

Influence of Adverse Ecological Factors on the Incidence of Malignant Neoplasms

*Izimbet Turdimambetov*¹, *Amet Madreymov*², *Lorant Foldvary*³, *Medetbay Oteuliev*^{1,*},
*Murat Kurbanov*², *Kamila Utarbaeva*¹, *Kuatbay Bekanov*⁴,

¹Karakalpak State University, Geography and Hydrometeorology Department, 230 112, Nukus, Uzbekistan

²Karakalpakstan Medical Institute, 230100, Nukus, Uzbekistan

³Obuda University, Alba Regia Technical Faculty, Institute of Geoinformatics, 8000, Szekesfehervar, Pirosalma str.1-3, Hungary

⁴National University of Uzbekistan, Cartography Department, 100174, Tashkent, Uzbekistan

Abstract. An analysis of the leading sanitary-ecological factors of the environment affecting the incidence rates among the population of the Republic of Karakalpakstan in 2009-2018 found that between the indicators of the primary incidence of malignant neoplasms and water samples of open reservoirs that are not standard in chemical composition, strong direct correlations in the Northern ($rx_y = 0.89$) zone, average direct correlations in the Western ($rx_y = 0.67$) and Central ($rx_y = 0.57$) zones were established. Similarly, strong connection was found in the Chimbay ($rx_y = 0.73$) district, moderate correlation in Nukus ($rx_y = 0.44$) and Ellikkala ($rx_y = 0.66$) districts. The moderate correlation of the dynamics of malignant neoplasms with indicators of chemical pollution of tap water in the Chimbay ($rx_y = 0.33$) district, well water in Kanlykul ($rx_y = 0.32$) and atmospheric air in the city of Nukus ($rx_y = 0.41$) was revealed and in the Republic of Karakalpakstan ($rx_y = 0.39$). The solution to the problem lies in providing for the population of the selected districts with centralized drinking water that meets the state standard.

Keywords: malignant neoplasms, open reservoir, primary oncological incidence, primary incidence rate, South Aral Sea region.

1 Introduction

At Karakalpak State University, together with the Medical Institute of Karakalpakstan and the Republican Center for Sanitary and Epidemiological Welfare (abbreviated RC SEW; former abbreviation RC SSES) a research is being carried out to study and assess the most important environmental pollution in the context of cities, regions and conditionally allocated zones, to determine their impact on human health, as well as identify the most contaminated areas, and to identify risks which may lead to diseases.

At the end of the 20th century and at the beginning of the 21st century, as a result of a sharp reduction in the water flow from the Amudarya and Syrdarya rivers into the Aral Sea,

* Corresponding author: medetbay.oteuliev@gmail.com

the actual disappearance of the Aral Sea, the ecological balance was disturbed in the Aral Sea region, the external environment was degraded, an extreme condition for people's habitation arose [1, 2, 3, 4].

Polluted atmospheric air, soil and water serve as a source of pollution of plant and livestock products, later used by the population as products of food [2, 3, 4,5].

One of the diseases that needs to be studied in connection with harmful ecological factors in the Republic of Karakalpakstan (hereinafter: RK) is malignant neoplasms (hereinafter: MN).

The purpose of this study is to identify and evaluate the leading sanitary-ecological factors of the environment that affects human health and appears on incidence level of malignant neoplasms among the population of cities, districts and conditionally allocated zones of the RK.

2 Data

The data for the study was f-12-health reports from the Health Institute of the Ministry of Health (hereinafter: MH) of the Republic of Uzbekistan (hereinafter: RUz) and the Ministry of Health of the Republic of Karakalpakstan, the results of studies of the laboratory complex of the Republican Center of the State Sanitary and Epidemiological Surveillance (hereinafter: RC SSES) of the MH of the RK for 2009-2018.

The dynamics of the incidence of MN with a diagnosis for the first time (incidence per 100 000) in the RUz and the RK, tends to decrease slowly (Table 1).

