko, and others.

In the republic, the issues of pollution of water resources of the Aral Sea basin: rivers, lakes and reservoirs, including the quality of the water of the Zarafshan River were studied by such uzbek scientists as R. Kulmatov, E. Chembarisov, S.Myagkov, I. Normatov, B. Karimov, R. Razakov, R. Toryannikova, B. Nishonov, A. Nasrulin and others.

However, in addition, the analysis of the above-mentioned scientific sources shows that the impact of anthropogenic (agricultural, industrial and communal-household) sources of pollution on the water quality of the Zarafshan River in terms of the amount of contamination with nitrogenous compounds. a comprehensive in-depth assessment, as well as scientific justification of the impact of climate change on this process, has not been carried out. From this point of view, the spatial distribution of sources of pollution with nitrogen compounds, their migration and change, as well as the assessment of the impact of household waste water, industrial and agricultural activities on the level of pollution with nitrogen compounds in the Zarafshan River basin are currently of great scientific and is of practical importance.

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[4] Resolution of the President of the Republic of Uzbekistan No. RP-5005 "On approval of the Strategy for water resources management and development of the irrigation sector in the Republic of Uzbekistan for 2021-2023" dated February 24, 2021.

[5] Resolution of the President of the Republic of Uzbekistan No. RP-145 "On measures to improve water resources management and regulate relations between water consumers at the downstream" dated March 1, 2022.

**The relation of the dissertation research with the research plans of the university in which the dissertation was completed.** The dissertation research was carried out as part of the research work of the “Tashkent Institute of Irrigation and Agricultural Mechanization Engineers” National Research University on the topic “Improving measures for adapting water resources and environmental management in the context of climate change” (Reg. No. 1.7 (2020-2022)) and was carried out within the framework of scientific research works on the topics of “Transition to closed systems of water utilization in water resources management and ensuring ecological stability” (Reg. No. 1.7 (2023-2024)).

**The aim of the research** is to assess the influence of anthropogenic nitrogen compounds on the formation of water quality in the Zarafshan River in the context of climate change.

**The research objectives:**

to establish the relationship between the concentrations of nitrogen compounds (ammonium, nitrite, nitrate) and the physical and hydrochemical parameters of water quality in the Zarafshan River

to quantify temporal and spatial changes in nitrogen concentration in the Zarafshan River and scientifically substantiate seasonal and long-term trends;

to assess the spatial distribution of nitrogen pollution sources, the impact of agricultural and municipal wastewater, and industry in the Zarafshan River catchment area using geographic information system (GIS) methods;

to determine the influence of climatic variables (air temperature and precipitation) on the concentration of nitrogen compounds in the Zarafshan River;

to develop recommendations for sustainable management of water quality of the Zarafshan River.

**The study area** is the middle and lower reaches of the Zarafshan River basin within the Republic of Uzbekistan.

**The subject of the research** is the impact of anthropogenic pollution and climate change on water quality indicators (electrical conductivity, total suspended solids, temperature, dissolved oxygen, chemical oxygen demand, ammonium, nitrite and nitrate forms of nitrogen) in the middle and lower reaches of the Zarafshan River.

**The research methods.** In **t**he dissertation the spectrophotometric method, computational, statistical and correlation analyses, as well as GIS technologies and spatial analysis methods were used.

**The scientific novelty of the research is as follows:**

the relationships between the concentration of nitrogen compounds and physico-hydrochemical parameters were established, the temporal and spatial characteristics of water quality changes were scientifically proven;

the spatial distribution of various sources of nitrogen pollution was assessed, the nitrogen loads of municipal and agricultural origin were calculated in the middle and lower reaches of the Zarafshan River basin;

it was established that the nitrogen compound most susceptible indicator to agricultural pollution is ammonium nitrogen ($N\text{-}NH_4$), and hot spots of nitrogen compound pollution were identified;

a slight increase in temperature (0.02-0.04°C) was found in the middle and lower reaches of the Zarafshan River basin in 1960-2020. However, it was found that there is no significant correlation between temperature, precipitation and nitrogen compounds.

**The practical results of the study are as follows:**

based on a comprehensive analysis of anthropogenic and climatic factors using GIS technologies, scientific-based practical recommendations for sustainable management of water quality pollution with nitrogen compounds in the Zarafshan River have been developed;

based on long-term data, long-term trends of water quality changes in the river have been established, which made it possible to predict possible changes and improve water use planning;

in the Zarafshan river basin, nitrogen loads of municipal and agricultural origin were determined and the electronic calculator program "Calculation of nitrogen load from agriculture to the river ecosystem" (No. DGU 43328) was created;

using GIS technologies, digital maps of the current level of pollution of the Zarafshan River were developed and hot spots of pollution with nitrogen compounds were determined.

**Reliability of the results of the study** is justified by the fact that long-term data were obtained from official sources, the analysis was carried out using modern statistical programs, field observations were carried out in accordance with established requirements, modern laboratory equipment was used, the results of the scientific work were published in prestigious foreign and national scientific journals, and the practical results were agreed upon and confirmed by the relevant government agencies.

**Scientific and practical significance of the research results.** The scientific significance of the results of the study is explained by the fact that seasonal and long-term trends in river water quality were substantiated, the main sources of pollution were identified, and demonstrated the significant contribution of anthropogenic impact and revealed that climate change has a very weak effect on the amount of nitrogen compounds in water.

The practical significance of the research results is explained by the fact that it can improve the state ecological monitoring system for the assessment of water quality in the Zarafshon River, establish clear guidelines for the procedure and frequency of water sampling using pollution maps, optimize management strategies, improve hydro-ecological and sanitary conditions and protect the environment. In addition, the study explains that the electronic calculator program was created to determine and predict agricultural nitrogen loads to the river basin.

**Implementation of the research results.** Based on the obtained scientific results on the study of the influence of anthropogenic nitrogen compounds on the

formation of the water quality of the Zarafshan River in the context of climate change:

practical recommendations on water quality management were developed and implemented in the “Karmana-Konimex” irrigation system department under the Lower Zarafshan Irrigation Systems Basin Department (Reference No. 03-03/3-9385 of the Ministry of Ecology, Environmental Protection and Climate Change of the Republic of Uzbekistan dated September 25, 2024). As a result, it made it possible to improve the protection of ecosystem services and public health, as well as the monitoring system;

developed electronic calculator program was implemented in the Department of Ecology, Environmental Protection and Climate Change of the Samarkand Region (Reference No. 03-03/3-9385 of the Ministry of Ecology, Environmental Protection and Climate Change of the Republic of Uzbekistan dated September 25, 2024). As a result, it made it possible to determine and predict agricultural nitrogen loads in the middle and lower reaches of the Zarafshan river basin;

developed scientific and practical recommendations were implemented in the Department of Ecology, Environmental Protection and Climate Change of the Samarkand Region (Reference No. 03-03/3-9385 of the Ministry of Ecology, Environmental Protection and Climate Change of the Republic of Uzbekistan dated September 25, 2024). As a result, this made it possible to improve water quality and ensure the environmental sustainability of the basin’s aquatic ecosystems.

**Approbation of the research results.** The results of this study were discussed at 2 international, 3 republican scientific and practical conferences.

**Publication of research results.** A total of 12 scientific papers have been published on the topic of the dissertation, including 2 scientific articles were published in Scopus journals, 3 articles were published in journals recommended by the Higher Attestation Commission of the Republic of Uzbekistan for the publication of the main scientific results of doctoral dissertations and 1 certificate for an electronic calculator program was obtained.

**Dissertation structure and volume.** The structure of the dissertation consists of an introduction, five chapters, conclusions and a list of references. The total volume of the dissertation is 117 pages.

## THE MAIN CONTENT OF THE DISSERTATION

In the introduction, the relevance and demand for the conducted research are justified, the goals and objectives are formulated, and the object and subject of the study are presented. The research’s alignment with the priority directions for the development of science and technology in the Republic of Uzbekistan, as well as its connection with the scientific work of the educational institution where the dissertation was completed, are highlighted. The scientific novelty and practical significance of the study are presented, the theoretical and practical significance of the obtained results are disclosed, information is provided on the implementation of the research results in practice, on the approbation and publication of the research results, as well as on the structure and scope of the dissertation.

