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Influence of antropogenic pollution of the river Zarafshan on intestinal infection morbidity of the population.

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Abstract

The role of the water factor in spreading typhoid and paratyphoids, dysentery, enterovirus infections among the population using surface sources of water for drinking has been already proved. However special investigation of combined influence of the total water pollution on development of the infectious pathology in the rural and urban population in the areas of small rivers is necessary. The task of the study was to reveal the rate of intestinal infections in the population in connection with the change of conditions of using water and the effect of chemical and bacteriologic pollution of water in the basin of the river Zarafshan. The obtained mathematical models represent adequately the interrelations of spreading infectious diseases in the population not only with indices of bacteriologic but also specific chemical pollution of water of the river Zarafshan.

1 Introduction

The major cause of degradation of water resources in Uzbekistan is usage of much water for irrigation and fields washing. In the rural area, open water reservoirs and underground water are contaminated by collector-drainage water washed from fields and sewage water from farms. This is an important risk factor leading to water deterioration. Since the range and forms of antropogenic impact on water quality in different provinces of the Republic are becoming more diverse, the problems of ecological risk for population health caused by the water factor are of the greatest importance.

The problems of rational utilization of water resources and their protection against different kinds of pollution are of top priority in Uzbekistan. Outstripping rate of national economy development compared to environment-protection activity is known to have a negative effect on formation of water quality in reservoirs for industrial and recreational goals and drinking.
Infectious diseases spread no doubt depends on changes in ecologic and social conditions and at the same time it was confirmed by both many-years and seasonable fluctuations. According to the Health Ministry of Uzbekistan, water-borne infections are the most common among infectious diseases reported in the region.
The problems of ecological and epidemiological characteristics of intestinal infections spread are rather urgent due to nature and climate peculiarities, the specific way of water consumption and the antropogenic press on water reservoirs in this region. The main sources of water supply in Uzbekistan are the following major rivers: the Amudarya, the Syrdarya, and minor rivers: the Zarafshan, the Naryn, the Kashkadarya, the Surkhandarya, the Chirchik and the Akhangaran.
Under specific conditions of Uzbekistan, the minor rivers are the main source of water used in economy and for drinking. Intensification of industrial and agricultural production, concentration of population and enlargement of rural settlements have been recorded in the rivers basin. The population is provided with centralized water supply insufficiently, i.e. 60.2% of rural and 85% of urban population, according to the data of 1996 [1].
Significant season fluctuations of the water quality, its intensive contamination reduced the reliability of work of purification facilities in waterworks. Unsatisfactory sanitary-technological condition and maintenance of the purification systems and the water-pipe branches network result in increasing stoppage of water supply, elevation of the negative opinion of the population of the drinking water quality. In the areas with intensive chemical load on water-sources, the restriction of all the types of water consumption was found out but in the greater degree it was noted for the population consumption of water for drinking and household purposes.

2 Characteristics of the Zarafshan River

The Zarafshan river basin is one of the most densely populated areas in Central Asia. The current social and economic situation in the region requires a significant increase of water supply to communal and household needs, developing industry, irrigated agriculture and other fields of national economy. At the same time a tense situation with water utilization and ecology is developing which no doubt manifests itself in the sanitary and hygienic conditions in the region. The situation is also worsening because a certain number of residents in the rural area use water from open reservoirs and canals for household needs and drinking. The level of water provision of population in the Navoi province with centralized water supply (50,6%), tube-wells (28,3%), water brought in tanks (15%) and utilization of water from open reservoirs for

household needs and drinking (6,1%) shows how high the risk of intestinal infection is in this area.
The river Zarafshan runs through the territory of the Samarkand, Navoi and Buchara provinces. It is one of the main sources of water consumption of the population, including economic, cultural, household and drinking use. Recently the quality of the Zarafshan water has sharply deteriorated due to the antropogenic press.
The Zarafshan River being the sole source of potable water supply receives communal, household, industrial and agricultural sewage in the Leninabad province of Tadjikistan, the Samarkand and Navoi provinces of Uzbekistan. The quality of water in the examined part of the river Zarafshan is formed by dropping industrial and municipal sewage of the cities Samarkand, Kattakurgan, Navoi, Pendjikent and towns Bulungur, Dzhambai as well as by agricultural sewage from the rural area. All these significantly worsen the sanitary and hygienic situation in the region. The most contaminated water is in the area below Navoi-city, i.e., in the investigated area. Here the Sarafshan receives the sewage from the chemical plant "Navoiazot" (Navoi-nitrogen), where the main contaminating components are acids, ammonium, nitrates, cyanides, organic substances, and phenols.
According to the report of the Central hydrological and meteorological service of Uzbekistan, the quality of water in the Zarafshan River by the water pollution index (WPI) is of class IV, i.e., extremely polluted. The maximum concentrations the major indicators of contamination of water reservoirs with organic and biogenic substances in this area: phenols – 0,005 mg/L (5 times higher of maximum allowable concentration - MAC), petroleum products – 0,64 mg/L (12.8 MAC), nitrates – 0.202 mg/L (10.1 MAC). According to the data of the Central Hydrological & Meteorological Unit in 1998 concentration of these substances are mostly due to the existing antropogenic impact on the water flow. Perhaps, small running of the river water and an intensive contamination with organic and biogenic substances contribute to qualitative and quantitative shifts in the in the microbes cenosis of the Zaravshan River. The main indices of the water quality in the place where the chemical plant sewage enters the river are shown in Table 1.