Table 1. Incidence rates (intensive incidence rates) per 100 000 population

Years	Uzbekistan	Karakalpakstan
1991	76.2	79.0
1995	68.5	63.1
2000	71.7	65.2
2005	63.7	66.1
2010	67.7	67.3
2015	67.7	69.6
2018	71.0	67.2

According to the statistical reports of oncological dispensaries, in 2010 in the RUz, intensive incidence rates for malignant neoplasms amounted to 67.7 (per 100 000 population; from now on the unit of incidence is not indicated but considered to be "per 100 000 population"), among rural residents 79.0 cases, among women 73.4 cases. In 2018, these values were 71.0, 82.6 and 82.9, respectively.

Breast cancer was the No. 1 form of MN in RUz in 2010 (11.9 cases), followed by stomach cancer (9.5) and circulatory and lymphatic tissue (8.6). In the RK, forms of MN (in descending order) are esophageal cancer (17.6), stomach cancer (10.4) and cervical cancer (10.0) [6].

In 2018, the form of oncological incidence in the whole RUz most often was breast cancer (10.9), followed by stomach cancer (5.7), and cervical cancer (5.0). In the RK in 2018, (in decreasing order) esophageal cancer has accounted for 12.0, stomach cancer 10.4, breast cancer 9.8 and cervical cancer 8.7 cases.

Compared with 2009, in 2018 in the RUz there was an increase in the incidence of breast cancer by 45.3%, in the RK by 22,5%.

According to the MH of the RUz [9], the incidence rates of MN in 2012 amounted to 156.0 in Kazakhstan, 114.0 in Kyrgyzstan, 72.8 in Tajikistan, and 64.5 in Uzbekistan.

In 2010, cancer mortality in Uzbekistan amounted to 34.5, while in Karakalpakstan 43.0, therefore the number of cases in the RK 24.6% above than the RUz average. And in 2018, cancer mortality in Uzbekistan amounted to 41.1, in Karakalpakstan 51.4, indicating again relevantly (25%) more cases in the RK.

The above regional differences in the primary oncological incidence and the excess of the incidence rate of Karakalpakstan over Uzbekistan prompted us to disclose their causes.

Given the uneven distribution of incidence by territory and by time, the territory of the RK is conditionally divided into 4 zones: the Western zone (Muynak, Kungrad, Kanlykul and Shumanay districts), the Northern zone (Takhtakupyr, Karauzyak, Chimbay, Kegeyli districts), the Central zone (Nukus city, Khodjeyli, Takhiatash and Nukus districts), and also the Southern zone (Amudarya, Beruni, Ellikkala and Turtkul districts).

In order to increase the visibility of the tendencies, the studied 10-year period is divided into 2 five-year periods: 2009-2013 and 2014-2018.

When studying the dynamics of the incidence of MN with a first established diagnosis, in the second five-year period compared with the first, an increase in the incidence rate was found in the Western (by 1,5%), Northern (by 1,8%), Central (by 7,6%) and Southern (5,1%) zone (Table 2).

Table 2. Primary incidence rates of MN in the RK per 100 000 population [7]