In the first chapter of the dissertation, titled “The Influence of Anthropogenic Nitrogen Compounds on the Formation of Water Quality in the Zarafshan River in the Context of Climate Change (Literature Review)” the issues of nitrogen compound pollution in river ecosystems and its ecological consequences are addressed. The chapter analyzes the impact of climate change on the dynamics of nitrogen compounds in river ecosystems and studies water quality and pollution problems in the Zarafshan River Basin based on domestic and international literature. According to the literature review, nitrogen pollution in rivers is a widespread problem globally, especially in arid and semi-arid regions. Research findings indicate that significant nitrogen compound pollution is observed in areas with intensive agricultural activity. Several studies have also focused on the influence of climate change and land use on nitrogen compound pollution levels in water bodies. It is expected that climate change will exacerbate the negative effects of nutrient pollution on water bodies.

The second chapter of the dissertation, titled “Methodology and Data Sources”, provides information on the research object, the studied water quality parameters, permissible concentrations of pollutants, sampling frequency and procedure, the names and locations of sampling points, the hydrochemical and statistical methods used, as well as the interpolation method for spatial analysis using GIS technologies. The author has compiled a map of the study area indicating the studied sections (fig. 1).

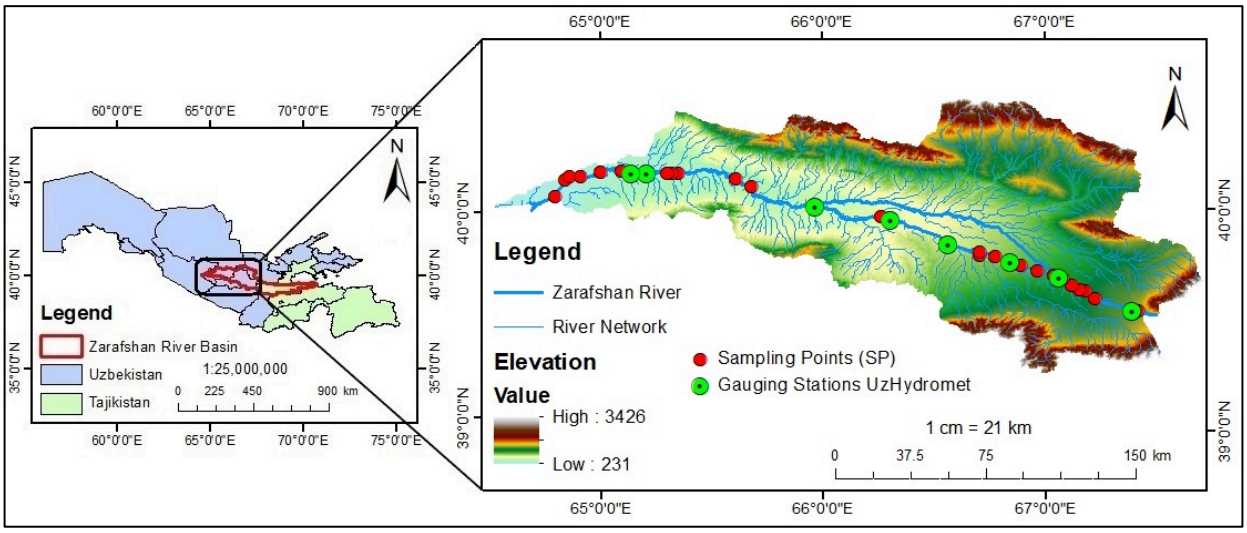



**Figure 1. Study area – Zarafshan River Basin**

In the third chapter of the dissertation, titled “Climate Change and Its Impact on Water Quality of the Zarafshan River Basin”, our analysis of climate data from the Zarafshan River Basin revealed significant trends and temperature fluctuations over the past few decades (1960-2020). Data from four meteorological stations - Samarkand, Kushrabad, Nurabad, and Dagbit - showed generally stable temperatures in the range of 10°C to 20°C, with a slight upward trend during certain periods (fig. 2). Using statistical analyses, including the Mann-Kendall test and Sen’s slope estimator, we discovered for the first time that during the decade of

1991–2000, there was a temperature increase trend of 0.12–0.15°C across all studied meteorological stations. Additionally, an overall trend of 0.02–0.04°C increase was observed for the entire study period. Specifically, at the Samarkand station, temperatures rose by 0.07°C between 2001 and 2010.

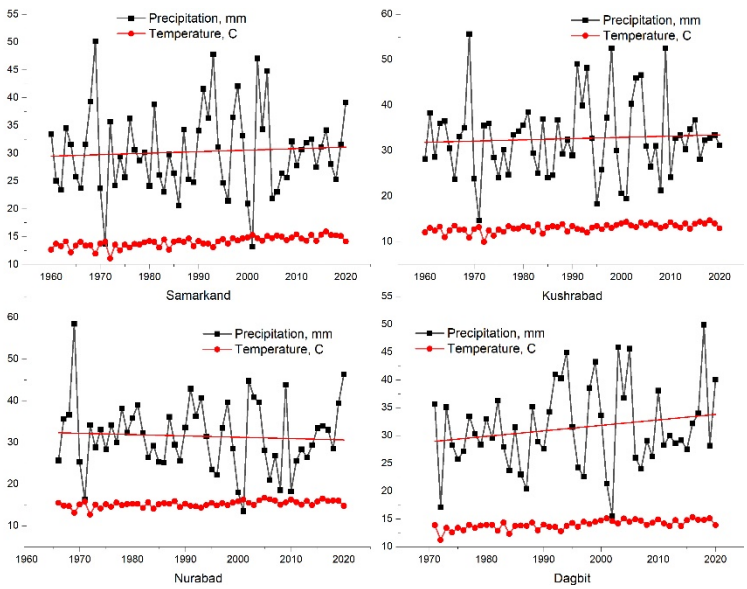



**Figure 2. Long-term average annual values of climatic variables in the Zarafshan River basin**

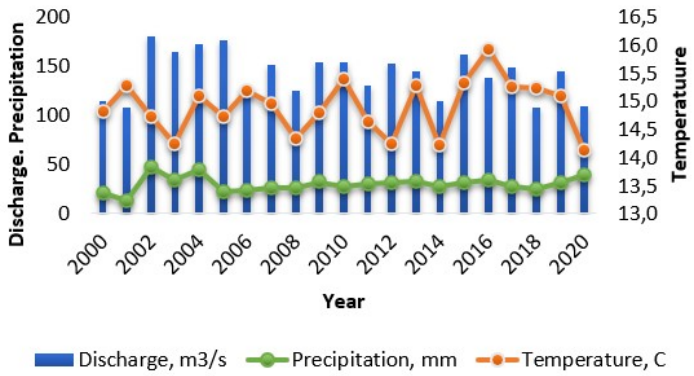



**Figure 3. Average annual long-term values of water flow (Ravotkhodja – 1U), precipitation and air temperature (Samarkand) in the Zarafshan River basin**

Data on precipitation and water discharge showed variability without a clear consistent trend. Significant peaks were recorded in 1969: 50.16 mm in Samarkand, 55.67 mm in Kushrabad, and 58.47 mm in Nurabad. The Dagbit station, which has been operational since 1970, recorded the highest average precipitation – 52.27 mm in 2020. Meanwhile, water discharge fluctuated between 86.5 m³/s and 163.3 m³/s. According to observations, a low-water period was recorded in 2021, while a high-water period occurred in 2016 (fig. 3).

It was established that the long-term average annual concentrations of nitrogen compounds at the Ravotkhodja station during the study period did not exceed the established MAC standards. Correlation analysis between N-$NH_4$, N-$NO_2$, N-$NO_3$ and water consumption showed values of -0.43, 0.08 and 0.21, respectively. The correlation analysis between climate variables and nitrogen compounds did not reveal any significant relationship, which suggests that the concentration of nitrogen compounds in water may be significantly influenced by other anthropogenic pollution factors (agricultural, industrial and municipal wastewater).

