IJIMM, Volume 3, Issue 10, 2025 ISSN: 2995-5319
http://medicaljournals.eu/index.php/IJIMM/issue/view/3

INTERNATIONAL JOURNAL OF INTEGRATIVE AND MODERN MEDICINE

The Relationship between Chlorine Residuals in Drinking Water, Gut Microbiota Disorders, and Cancer Development

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Annotation: Residual chlorine in centralized urban drinking water is essential for disinfection but may pose health risks associated with gut microbiota imbalance and cancer development. This article analyzes 21 scientific studies published between 2020 and 2025 to examine the effects of chlorine (0.2–1.0 mg/L) and wastewater admixture on gut bacteria and cancer risk. The findings indicate that chlorine slightly alters gut microbiota composition, increases antibiotic resistance by 5–7 times, and elevates colorectal cancer risk by 1.3–1.8 times through trihalomethanes (THMs). In children, Akkermansia and Escherichia populations increase, while beneficial bacteria decrease, leading to dysbiosis and inflammation. In Uzbekistan, chlorination has reduced diarrhea incidence by sixfold; however, the impact of municipal tap water quality on gut health and cancer risk remains unstudied. The paper recommends improving water filtration systems, strengthening monitoring, and conducting further research in this field.

Keywords: chlorinated water, gut microbiota, cancer, colorectal cancer, trihalomethanes, antibiotic resistance, Akkermansia, Escherichia.

Introduction. In city life centralized drink water population main drink water source to be, to be safety health for important factor World Health Save According to the World Health Organization (WHO), according to, clean drink water every 1.4 million cases of diarrhea per year status prevent (WHO, 2023)[1]. Urban water in supply chlorine the most wide widespread disinfection tool such as Escherichia coli, Salmonella pathogen bacteria effective no does. However chlorination in the process harvest to be residue chlorine compounds — trihalomethanes (THMs), chloramines and other organochlorine of substances far term consumption health for danger [2,4,9,11]. WHO and USA The environment protection to do according to the Environmental Protection Agency (EPA) according to, drink in the water total THM content not exceeding 0.1 mg/L necessary, but some city water in networks this indicator up to 0.18–0.25 mg/L (EPA, 2022) [1,3].

Epidemiological research this It turns out that chlorine water far term consumption to do urine bubble cancer risk by 21–33%, obesity or right intestine cancer increases the risk of cancer by 15–18% (Villanueva et al., Environmental Health Perspectives, 2017) [7,8]. Canada and In Spain take 10 years ago observation In studies, THM levels were found to be above 0.05 mg/L was water consumption did in the population urine bubble cancer with 2 times the incidence many encountered (Cantor et al., Journal of Epidemiology, 2020) [5].

Trihalomethanes and chloramines intestine of the wall conductivity increased, “leaky gut” syndrome [12], chronic inflammation and microflora imbalance brought In animals held in experiments chlorinated water consumption as a result, such as Bifidobacterium and Lactobacillus useful bacteria number up to 40% decreased, such as Clostridium difficile pathogens and 2.3 times increased identified (Yoon et al., Toxics, 2022)[5].

urban conditions network drink water sometimes sewage water with interferes . As a result chlorine amount increases and THM concentration increases. According to WHO estimates According to the THM content is higher than 0.1 mg/L was in the regions residents between cancer 1.4 times the risk high (95% CI: 1.1–1.7).

In Uzbekistan centralized water More than 40% of the networks are more than 30 years old. since not updated . As a result, cities like Tashkent, Namangan, Samarkand in cities in the water chlorine permanent excess amount and sewage mixtures cases is being monitored . Local laboratory to the measurements according to some on the networks residue chlorine level up to 0.7 mg/L reaches (***data from SanPiN 2.1.4.559-96***)[10,13].

Last in years various in countries held research this of the matter complexity shows. Held in Australia (2024) in research chlorinated water consumption in babies to antibiotics resistant bacteria number increased; in Bangladesh (2022) water chlorination diarrhea circumstances reduced, but in the microflora imbalance brought issued .

In Uzbekistan and in the water chlorine remains, intestines microflora and cancer danger between dependency still wide in scope unexplored. Therefore this article centralized drink in the waters chlorine remains and sewage water mixture health , in particular intestine microflora and cancer to develop the impact analysis does , exists scientific evidence summarizes and Uzbekistan to the conditions suitable practical recommendations previously The study purpose — centralized drink in the water chlorine remains and trihalomethanes intestine microflora disorders and cancer development at risk the impact is to determine .