2.1 Water Pollution in minor rivers and intestinal infections morbidity rate

Prevalence of hot and warm climate periods contributes to more intensive metabolism of water microorganisms in biochemical oxidation and transformation of organic substances. Under the conditions of active organic and biogenic pollution, the signs of disbalance in proportion and species contents of microorganisms appear in the water reservoir. This leads to increase of pathogenic bacteria number (Salmonella) in the range 16 – 33 MPN (most probable number) per liter and that of opportunistic bacteria up to 240 microbe bodies per liter of water with reduced content of the indicator micro-flora [2].

Identification of pathogenic microorganisms in the water (Salmonella, Shigella, etc.) indicates the potential danger of water reservoirs as the source of intestinal infections spread [3].

It is useful to cite also the findings of studies on correlation between the intestinal infection rate in population of Kattakurgan district situated in the basin of the Zarafshan River on the territory of the Samarkand province and application of pesticides. The studies revealed an obvious dependence of phosphamide use and the intestinal infection rates that demonstrates a considerable contribution of the amount of this organophosphate pesticides used in agriculture to the rate of typhoid-parathyphoid infections [4].

In the areas of intensive exposure of industrial, agricultural and household wastewater, the quantitative relation between the level of bacterial and chemical water pollution and the incidence of typhoid fever, paratyphoids and bacterial dysentery was established. It being closely connected with the level of the total pollution of the rivers Chirchic and Akhangaran in the Tashkent province below the places of sewage entry [5]. Intestinal infections distribution in months during long-term observation occurs irregularly and is characterized by elevation of high incidence of water-borne diseases (typhoid fever, paratyphoid fever and bacterial dysentery) in summer and autumn. This seasonal character of intestinal infections is in direct correlative connection with sharp deterioration of the water quality in the river Chirchik during summer and autumn period (r =0.82-0.89).

2.1.1 Analysis of the findings

The cases of water-borne diseases had been studied in the regions experiencing the effect of industrial and communal sewage to confirm the obtained findings of these diseases incidence in the population in connection with a chemical factor. The results of the study demonstrated the findings on the influence of the real chemical load on the incidence of intestinal infections among the population. To reveal the complex interrelationship between the dynamics of the population morbidity with intestinal infections, the quality of water and the conditions of water consumption by the population, we have carried out the multiple correlative and regressive analysis of materials of long-term studies (1992-1998). The results of examination of the water from the river Zarafshan were mathematically processed by the chemical and bacteriologic indices of priority importance. To establish the inner complex interrelations between the dynamics of the intestinal infection rates in the population, the quality of water in the established ranges of observation and the conditions of water using, we had performed the multiple correlation and regression analyses. The strongest connection was found out between the rate of typhoid fever and the indices of water supply of population (r =0.77-0.99). The same is true for the connection between the quality of water supply and incidence of dysentery (r=0.72-0.92). As for paratyphoid, other salmonellosis, viral hepatitis and acute intestinal diseases, no quantitative dependence of long-term dynamic of their rates on the level of bacterial and chemical indices of the water-source was revealed. The data on centralized and non-centralized water supply have been also mathematically analyzed (Table 2a,b).

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Table 1: Mean Annual Pollutant Concentrations in the Zarafshan River near Navoi, 1991-1998

Pollutant	Mean annual pollutant concentrations							
	1991	1992	1993	1994	1995	1996	1997	1998
BOD	0.80	1.27	1.20	1.24	0.90	0.89	0.82	1.43
COD	18.8	23.5	21.9	19.9	19.8	19.9	18.49	16.9
Ammonia	0.27	0.72	0.23	0.16	0.14	0.15	0.11	0.16
Nitrates	2.01	2.37	1.51	2.24	3.95	5.81	6.31	9.02
Nitrites	0.053	0.046	0.035	0.019	0.087	0.10	0.104	0.08
Fe(III)	0.03	0.05	0.05	0.1	0.04	0.07	0.06	0.08
*Copper (II)	2.4	2.9	4.4	3.3	2.5	2.56	2.3	2.3
*Zinc (II)	4.0	4.1	3.5	4.0	4.6	3.33	2.3	4.2
Phenols	0.004	0.003	0.001	0.002	0.003	0.0041	0.003	0.001
Oil products	0.07	0.03	0.03	0.04	0.04	0.052	0.03	0.1
*Chromium	7.0	3.7	4.2	4.1	1.8	1.99	2.9	5.8
SAS	0.03	0.05	0.08	0.07	0.05	0.024	0.04	0.04
*Alpha-HCH	0.073	0.022	0.003	0	0.006	0.008	0.001	0.0
*Gamma-BHC	0.044	0.013	0.004	0	0.006	0.005	0.001	0.0
Fluorine	0.46	0.35	0.50	0.39	0.32	0.34	0.22	0.31
Salinity	1203	1424	1233	1600	1141	1335	1477.9	1201.7