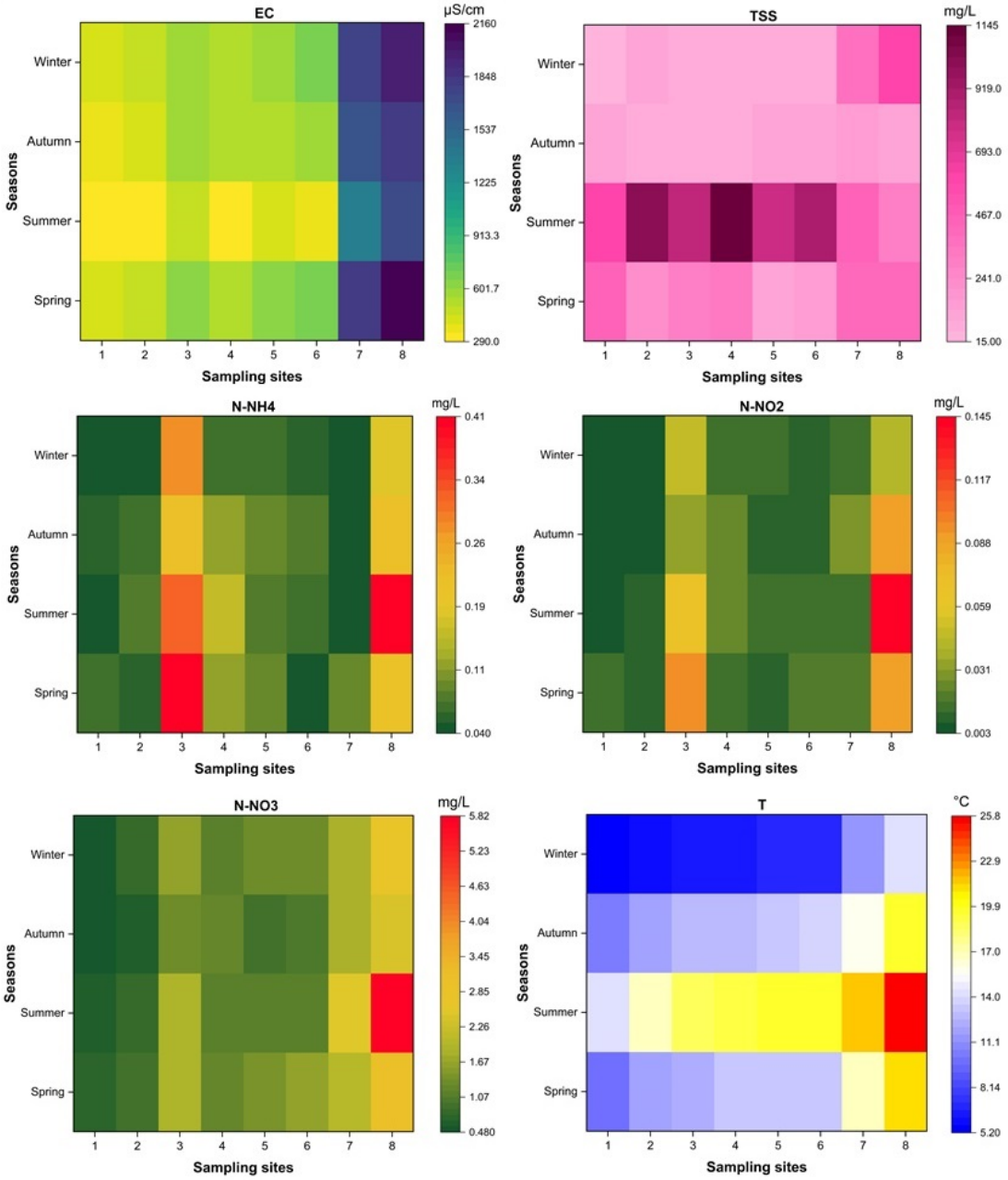



**Figure 4. Temporal and spatial changes in water quality parameters of the Zarafshan River (EC=Electrical Conductivity, TSS=Total Suspended Solids, N-$NH_4$=Ammonium Nitrogen, N-$NO_2$=Nitrite Nitrogen, N-$NO_3$=Nitrate Nitrogen, T=Temperature)**

The fourth chapter of the dissertation, titled “Assessment of Temporal and Spatial Variations of Water Quality Parameters in the Zarafshan River Basin”, consists of eight sections dedicated to studying the temporal (seasonal and annual) and spatial dynamics of water quality pollution in the Zarafshan River, as well as the correlation analysis and identification of long-term trends in the studied parameters. The study established that the levels of total suspended solids (TSS), temperature (T), and dissolved oxygen (DO) demonstrate significant seasonal fluctuations, while electrical conductivity (EC), concentrations of ammonium ($N\text{-}NH_4$), nitrite ($N\text{-}NO_2$), nitrate nitrogen ($N\text{-}NO_3$), and chemical oxygen demand (COD) vary depending on the spatial location.

As shown in figure 4, at hydroposts 1U to 8U, the electrical conductivity of the water ranged from 362 to 2160 µS/cm, with a noticeable increase at stations U7 and U8. The lowest conductivity (362 µS/cm) was observed in summer, while the highest (2160 µS/cm) occurred in spring. TSS values peaked in summer (1145 mg/L) and dropped to a minimum in winter (28.8 mg/L). High levels of $N\text{-}NH_4$ and $N\text{-}NO_2$ were recorded at U3 and U8 across all seasons, while the maximum $N\text{-}NO_3$ (5.81 mg/L) was detected in summer at U8. Water temperatures were consistently high at U7 and U8 (23.7 ºC).

Long-term analysis showed that the highest pollution levels were observed downstream of the Navoiazot plant. Spatial analysis along the river revealed different sources of pollution (fig. 5). In addition to the influence of the Navoiazot plant, significant pollution impacts are exerted by discharges from the Siab and Dargom canals, especially related to nitrite pollution, as well as the influence of the city of Samarkand, which contributes to increased COD levels. Saline soils of the Navoi region also contributed to increased electrical conductivity (EC). Positive correlations between nitrogen compounds indicate common sources of pollution, while elevated COD levels indicate significant pollution, mainly by various organic substances, which emphasizes their municipal origin.

The Pearson correlation coefficient (r) matrix showed that EC has a strong positive correlation with COD, T, $N\text{-}NO_3$ and $N\text{-}NO_2$ ($r>0.50$). TSS shows a weak correlation with all the studied parameters. N-NH4 is negatively correlated with DO (-0.89) and has a strong positive correlation with $N\text{-}NO_2$ and $N\text{-}NO_3$ ($r>0.50$), as well as a moderate correlation with COD (0.35). In addition, $N\text{-}NO_2$ is positively correlated with COD, T, $N\text{-}NO_3$, $N\text{-}NH_4$ and EC ($r>0.50$) and negatively with DO (-0.7). $N\text{-}NO_3$ and T have a strong and moderate positive correlation with most of the studied parameters ($r>0.40$), except for TSS (0.24) and DO (-0.39). COD is positively correlated with T, $N\text{-}NO_3$, $N\text{-}NO_2$, EC ($r>0.50$), $N\text{-}NH_4$ and TSS ($r<0.50$) (fig. 6).