City, districts	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Muynak	84.2	77.5	96.9	79.0	92.1	87.8	83.3	66.2	78.2	74.0
Kungrad	67.7	67.2	48.5	64.4	63.7	59.6	66.0	65.5	66.7	55.6
Kanlykul	86.0	43.1	57.1	106.5	64.4	57.2	50.1	87.0	97.2	74.0
Shumanay	32.0	46.0	59.5	49.6	41.6	41.2	72.4	57.2	52.8	56.0
Western zone	67.5	58.5	65.5	74.9	65.5	61.5	68.0	69.0	73.7	64.9
Takhtakupyr	90.0	50.8	81.4	59.4	64.6	67.0	66.7	71.6	60.6	125.6
Karauzyak	48.8	57.3	80.4	65.4	56.7	54.0	75.1	59.1	79.3	72.8
Chimbay	69.1	82.8	74.9	70.3	65.9	67.0	82.5	93.5	92.7	74.2
Kegeyli	63.1	71.3	74.9	70.7	78.2	61.0	62.5	71.3	70.1	78.5
Northern zone	67.8	65.6	77.9	66.5	66.4	62.3	71.7	73.9	75.7	87.8
Nukus city	73.3	79.7	75.7	59.7	80.4	74.9	81.7	67.2	80.9	70.6
Nukus district	69.6	67.1	79.2	83.7	74.3	82.8	70.3	91.1	98.5	63.8
Khodjeyli	50.1	65.5	84.6	69.9	68.4	75.9	84.3	58.7	100.0	63.1
Takhiatash	64.7	60.9	65.7	78.2	x	x	x	x	79.7	62.2
Central zone	64.4	68.3	76.3	72.9	74.4	77.9	78.8	72.3	89.8	64.9
Amudarya	58.5	71.7	60.6	55.3	62.9	41.0	46.7	53.9	56.3	67.7
Beruni	68.1	74.2	67.9	62.6	62.8	58.1	63.8	63.8	60.9	67.8
Ellikkala	41.5	59.5	43.2	21.2	61.8	45.8	66.9	52.5	74.0	57.0
Turtkul	65.0	52.6	53.1	45.9	85.4	76.1	64.7	85.6	84.5	59.5
Southern zone	59.4	65.0	56.0	47.0	69.1	55.3	60.5	64.0	68.9	63.0
RK	63.7	67.3	68.5	59.8	69.9	63.6	69.6	67.8	76.1	67.2
RUz	68.4	71.0	65.9	64.5	66.2	65.7	67.7	66.7	70.2	71.0

Note: x-Takhiatash was included in the Khodjeyli district

The average the primary incidence rate of MN for RK over the first five-year period (2009-2013) is 65.8. High rates were observed in Muynak (85.9), in Nukus (74.8), in Chimbay (72.6), in Kegeyli (71.6), in Kanlykul (71.4) districts and the city of Nukus (73.8). In the next five-year period, the regional (RK) average was 68.9; relatively high primary incidence rates of MN were recorded in Chimbay (82.0), Nukus (81.3), Takhtakupyr (78.3),

Muynak (77.9), Khodjeyli (76.4), Kanlykul (73.1) districts and in the city of Nukus (75.1) (Table 2). Relatively low primary incidence rates of MN were detected in the first five-year period in Shumanay (45.7) and Ellikkala (45.4) districts.

The highest incidence rates of MN were recorded in Muynak district (84.2, 96.9, and 92.1 in 2009, 2011 and 2013, respectively), in Kanlykul (86.0 and 106.5 in 2009 and 2012). The lowest rates were observed in Ellikkala district (21.2 in 2012) and in Shumanay (32.0 in 2009).

3 Tests and results

We presume that the dynamics of the level of oncological incidence for regions under similar living conditions, lifestyle and nutritional features should be similar; significant influences are exerted by harmful external environmental factors resulting from the Aral ecological disaster. Therefore, we attempt to connect the dynamics of the primary incidence of MN with the main harmful sanitary-ecological factors that formed in the South Aral Sea region with variations of chemical pollution of drinking water and atmospheric air (Fig. 2).

At the end of 2018, 62% of the population of the Republic was provided with tap water, the rest uses well water (mainly water from tubular wells) and water from open reservoirs.

First of all, we compared the levels of primary oncological incidence (Table 2) with indicators of non-normative water samples of open reservoirs by chemical composition (by hardness and mineralization) (Table 3).

The strength of the relationship between the primary incidence rates of oncological diseases (Table 2) and the indicators of water samples from open reservoirs, exceeding the maximum permissible concentration (MPC) of chemicals and indicators (Table 3) was analyzed for each zones and districts. As an example, the time series are plotted on Fig 1. for the Western zone of the RK.