Methodology. This analytical research 2020–2025 21 scientific papers published during source based on done increased . Selected scientific affairs drink in the water chlorine residues , trihalomethanes level and their intestine microflora and oncological to the dangers the impact learned the results cover takes. In studies drink in the water chlorine The amount is between 0.2–1.0 mg/l. identified , microbiological assessment and 16S rRNA sequencing , qPCR or clinical correlation methods using held It was requested to be. The data reliability statistic indicators (percentage odds ratio , confidence via range) was evaluated . Also, water to the quality circle regulations World health storage WHO recommendations (chlorine level 0.2–0.5 mg/L) compared. Uzbekistan according to indicators Health storage ministry water supply to the system related reports and local hygienic monitoring results based on analysis The study was conducted in Tashkent State Medicine University Ethics Committee by approved (No. 25-30/124-t, 2025).

Results

Analysis done research city centralized drink in the water chlorine remains intestine to the microflora relatively minimal, but biological importance has changes brought release and far term consumption thick intestine cancer the risk increase possible showed .

In children held to observations According to, chlorinated tap water (0.37 mg/L) in Perth , Australia (2024) has microflora diversity noticeable impact (Shannon index , p= 0.45), but Akkermansia species increased by 2.4- fold (95% CI: 1.9–3.0), and Escherichia by 1.1- fold (95% CI: 0.7–1.6) record With this together with antibiotics resistant genes — mdf (A) and tet (A) — 0.9–7.3 times increased (p=0.019) [18.19]. Trihalomethanes (THM) levels high was water consumption did in children thick intestine inflammation 1.5 times many encountered , this and in the future cancer to develop ground create possible .

In Bangladesh in 2022 held research to the results (130 children, 6–61 months), chlorinated water diarrhea 6 times more cases reduced , but Phascolarctobacterium species 2.1 times increased . THM high was in the regions inflammation markers — IL-6 and TNF-α — increased by 12% , which and thick intestine cancer with related inflammation processes strengthened [12.15].

Adults between held USA studies (2023, 1200 participants) showed that chlorinated tap water (0.5 mg/L) was used for a long time term consumption to do thick intestine cancer 1.3 times the risk (OR= 1.3 ; 95% CI: 1.1–1.6). This is due to THM and intestine in the microflora dysbiosis as a result inflammation processes increase with Microflora Wealth (Chao1 index) decreased by 10% this is cancer the risk increasing factor as is evaluated [17].

15 studies own inside to the results of a meta- analysis (N>6000) According to [15,19,21], chlorine microflora diversity noticeable impact not shown (p>0.05), but antibiotic endurance (p=0.019) and thick intestine cancer increased risk (OR=1.4; 95% CI: 1.1–1.7) .

Water water mixture there is was city in networks chlorine amount Increased THM production to be take coming . 2022 THM levels in the study high was water consumption intestine dysbiosis by 1.8 times (95% CI: 1.3–2.4) and thick intestine cancer 1.5 times the risk increased . THM intestine of the wall conductivity increase inflammation markers — IL-6 levels increased by 15% , which and cancer development mechanisms activated [20.23,24].

In Uzbekistan held hygienic observations this shows that chlorination diarrhea diseases in reduction important importance For example, in the city of Nukus (2023) chlorinated water consumption diarrhea 6 times more cases (from 179 cases per 1,000 people to 28). together , Tashkent and other tap water in cities chlorine amount In 30% of cases , the concentration of microorganisms is below the WHO standards (0.2–0.5 mg/L). complete no not to be done reason is taking place in Tashkent in 2017 . held in research chlorine to the Cryptosporidium parasite relatively inefficiency infection was detected The risk has increased by 100% . Water in Namangan (2020) in 15% of networks sewage water involvement record This reduces THM levels to 0.05 mg/L . increased and microflora violation and cancer of danger to increase take arrived [3.8].

Age factor is also important impact shows: babies and young children intestine microflora still unformedness because of chlorine and THM exposure two even more sensitive. water mixture there is on the networks chlorine and THM levels increased, dysbiosis 1.8 times the risk of cancer the risk and 1.5 times Social in terms of less provided city in the regions water low quality because of this problems are 15% higher record [9]. Also , the city population between probiotic products less consumption to do chlorine intestine to the microflora the impact further strengthens .

Interesting aspect is that chlorine some useful There are also effects: Akkermansia bacteria increase intestine the wall strengthen , obesity and chronic from inflammation protection to do possible . But chlorinated in the water antibiotic endurance 1–7 times more genes increase according to WHO data According to [1], every 1.27 million deaths per year to the circumstances directly or indirectly reason is happening. THM is fat intestine cancer 1.3–1.8 times the risk increasing chemical factor as confession Like Tashkent large in cities water in networks sewage water interference this the danger further strengthens.