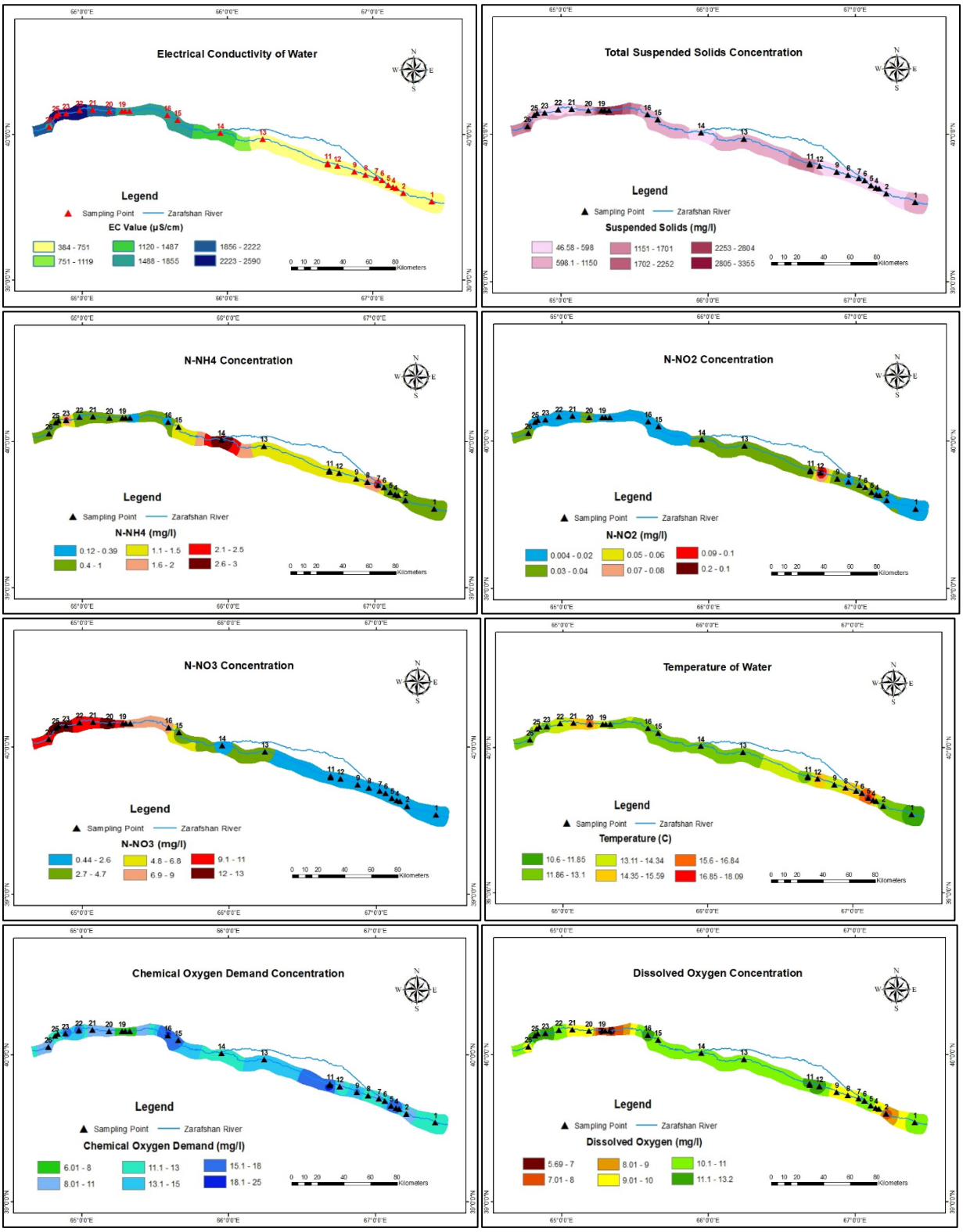



**Figure 5. Spatial variations of EC, N-$NH_4$, N-$NO_2$, N-$NO_3$, COD, DO, TSS and T in the Zarafshan River (autumn 2022)**

The results of the Mann-Kendall test revealed increasing trends for EC and N-$NH_4$ at some gauging stations (2U and 6U), while decreasing trends were observed for TSS, N-$NO_3$, T and COD. Other water quality parameters did not show significant trends.

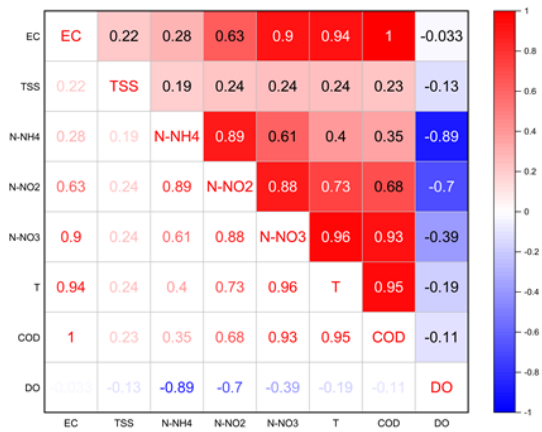



**Figure 6. Pearson correlation coefficient (r) matrix of different water quality parameters studied in the Zarafshan River (annual averages for each gauging station)**

The fifth chapter of the dissertation "Urban, industrial and agricultural impacts on water quality of the Zarafshan river" includes four sections. The first section examines the impact of land use on water quality. The second section is devoted to the impact of population growth and industrial development on the state of water resources. The third section analyzes the impact of agricultural practices, including the use of mineral fertilizers and collectors, on water resources in the Zarafshan River basin.

To assess the impact of land use on water quality, an RDA analysis was conducted focusing on three main land use types: pasture, cropland and built-up areas (figs. 7, 8). The results showed a moderate positive relationship between built-up areas and ammonium and nitrate nitrogen concentrations (RDA = 0.66), indicating elevated levels of these compounds in urbanized areas.

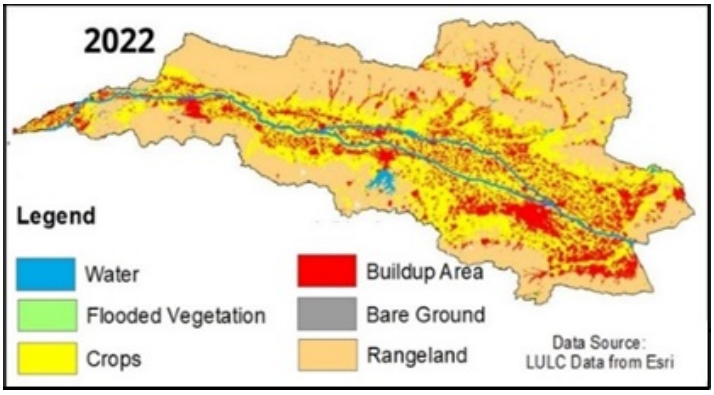



**Figure 7. Land cover and land use map in the middle and lower reaches of the Zarafshan River basin (2022)**

In addition, a strong correlation was noted between COD and built-up areas (RDA = 0.89), indicating a significant impact of urbanization. Pasture and cropland had little effect on nitrogen content, although a significant relationship was found between $N\text{-}NO_3$ and $N\text{-}NH_4$, which may indicate synergies or common sources of pollution.

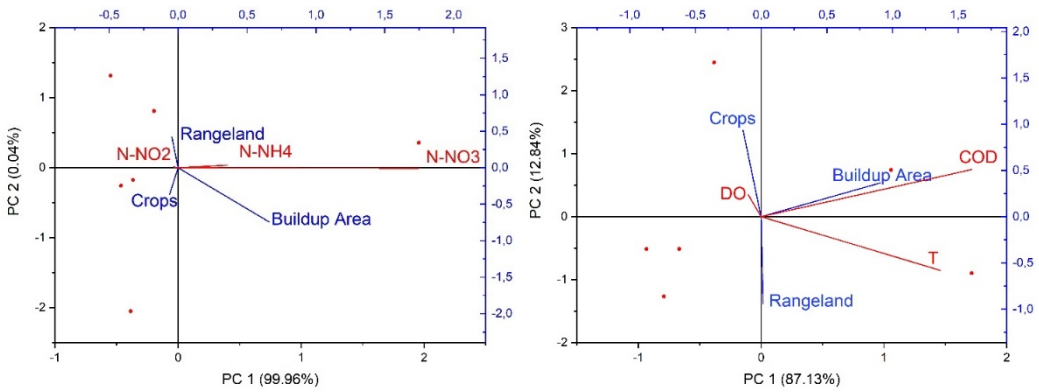



**Figure 8. RDA ordination plots of the impact of land use types (represented by blue lines) on water quality (represented by red lines)**

Our analysis shows that the population in the basin is growing year by year, contributing to the increase in nitrogen concentrations. For example, in 2020, the population increased by 1.17 times compared to 2010.

Consequently, there has been a steady upward trend in wastewater volumes over the decade, with a significant increase since 2016 (212 million $m^3$). This trend highlights the increasing impact of urbanization and industrial activity on water quality in the basin (fig. 9).