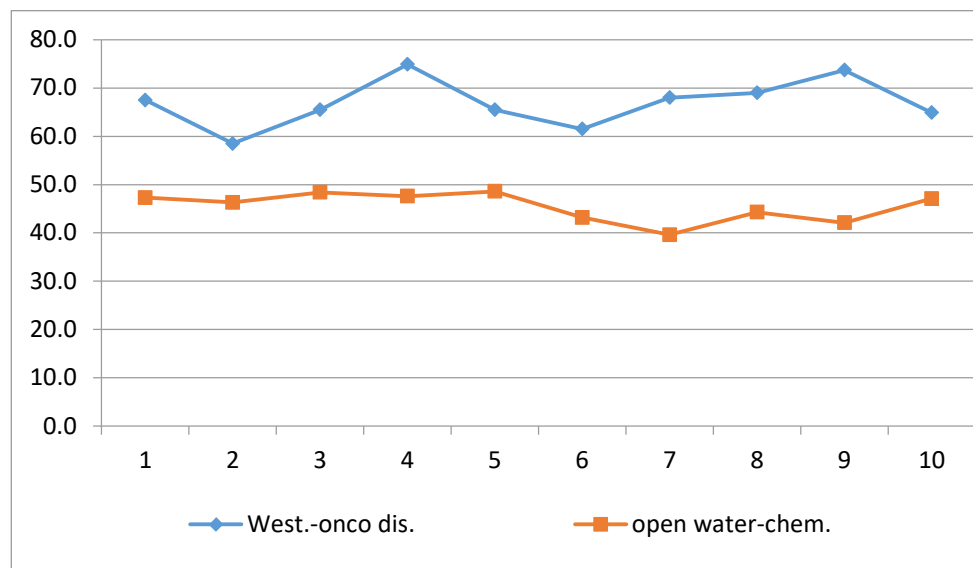


Fig. 1. The MN incidence indicators in the western zone of the RK per 100 000 population and % of water samples of open reservoirs with excess of the MPC of chemicals substances.

MAP OF THE PRIMARY INCIDENCE OF MALIGNANT NEOPLASMS IN THE REPUBLIC OF KARAKALPAKSTAN

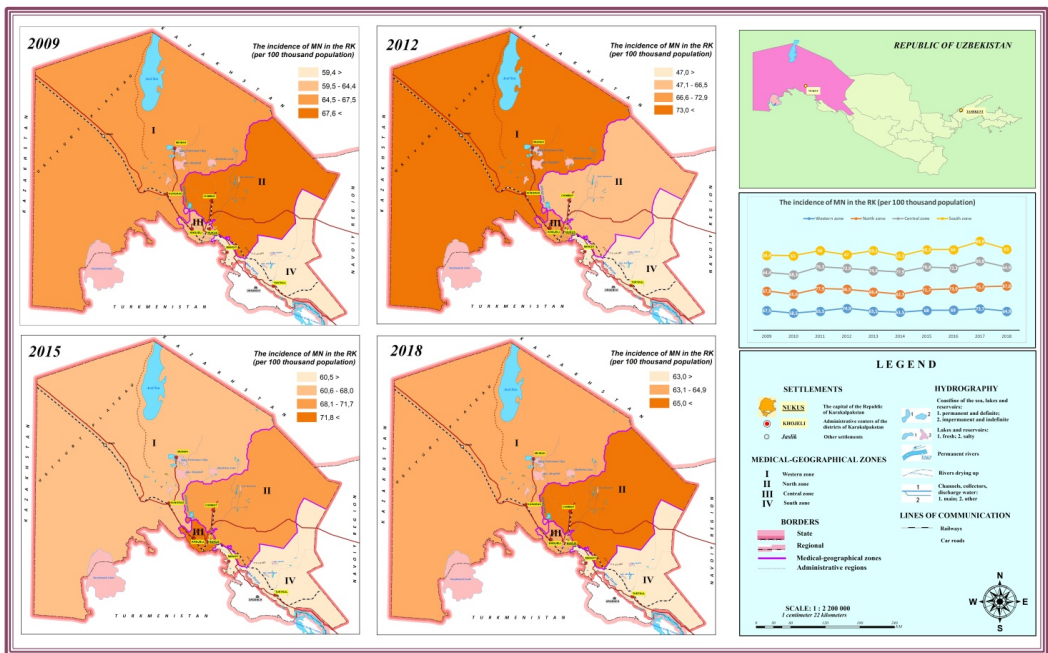


Fig. 2. Map of the primary incidence of malignant neoplasms

Table 3. The percentage of open water reservoirs samples, which found the maximum permissible concentration (MPC) of chemical substances and chemical indicators for the 2009-2018 [8]