Discussion . Analysis results this shows that in city tap water chlorine human to your health bilateral impact shows — one from the microbiological side security provides , second from the side and intestine microflora natural balance to break and chemical by- products through oncological the danger increase Chlorination is possible . main benefit — drink in the water pathogen microorganisms , in particular Escherichia coli, Vibrio cholerae, Salmonella spp . bacteria inactivation This is especially true in developing countries. in countries diarrhea , dysentery and other intestine infections status in reduction important hygienic measure For example , the 2023 Nukus under observation chlorination as a result diarrhea 6 times more cases decreased water disinfection practical efficiency confirms . However, far term chlorinated water consumption intestine microbiota in the composition changes brought In research useful bacteria (e.g. Bifidobacterium and Lactobacillus) decreased , opportunistic species (e.g. , Akkermansia and Phascolarctobacterium) increased . This is dysbiosis status inflammation markers — IL-6, TNF-α — of increase and immune system activation with related to be, to be thick intestine mucus floor protection function weakens.

Chlorine itself is not mutagenic, but his/her in the water organic substances with reaction as a result trihalomethanes (THMs) and chloramines harvest These compounds are To DNA impact cell proliferation and oxidative stress THM levels in studies high was water far consumption did in populations thick intestine cancer risk 1.3–1.8 times increased determined.

Socio-economic These are also factors the effect strengthens: water networks obsolescence, waste water mixtures, water pressure low and disinfection monitoring weakness THM concentration in Uzbekistan to increase take Namangan and In Tashkent observations this the situation confirmed.

With this together with chlorine positive biological side also available: Akkermansia muciniphila such as bacteria increase intestine of the wall integrity save, obesity, diabetes and metabolic syndrome against protection factor to be possible. But this positive impact only short term and control under chlorine observed in small amounts (0.2–0.5 mg/L) .

The following in the table chlorine intestine microflora and cancer with related main mechanisms systematic in a way quoted :

Drink in the water chlorine bilateral impact

Impact direction	Mechanism	Biological consequence	Statistical expression
Useful impact	Pathogens inactivation (E. coli, Vibrio, Salmonella)	Diarrhea cases 4–6 times decreases	Nukus (2023): 179 → 28 cases / 1,000 people
Dysbiosis danger	Useful bacteria decreases , Akkermansia increases	Intestine balance will break	Akkermansia ↑ 2.4 -fold ; p=0.019
Inflammation mechanism	THM intestine IL-6, TNF-α in the epithelium activates	Chronic inflammation and epithelial weakness	IL-6 ↑ 12–15%
Cancer danger	THM and chloramines cause DNA damage strengthens	Fat intestine cancer danger increases	OR = 1.3–1.8 (95% CI)
Social impact	Low quality water networks and control shortage	Water water mixture , THM ↑ 0.05 mg/L	Namangan (2020): 15% online sewage mixture

Above results chlorination controlled and scientific based application health for useful to be , but too much or unclear level chlorination and dysbiosis and cancer the risk increasing factor to be shows. Therefore for In Uzbekistan water networks hygienic monitoring increase THM levels regular control to do and probiotic products consumption encouragement necessary.

Conclusion and recommendations. Analysis results this shows that drinking in the water chlorine remains far term during to the organism when falling intestine microflora natural balance from the trail output, useful bacteria number to decrease and conditional pathogen microorganisms to increase reason to be It is possible. This is food digestion to do disorders, inflammation processes and immune system weakening such as to the circumstances take comes. Some epidemiological in research and chlorination as a result harvest to be trihalomethanes and other organochlorine of compounds far term impact liver, urine bubble and thick intestine cancer development danger with dependency determined.

Therefore, water disinfection to do in the process chlorine amount strict control under storage, WHO recommendation from the range of 0.2–0.5 mg/l not to exceed provide necessary. Also, chlorination method step by step safer technologies — ultraviolet, ozonation or membrane filtering systems with replacement promising direction is considered.

Medical prevention point from the point of view and , intestine microflora support for probiotic and prebiotic from products rich in nutrients use , water quality monitoring regular take go , water in the networks chlorine amount periodic measurement and the population this regarding hygienic culture increase according to educational events strengthen recommendation In this way , the drink of water

safety provide with together , the population intestine health and cancer prevention support possible will be .

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