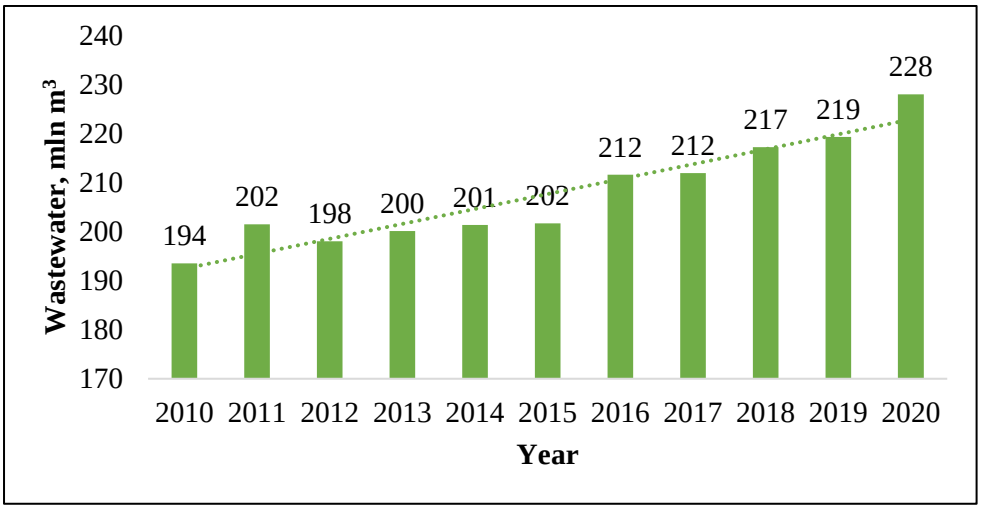



**Figure 9. Total annual wastewater volume**

The current efficiency of municipal wastewater treatment in the Zarafshan River basin is 70%. At 70% treatment efficiency, the nitrogen load was 21,648 kg (2020). Increasing this efficiency to 80% can reduce the nitrogen load (14,432 kg per year) by 1.5 times compared to the current level. Increasing the efficiency to 90% can further reduce the nitrogen load (7,216 kg per year) by 2-3 times compared to 70% and 80% efficiency, respectively (fig. 10).

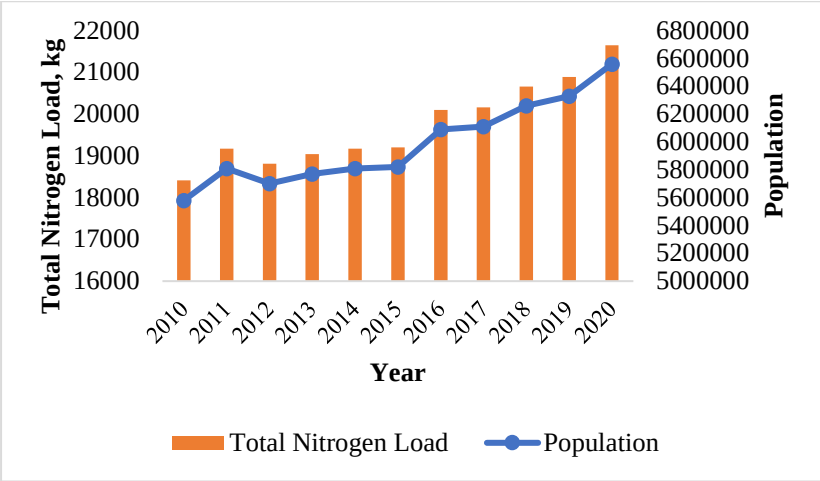



**Figure 10. Nitrogen load from municipal wastewater with 70% purification efficiency**

Analysis of industrial activity in the Zarafshan River basin shows a significant impact on water quality and ecosystem health. Of the 5,353 industrial enterprises classified into four hazard categories, the greatest contribution to pollution caused by high-risk enterprises is observed in the Farish, Jombay, Nurabad, Pastdargom districts and the city of Samarkand (fig. 11).

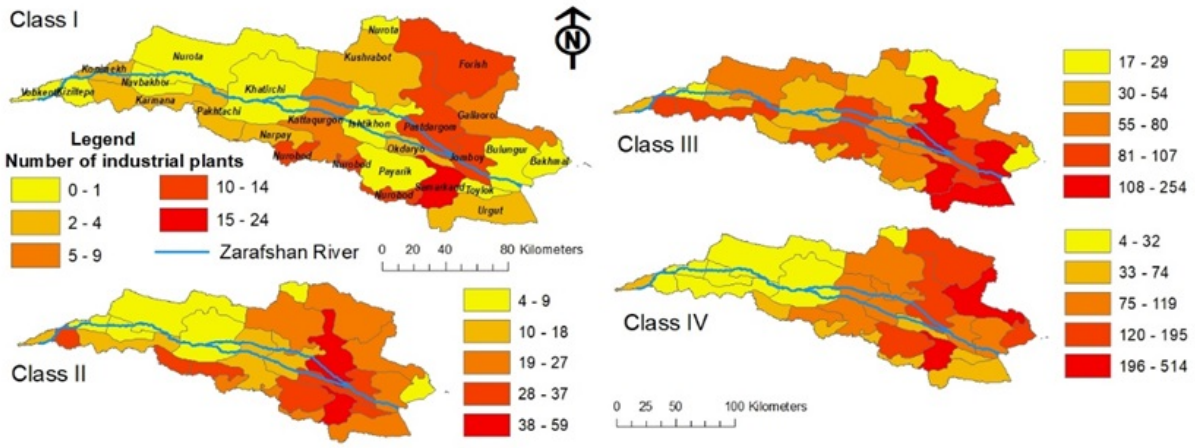
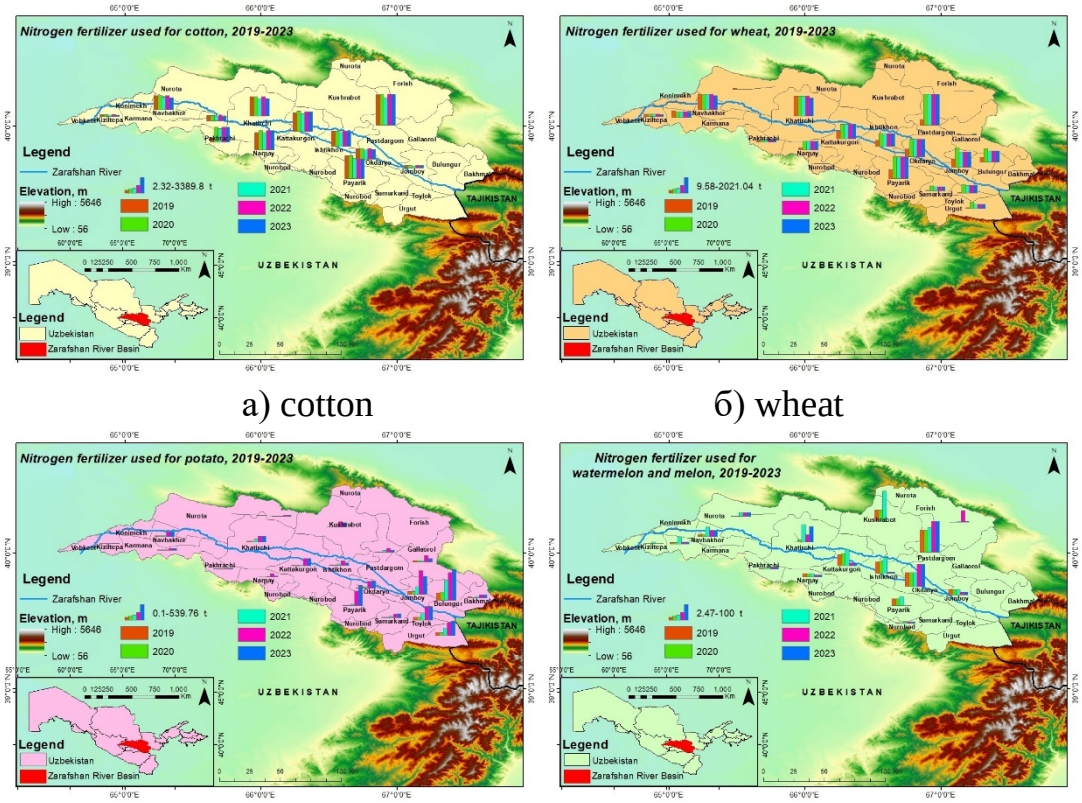



**Figure 11. Spatial distribution of industrial enterprises in the Zarafshan River basin (I-IV hazard categories)**

During the study of fertilizer use in the Zarafshan River basin, it was found that the Pastdargom region (middle reaches) of the Samarkand region is the main source of nitrogen fertilizers for growing cotton, wheat, watermelons and melons. In addition, the Bulungur region of the Samarkand region stands out as the main source of nitrogen fertilizers for growing potatoes (fig. 12).