№	Districts	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	Muynak	60.8	24.3	19.4	8.3	16.7	36.9	29.9	17.0	18.2	10.6
2	Kungrad	25.4	30.1	37.3	48.8	41.3	7.6	0.9	28.3	20.2	32.0
3	Kanlykul	73.5	100.0	100.0	100.0	100.0	100.0	96.4	100.0	100.0	100.0
4	Shumanay	29.4	30.8	36.9	33.3	36.2	28.2	31.3	31.7	30.1	45.8
	Western	47.3	46.3	48.4	47.6	48.6	43.2	39.6	44.3	42.1	47.1
5	Takhtakupyr	100.0	72.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	Karauzyak	46.0	42.9	31.0	35.8	31.2	23.3	36.8	22.5	26.0	27.3
7	Chimbay	4.8	15.3	13.6	6.3	1.5	9.6	19.8	18.8	12.6	15.5
8	Kegeyli	11.1	20.0	0.0	0.0	26.3	36.4	71.4	75.0	94.0	76.6
	Northern	40.5	37.7	36.2	35.5	39.8	42.3	57.0	54.1	58.2	54.9
9	Nukus city	23.1	12.2	37.5	27.3	31.4	24.7	41.9	40.8	45.1	41.4
10	Nukus district	75.0	50.0	77.8	52.2	100.0	77.8	13.0	95.0	100.0	84.3
11	Khodjeyli	20.7	28.9	12.9	10.3	14.3	21.9	30.2	31.5	49.5	51.4
12	Takhtatash	16.3	0.0	43.3	36.4	x	x	x	x	75.0	21.0
	Central	33.8	22.8	42.9	31.6	48.6	41.5	28.4	55.8	67.4	49.5
13	Amudarya	72.2	89.9	97.3	5.8	30.6	78.0	81.1	77.5	73.6	63.5
14	Beruni	69.0	51.0	82.0	83.6	90.3	59.1	63.3	78.0	26.7	69.0
15	Ellikkala	20.0	83.3	95.8	0.0	85.7	25.7	40.9	37.8	100.0	100.0
16	Turtkul	100.0	82.9	100.0	100.0	100.0	91.7	70.0	87.0	100.0	100.0
	Southern	65.3	76.8	93.8	47.4	76.7	63.6	63.8	70.1	75.1	83.1
	RK	41.9	39.4	43.5	31.3	38.3	48.7	45.4	55.8	47.9	49.9

The strength of the relationship between the curves on Fig 1. (and in other cases), correlation coefficient according to Pearson [10] has been determined. The calculation was carried out on a computer program Formulas. Though the time series is “short”, i.e. including 10 samples only ($k=10$), to decide on the dependence of oncological cases and water quality measures, a hypothesis test should be conducted. The hypothesis-test for correlation coefficient can be performed by a Student’s t-test with degrees of freedom $k-2$ [11], where the null-hypothesis is that the two time series are uncorrelated, i.e.

$$H_0: r_{xy} = 0 \quad (1)$$

For ‘large’ number of samples, it is known that

$$\bar{t} = \frac{r_{xy}\sqrt{k-2}}{\sqrt{1-r_{xy}^2}} \quad (2)$$

follows a Student’s t-distribution with degrees of freedom $k-2$. If

$$|\bar{t}| \leq t(p, k-2) \quad (3)$$

then the null-hypothesis should be accepted, thus the two time series are independent at a confidence level p . The values of t-distribution at $k-2=8$ freedom for probability of 0.8, 0.9 and 0.95 are 1.397, 1.806 and 2.306, respectively. Accordingly, the dependence can reliably be assumed, when the null-hypothesis is rejected, i.e.

$$|\bar{t}| > t(p, k-2) \quad (4)$$

Note, however, that the results may be distorted due to the small number of samples. According to [12], in case of small samples, the distribution may differ.