Source: State Hydrological & Meteorological Unit
(*) - values are given in micrograms

Table 2a: Correlative connections of the water supply & water quality indices in the Zarafshan River basin with the rate of population morbidity by of typhoid fever, paratyphoid, and dysentery

Indices of Water supply & Water Quality	Intensive indices of morbidity		
	Typhoid fever	Paratyphoid	Dysentery
Provision with centralized water supply	-0.96	-0.33	-0.92
% of tests of water from water-pipes with the coli-index over 3	0.92	0.67	0.79
Provision of population with de centralized water supply	0.99	0.71	0.92
Results of culture analysis of pathogenic enterobacteria from the river water (%)	0.82	0.53	0.77
Coli-index of the river water over 5000 (%)	0.81	0.68	0.84
Ammonia (mg/l)	0.93	0.73	0.86
Nitrates (mg/l)	0.77	0.80	0.72
Phenols (mg/l)	0.93	0.68	0.87

Table 2b: Correlative connections of the water supply & water quality indices in the Zarafshan River basin with the rate of population morbidity by viral hepatitis, salmonellosis, and acute intestinal infections-AII

Indices of Water Supply & Water Quality	Intensive indices of morbidity		
	Viral hepatitis	Salmonellosis	AII
Provision with centralized water supply	-0.20	-0.47	-0.33
% of tests of water from water-pipes with the coli-index over 3	0.39	0.56	-0.56
Provision of population with de centralized water supply	0.20	0.47	-0.53
Results of culture analysis of pathogenic enterobacteria from the river water (%)	0.21	0.39	-0.20
Coli-index of the river water over 5000 (%)	0.22	0.41	-0.26
Ammonia (mg/l)	0.26	0.42	-0.39
Nitrates (mg/l)	0.21	0.32	-0.26
Phenols (mg/l)	0.28	0.4	-0.40

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2.2 Modeling of the interrelation of morbidity with intestinal infections and quality of water and conditions of water consumption

On the basis of modeling the interrelation of the population morbidity with intestinal infections (dependent variables) with the quality of the river water and conditions of water consumption (independent variables), we have obtained multi-factor mathematical models. Comparison of calculated (by the levels of regression) and real morbidity rates of typhoid fever and bacterial dysentery showed a high prognostic ability of the obtained equations: 75%- 86% of coincidence of the results by equations 1and 2.

The values of the regression coefficients in these equations demonstrate approximately similar dependence of the population morbidity rate of typhoid fever and dysentery on intensive chemical and bacteriological pollution of the river Zarafshan and indicate greater influence of the corresponding indices of the river water on morbidity rates for these nozologic forms of intestinal infections.

The regression equation for calculation of expected in future level of morbidity with typhoid fever depending on the total pollution of the river Zarafshan looks like follows:

$$Y = 232,3 + 0,732 * X1 - 2,3 * X2 + 2,621 * X3 + \quad (1)$$

$$2,631 * X4 + 1,23 * X5 + 0,676 * X6 + 1,261 * X7,$$

Y – intensive indices of the population morbidity with typhoid fever,
X1 – samples of water from the water-pipes with the Coli-index over 3(%),
X2– provision of the population with centralized water supply (%),
X3 – Coli-index of the river's water over 5000 (%),
X4 – results of culture analysis of pathogenic bacteria from the river's water (%),
X5 – ammonia (mg/l),
X6 – nitrates (mg/l),
X7 – phenols (mg/l).

The regression equation for expected changes of morbidity rate of the population with bacterial dysentery was obtained as

$$Y = 555,6 + 4,67 * X1 - 5,6 * X2 + 1,935 * X3 + \quad (2)$$

$$8,347 * X4 + 39,85 * X5 + 27,962 * X6 + 6,731 \times X7,$$

Y- intensive indices of the population morbidity with bacterial dysentery,
X1- X7 – independent variables as in (1).

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Conclusions

Application of models allows to obtain theoretically expected changes of the population morbidity rate of typhoid fever and bacterial dysentery in the territory under study which depend on bacterial and chemical pollution of the water source under the same sanitary conditions. This, in its turn, would allow to evaluate properly the ecological and epidemiological situation in the region and to develop a scientific basis for the decision-making in order to prevent appearance of water-borne diseases through elaboration of targeted and effective water-protection measures.

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