а) cotton б) wheat

в) potato г) watermelon and melon

**Figure 12. Use of nitrogen fertilizers for growing agricultural and melon crops in the Zarafshan River basin (2019-2023)**

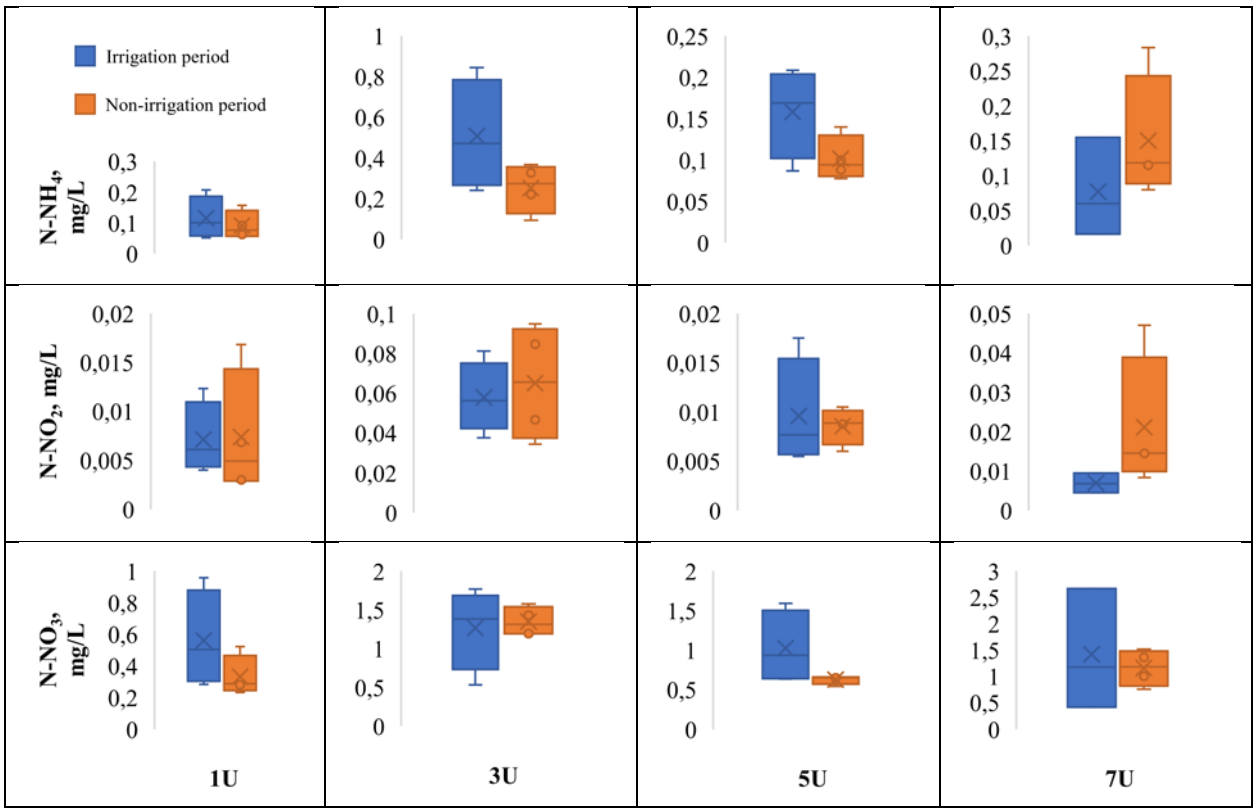



**Figure 13. Long-term average concentrations of nitrogen compounds during the growing (irrigation) and non-growing seasons**

Analysis of N-$NH_4$ concentrations over the past five years showed significant excess of MAC at site 3U during the irrigation period (by 1.5–2.1 times). N-$NO_2$ concentrations were also high at site 3U, but during the non-vegetation period, indicating pollution sources unrelated to agriculture. N-$NO_2$ levels exceeded MAC by 1.5–4.5 times. N-$NO_3$ concentrations increased during the irrigation period, but did not exceed MAC, with the lower reaches (7U) demonstrating higher N-$NO_3$ values compared to the upper and middle reaches of the river (fig. 13).

Analysis of the spatial distribution of nitrogen fertilizers shows that the greatest impact is observed in the middle reaches of the river, where agricultural practices significantly increase the nitrogen load (fig. 14). This confirms our previous findings of increased N-$NH_4$ concentrations in the 3U (middle reaches) due to agricultural activities, highlighting the impact of agriculture on nitrogen pollution in the Zarafshan River basin.

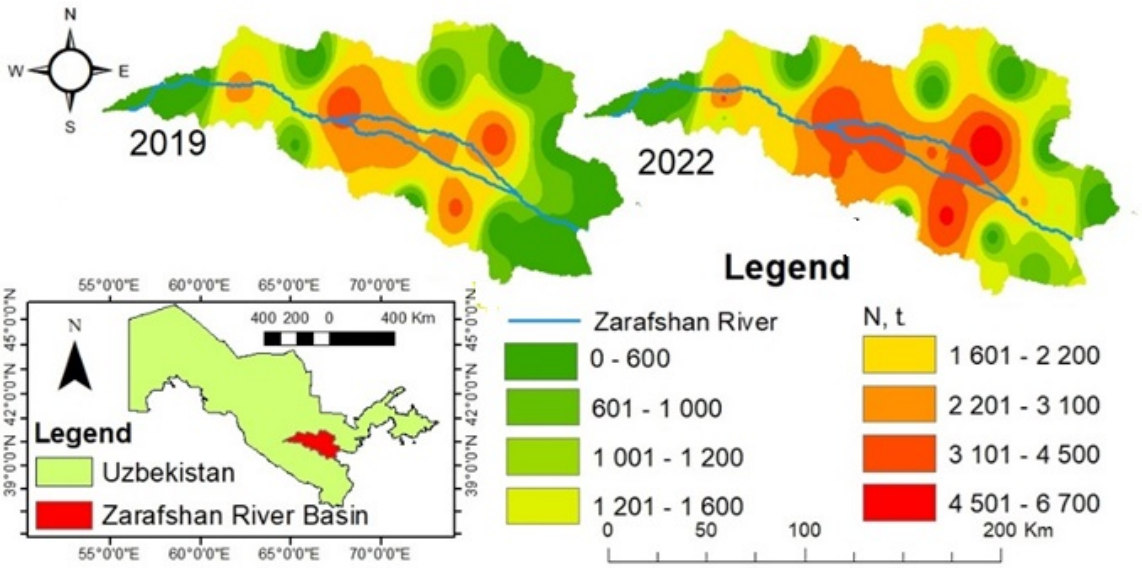



**Figure 14. Maps of the spatial distribution of applied nitrogen fertilizers in the Zarafshan River basin in 2019-2022**

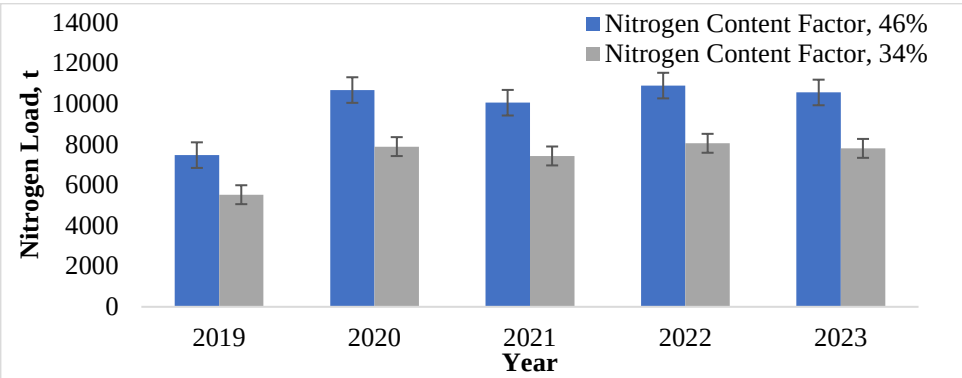



**Figure 15. Nitrogen load when using fertilizers with a nitrogen content of 34% and 46%**

We calculated the nitrogen load on the river as a result of the total use of fertilizers. The nitrogen load from carbamide fertilizer (urea) ranged from 7472.04 to 10897.81 tons, and the nitrogen load from ammonium nitrate ranged from 5522.81 to 8054.9 tons (fig. 15).