The correlation coefficient for the Western zone for 2009-2018 was -0.1488, for 2009-2013 it is 0.3843, and for 2014-2018 it became -0.3378. The indicator $\bar{t} = -0.426, 1.1774$ and -1.0151 , respectively for the 2009-2018, 2009-2013 and 2014-2018 periods have not met the criteria t , so for this case the hypothesis should be rejected. All the resulted correlations and values are listed in Table 4. In the Table those cells has been emphasized by green color, where correlation has been accepted: light green is used for cases accepted on 0.8 probability level (the value of t exceeds 1.397), darker green shows the cases, which are accepted on 0.9 probability level (the value of t exceeds 1.806), while the darkest green shows those cases, which could have been accepted on 0.95 probability level (the value of t exceeds 2.306).

The results in Table 4 suggest no systematic correlation by time or by location. The strong correlation in Chimbay is mainly a result of the strong correlation during the 2009-2014 period, which cannot be observed anymore. A notable (a quite unfavorable) feature is that in Muinak, Kalykul and in Amudarya there was no correlation observed in the 2009-2013 period, but it became relevant in the 2014-2018 period.

Then we compared the levels (incidence) of primary oncological diseases (Table 2) with the indicators of tap water samples, the percentage of which exceeded the MPC of chemical substances and indicators (Table 5).

Rationing of drinking tap water is based on the application of the State Standard of Uzbekistan (UzSS) 950-2011 “Drinking water. Hygienic Requirements and Quality Control” (SS-state standard) updated every 10 years. The district laboratories of the sanitary-epidemiological service measured the hardness, mineralization (dry residue) in the water sample. This dry residue in our regions mainly consisted of nitrates, sulfates and chlorides. No pesticide contamination of water and food has been detected over the past 10 years. They have ceased to be used in agriculture for 25 years.

The results of the comparison are shown on Table 6. In the Table light green is used for cases accepted on 0.8 probability level (the value of t exceeds 1.397), darker green shows the cases, which are accepted on 0.9 probability level (the value of t exceeds 1.806), while the darkest green shows those cases, which could have been accepted on 0.95 probability level (the value of t exceeds 2.306).

The levels of primary oncological diseases depended on chemical contamination (Table 2 and Table 5) at several locations in the Western, Northern and Southern regions during the 2014-2018 period. It is quite unfavourable situation as at most locations no strong correlation was observed before. As for the Central region, no relevant correlation was observed for the 5 year periods (apart from Khojeli during the 2009-2013 period), but the correlation seems to be convincing for the 10 year period (Fig.3).

Table 4. Correlation between the primary incidence rates of MN in the RK per 100 000 population (Table 2) and the percentage of open water reservoirs samples, which found the maximum permissible concentration (MPC) of chemical substances and chemical indicators (Table 3)

Zones, district	rxy (2009-2018)	\bar{t} (2009-2018)	rxy (2009-2013)	\bar{t} (2009-2013)	rxy (2014-2018)	\bar{t} (2014-2018)
Muinak	0.2471	0.7213	-0.0777	-0.1350	0.8213	2.4935
Kungrad	-0.2128	-0.6161	-0.2397	-0.4276	-0.3321	-0.6098
Kanlykul	-0.1785	-0.5131	-0.3261	-0.5975	0.6518	1.4886
Shumanai	0.2709	0.7961	0.6825	1.6174	0.1619	0.2842
Western	-0.1488	-0.4255	0.3843	0.7210	-0.3378	-0.6216
Takhtakupyr	0.3781	1.1553	0.6401	1.4431	NaN	NaN
Karauzyak	-0.2943	-0.8711	-0.7027	-1.7107	0.3244	0.5940
Chimbay	0.7331	3.0486	0.9429	4.9032	0.4969	0.9918
Kegeyli	-0.0029	-0.0082	0.2663	0.4785	0.6031	1.3096
Northern	0.5447	1.8373	0.3683	0.6861	0.6462	1.4666
Nukus city	0.0479	0.1357	-0.1278	-0.2232	0.1588	0.2786
Nukus district	0.4356	1.3689	-0.0196	-0.0340	0.5696	1.2003
Khojeli	0.2143	0.6205	-0.4818	-0.9523	0.1796	0.3162
Takhiatash	NaN	NaN	NaN	NaN	NaN	NaN
Central	0.4872	1.5779	0.6225	1.3777	0.2840	0.5130
Amudarya	-0.0230	-0.0650	0.5423	1.1180	-0.8874	-3.3341
Beruni	0.0364	0.1032	-0.9282	-4.3208	0.4736	0.9314
Ellikkala	0.6560	2.4582	0.7962	2.2793	0.5923	1.2733
Turtkul	0.0104	0.0293	0.2799	0.5050	0.1988	0.3513
Southern	0.5125	1.6880	0.5201	1.0547	0.6028	1.3085
RK	0.4109	1.2749	0.6506	1.4839	-0.2496	-0.4465