During the field trip to the Zarafshan River basin (2022-2023), water samples were collected from several collectors (Korasu, Siyob, Shakhob, Khovzaksoy, Guzalkent, Zarmon, Karmana, Amu-Bukhoro - from middle to lower reaches) and analyzed in the laboratory. The results showed that the highest concentrations of N-$NH_4$ (3.7 mg/L) and N-$NO_2$ (0.107 mg/L) were recorded in Khovzaksoy, while the maximum levels of N-$NO_3$ (19.58 mg/L) and COD (70 mg/L) were observed in Karmana. In general, the most significant pollution was associated with N-$NH_4$, whose concentrations in all collectors exceeded the MAC by 2.56-9.49 times. The concentrations of N-$NO_2$ in the Korasu, Siyob and Khovzaksoy collectors exceeded the MAC by 1.7, 1.1 and 5.3 times, respectively. The concentrations of N-$NO_3$ in Korasu, Khovzaksoy, Guzalkent and Amu-Bukhoro exceeded the MAC by 1.3 times, and in Karmana by 2.2 times (fig. 16).

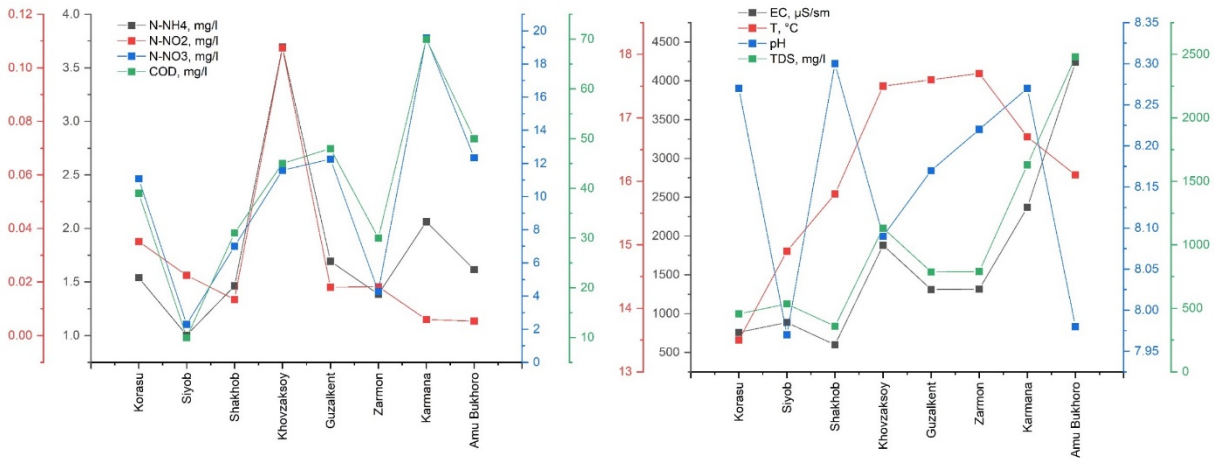



**Figure 16. Current state of water quality in collectors**

## CONCLUSIONS

The present study provides a comprehensive analyses of nitrogen compounds of anthropogenic origin in the Zarafshan river and their role in water quality formation under a changing climate. Based on the results of research conducted, the following conclusions were formulated:

1. Water quality parameters such as TSS, T and DO were revealed as vulnerable to seasonal (temporal) changes, negative impacts were observed especially during summer season. Elevated TSS (3,355 mg/L) in summer indicates increased sediment load. Other parameters (N-$NH_4$, N-$NO_2$, N-$NO_3$, COD, EC) were dependable on the spatial distribution. Long-term analysis have revealed that one of the major pollution source was the Navoiazot factory.

2. For the first time the Mann-Kendall Test was applied in Zarafshan river basin and results showed trends with increasing EC ($\tau$ = 0.72) and N-$NH_4$ ($\tau$= 0.46) at 2U and 6U respectively, while other parameters like TSS, N-$NO_3$, T, and COD

showed decreasing trends. The correlation analysis showed that water discharge had positive correlation with TSS (r = 0.53), however, EC (r = -0.55), N-$NH_4$ (r = -0.43) and COD (r = -0.59) showed negative correlation coefficients. The strong inverse relationship between DO and N-$NH_4$ (r = -0.89) was revealed.

3. It was revealed that cotton and wheat had the highest contribution of nitrogen fertilizer application, with 18,601.33 t and 18,167.50 t respectively. Melon and watermelon crops had the minimum usage of fertilizers, with 351.68 t. In total, the highest amount of fertilizer was used in 2022 (42,305.17 t), which is 45.85% more than the least amount used in 2019 (29,006.36 t). The nitrogen load from urea fertilizer ranged from 7,472.04 t to 10,897.81 t, while the nitrogen load from ammonium nitrate ranged from 5,522.81 t to 8,054.9 t.

4. Increased nitrogen fertilizer use in agricultural practices, particularly in the Pastdargom and Bulungur districts, affects the elevated nitrogen compound levels in the river. The analysis of nitrogen compound concentrations during irrigation and non-irrigation periods allowed to assess agriculture's impact on the Zarafshan River water. Elevated concentrations of N-$NH_4$ exceeding the MAC 1.5-2.1 times and N-$NO_3$ within the MAC were observed during the irrigation period, particularly in the midstream region where nitrogen fertilizers are most heavily applied. This indicates that these compounds likely originate from agricultural activities and are significantly influenced by agricultural practices. At the same time, concentrations of N-$NO_2$ exceeding the MAC 1.5-4.5 times detected during non-irrigarion period, suggesting its origin not agricultural but industrial or municipal.

5. It has been established that among the nitrogen compounds most susceptible to agricultural pollution is N-$NH_4$. The study has revealed N-$NH_4$ concentrations exceeding the MAC by 2.56 to 9.49 times in all studied canals, particularly in the Khovzaksoy (N39.802960, E66.660802) and Karmana (40.159839, 65.173717) canals. Additionally, the Karmana and Amu-Bukhoro (40.140048, 64.902515) canals exhibited the high degrees of pollution with mineral salts (EC 2370 and 4240 µS/cm) and TDS (1630 and 2480 mg/L), indicating significant water quality issues in these areas.

6. Following pollution hotspots have been established: for the N-$NH_4$ exceeding the MAC 7.5 times was identified at sampling point 14 (40.0091927, 65.9526564), for N-$NO_2$ exceeding the MAC 4.2 times at S12 (39.7848620, 66.7582210), and for N-$NO_3$ within the MAC from S16 (40.1329150, 65.5889920) to S26 (40.1608890, 65.1893340). The COD concentrations in the river had a moderate degree of water pollution at S10 (39.7928880, 66.6900640) and S16.

7. It was revealed tendention that the expansion of urban areas leading to increased COD levels (RDA=0.89), indicating an increase of organic pollution from domestic sources. The population is increasing year by year, therefore, the wastewater generation and the total nitrogen load with current 70% nitrogen removal efficiency increased by 17.56% from 2010 to 2020. Urban wastewater, often inadequately treated, obviously contributes high levels of nitrogen compounds to the river system. The region's industrial activities, plants with varying hazard levels,

significantly affect water quality too. The Farish, Jamboy, Nurobod, Pastdargom districts and Samarkand city show the highest contribution of industrial pollution.

8. Assessing climate change impact shows slight increase trends in temperature (0.02-0.04°C) during the studied period (1960-2020). However, precipitation and discharge data reveal no significant long-term trends. The correlation analysis between climate variables (precipitation and temperature) Although a trend of temperature increase (0.12-0.15°C) was observed in 1991-2000, no temperature increase trend was observed during our period of nitrogen pollution study (2010-2023). As a result, the correlation analysis between climate variables (precipitation and temperature) and nitrogen compounds did not show a significant relationship, which mainly showed that other all above (agro-industrial) factors influence the level of nitrogen in water. Perhaps, studying nitrogen compounds and their correlation with climate variables for the latter period allows accurately assess possible interdependence between these factors.

9. The social-economic effect of the obtain ed results and practical recommendations is expressed in the preservation of ecosystem services and biodiversity, improvement of the well-being and health of the population by reducing the level of pollution by harmful nitrogen compounds.