**MAP OF NON-NORMATIVE SAMPLES OF OPEN RESERVOIRS BY CHEMICAL PARAMETERS
 IN THE REPUBLIC OF KARAKALPAKSTAN**

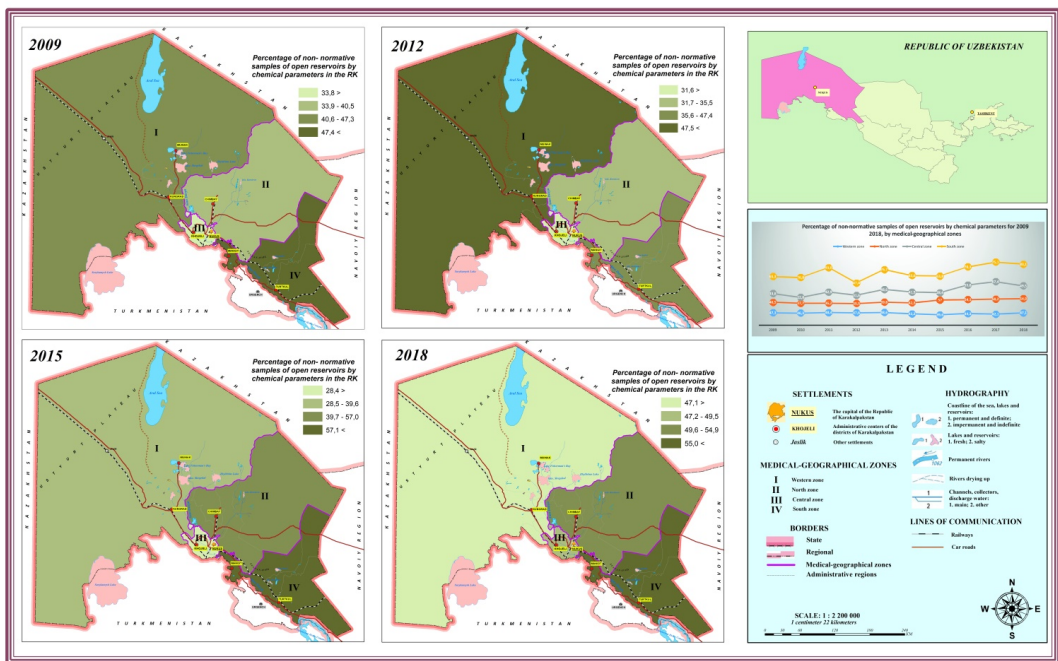


Fig. 3. Map of non-normative samples of open reservoirs by chemical parameters

Table 5. Percentage of tap water samples exceeding the MPC of chemical substances and indicators for the RK