**РАЗОВЫЙ НАУЧНЫЙ СОВЕТ ПРИ НАУЧНОМ СОВЕТЕ DSc.03/30.12.2019.T.10.02 ПО ПРИСУЖДЕНИЮ УЧЕНЫХ СТЕПЕНЕЙ ПРИ НАЦИОНАЛЬНОМ ИССЛЕДОВАТЕЛЬСКОМ УНИВЕРСИТЕТЕ “ТАШКЕНТСКИЙ ИНСТИТУТ ИНЖЕНЕРОВ ИРРИГАЦИИ И МЕХАНИЗАЦИИ СЕЛЬСКОГО ХОЗЯЙСТВА”**

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**НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ УНИВЕРСИТЕТ “ТАШКЕНТСКИЙ ИНСТИТУТ ИНЖЕНЕРОВ ИРРИГАЦИИ И МЕХАНИЗАЦИИ СЕЛЬСКОГО ХОЗЯЙСТВА”**

**ШОЭРГАШОВА ШОБЕГИМ ШАРОФ КИЗИ**

# ВЛИЯНИЕ АНТРОПОГЕННЫХ АЗОТНЫХ СОЕДИНЕНИЙ НА ФОРМИРОВАНИЕ КАЧЕСТВА ВОДЫ РЕКИ ЗАРАФШАН В УСЛОВИЯХ ИЗМЕНЕНИЯ КЛИМАТА

**11.00.05 - Охрана окружающей среды и рациональное использование природных ресурсов**

**АВТОРЕФЕРАТ ДИССЕРТАЦИИ ДОКТОРА ФИЛОСОФИИ (PhD) ПО ТЕХНИЧЕСКИМ НАУКАМ**

**Ташкент – 2024**

**Тема диссертации доктора философии (PhD) по техническим наукам зарегистрирована в Высшей аттестационной комиссии при Министерстве Высшего образования, науки и инноваций Республики Узбекистан за номером B2024.3.PhD/T4999.**

Диссертация выполнена в Национальном исследовательском университете «Ташкентский институт инженеров ирригации и механизации сельского хозяйства».

Автореферат диссертации на трех языках (узбекский, английский, русский (резюме)) размещен на веб-странице Научного совета: (www.tiiame.uz) и информационно-образовательном портале "ZiyoNet" (www.ziyonet.uz).

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|---|---|
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Защита диссертации состоится «3» декабря 2024 г. в 12$^{00}$ часов на заседании разового Научного совета при научном совете DSc.03/30.12.2019.T.10.02 Национального исследовательского университета «Ташкентский институт инженеров ирригации и механизации сельского хозяйства» по адресу: 100000, г. Ташкент, ул. Кары-Ниязий, 39. Тел/Факс: (+99871) 237-46-68, e-mail: admin@tiiame.uz.

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(Реестр протокола рассылки № 345 от "21" ноября 2024 года).

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## ВВЕДЕНИЕ (аннотация к диссертации доктора философии (PhD))

**Целью исследования** является оценка влияния антропогенных азотных соединений на формирование качества воды реки Зарафшан в условиях изменения климата.

**Задачи исследования:**

установить взаимосвязь между концентрациями соединений азота (аммоний, нитрит, нитрат) и физико-гидрохимическими показателями качества воды реки Зарафшан;

количественно оценить временные и пространственные изменения концентрации азота в реке Зарафшан, научно обосновать сезонные и долгосрочные тенденции;

оценить пространственное распределение источников загрязнения азота, влияние сельскохозяйственных и коммунально-бытовых стоков, а также промышленности в водосборе реки Зарафшан с использованием методов географической информационной системы (ГИС);

определить влияние климатических характеристик (температура воздуха и осадки) на концентрацию соединений азота в реке Зарафшан;

разработать рекомендации по устойчивому управлению качеством воды реки Зарафшан.

**Объектом исследования** является среднее и нижнее течение бассейна реки Зарафшан в пределах Республики Узбекистане.

**Предметом исследования** является влияние антропогенных факторов на показатели качества воды (электропроводность, общее количество взвешенных твердых частиц, температура, растворенный кислород, химическое потребление кислорода, аммонийные, нитритные и нитратные формы азота), а также влияние изменения климата на азотные соединения в среднем и нижнем течении реки Зарафшан.

**Методы исследования.** В диссертации использованы спектрофотометрический метод, статистические и корреляционные анализы, а также ГИС-технологии и методы пространственного анализа.

**Научная новизна исследования** заключается в следующем:

установлены зависимости между концентрациями соединений азота и физико-гидрохимическими показателями, а также научно обоснованы временно-пространственные характеристики изменения качества воды;

оценены пространственные распределения различных источников загрязнения азота, рассчитаны азотные нагрузки коммунально-бытового и сельскохозяйственного происхождения в среднем и нижнем течении бассейна реки Зарафшан;

обосновано, что аммонийный азот ($N\text{-}NH_4$) является наиболее чувствительным индикатором к сельскохозяйственному загрязнению, а также выявлены горячие точки загрязнения азотными соединениями;

обнаружены незначительные тенденции повышения температуры (0,02-0,04°C) в среднем и нижнем течении бассейна реки Зарафшан в 1960-2020 гг. Однако было установлено, что значимой корреляции между температурой, осадками и соединениями азота нет.

**Практические результаты исследования** заключаются в следующем:

разработаны научно-обоснованные практические рекомендации по устойчивому управлению качеством воды в реке Зарафшан по уровню загрязнения азотными соединениями, основанные на комплексном анализе антропогенных и климатических факторов с использованием, ГИС-технологий;

установлены долгосрочные тенденции изменения качества воды в реке на основе многолетних данных с учетом изменения климата, что способствует прогнозированию возможных изменений и улучшению планирования водопользования;

рассчитаны азотные нагрузки коммунально-бытового и сельскохозяйственного происхождения, создана программа ЭВМ «Расчет азотной нагрузки от сельского хозяйства на речную экосистему» (№ DGU 43328);

разработаны электронные карты современного уровня загрязнения реки Зарафшан с использованием ГИС-технологий, а также обнаружены горячие точки загрязнения азотными соединениями.

**Внедрение результатов исследования.** На основе полученных научных результатов по изучению влияния антропогенных азотных соединений на формирование качества воды реки Зарафшан в условиях изменения климата:

разработаны практические рекомендации по управлению качеством воды и внедрены в управлении ирригационных систем «Кармана-Конимех» при Нижнезарафшанском бассейновом управлении ирригационных систем (справка №03-03/3-9385 с Министерства экологии, охраны окружающей среды и изменения климата республики Узбекистан от 25 сентября 2024 года). В результате, это дало возможность улучшить защиту экосистемных услуг и здоровья населения, а также систему мониторинга;

разработана программа ЭВМ в Управление экологии, охраны окружающей среды и изменения климата Самаркандской области (справка №03-03/3-9385 с Министерства экологии, охраны окружающей среды и изменения климата республики Узбекистан от 25 сентября 2024 года). В результате, это позволило определить и спрогнозировать азотную нагрузку сельскохозяйственного происхождения в среднем и нижнем течении бассейна реки Зарафшан;

разработаны научно-практические рекомендации и внедрены в Управление экологии, охраны окружающей среды и изменения климата Самаркандской области (справка №03-03/3-9385 с Министерства экологии, охраны окружающей среды и изменения климата республики Узбекистан от 25 сентября 2024 года). В результате, это дало возможность улучшения качества воды и обеспечения экологической устойчивости водных экосистем бассейна.

**Апробация результатов исследования**. Результаты данного исследования были обсуждены на 2 международных и 3 республиканских научно-практических конференциях.

**Структура и объем диссертации.** Структура диссертации состоит из введения, пяти глав, выводов и списка использованной литературы. Объем диссертации составляет 117 страниц.

## E'LON QILINGAN ISHLAR RO'YXATI
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Avtoreferat “O‘zbekiston qishloq va suv xo‘jaligi” jurnali tahririyatida tahrir qilindi (07.11.2024 y.)

№ 10-3279

Bosishga ruxsat etildi: 20.11.2024.
Bichimi: 60x84 1/16 «Times New Roman» garniturada raqamli bosma usulda bosildi.
Shartli bosma tabog‘i 3. Adadi 100. Buyurtma: № 151

Tel: (99) 832 99 79; (77) 300 99 09

Guvohnoma reestr № 10-3279
“IMPRESS MEDIA” MChJ bosmaxonasida chop etildi.
Manzil: Toshkent sh., Yakkasaroy tumani, Qushbegi ko‘chasi, 6-uy.