Zones, districts	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Muynak	43.8	16.0	0.0	16.9	20.9	26.2	36.4	7.3	15.8	11.6
Kungrad	39.2	43.6	36.7	42.9	26.8	18.4	8.9	14.1	13.1	14.6
Kanlykul	53.8	33.3	50.0	28.2	63.2	60.9	54.8	51.5	47.0	51.5
Shumanay	29.3	21.5	25.1	29.3	35.4	34.4	37.3	27.2	21.2	29.0
Western	41.5	28.6	37.3	29.3	36.6	35.0	34.3	25.0	24.3	26.7
Takhtakupyr	13.4	7.1	11.2	23.5	30.7	29.9	13.6	18.2	9.9	16.7
Karauzyak	29.0	25.4	21.5	16.6	21.2	9.6	14.3	8.6	22.2	14.7
Chimbay	37.4	57.2	21.0	32.3	13.3	23.0	35.0	42.8	16.2	12.6
Kegeyli	16.1	11.4	3.8	0.7	12.1	12.7	20.5	6.5	7.2	20.4
Northern	24.0	25.3	14.4	18.3	19.3	18.8	20.8	19.0	13.9	16.1
Nukus city	37.8	1.1	20.8	6.1	30.5	29.8	20.2	14.4	24.1	34.5
Nukus district	31.3	8.3	32.8	11.0	12.3	12.9	10.2	32.4	51.5	33.4
Khodjeyli	75.9	51.9	40.4	19.5	29.6	29.3	16.6	21.8	26.8	52.7
Takhiatash	25.3	7.6	38.5	20.3	x	x	x	x	2.2	14.8
Central	42.6	17.2	33.1	14.2	24.1	24.0	15.7	22.9	26.2	33.9
Amudarya	18.6	36.1	24.0	0.0	26.6	33.9	31.6	33.3	37.8	43.1
Beruni	40.0	30.7	35.6	40.7	37.7	58.5	54.7	47.3	34.0	70.9
Ellikkala	34.9	25.9	33.3	5.2	15.1	12.3	19.6	12.2	10.4	21.4
Turtkul	31.3	15.9	39.2	22.6	25.9	37.3	29.7	18.5	14.5	19.6
Southern	31.2	27.2	33.0	22.8	26.3	35.5	33.9	27.8	24.2	38.8
RK	34.5	24.7	28.0	18.5	28.6	30.6	26.6	23.1	23.2	31.6

Table 6. Correlation between the primary incidence rates of MN in the RK per 100 000 population (Table 2) and the percentage of tap water samples exceeding the MPC of chemical substances and indicators (Table 5)

Zones, district	rxy (2009- 2018)	\bar{t} (2009- 2018)	rxy (2009- 2013)	\bar{t} (2009- 2013)	rxy (2014- 2018)	\bar{t} (2014- 2018)
Muinak	0.1244	0.3546	-0.3788	-0.7090	0.8378	2.6581
Kungrad	-0.0190	-0.0537	0.2168	0.3846	-0.5742	-1.2148
Kanlykul	-0.2995	-0.8878	-0.2257	-0.4013	-0.8216	-2.4960
Shumanai	0.0662	0.1877	-0.4028	-0.7623	0.2817	0.5084
Western	-0.2713	-0.7972	0.0440	0.0762	-0.6590	-1.5176
Takhtakupyr	-0.0523	-0.1482	-0.1448	-0.2535	-0.0036	-0.0062
Karauzyak	-0.0932	-0.2647	-0.5817	-1.2387	0.8832	3.2617
Chimbay	0.3272	0.9792	0.7644	2.0532	0.4125	0.7843
Kegeyli	-0.2162	-0.6262	-0.3501	-0.6474	0.0173	0.0300
Northern	-0.5922	-2.0789	-0.7309	-1.8549	-0.4897	-0.9728
Nukus city	0.2195	0.6363	0.2793	0.5039	0.0153	0.0265
Nukus district	0.4684	1.4997	0.0350	0.0606	0.5422	1.1177
Khojeli	-0.5487	-1.8562	-0.6561	-1.5060	-0.3651	-0.6793
Takhiatash	NaN	NaN	NaN	NaN	NaN	NaN
Central	-0.3329	-0.9984	-0.3419	-0.6302	-0.4195	-0.8003
Amudarya	0.1331	0.3798	0.8940	3.4550	0.8616	2.9406
Beruni	-0.2626	-0.7698	-0.8148	-2.4346	0.4826	0.9543
Ellikkala	0.0116	0.0327	0.3306	0.6068	0.0366	0.0634
Turtkul	-0.1510	-0.4320	0.0975	0.1698	-0.2858	-0.5166
Southern	-0.0795	-0.2255	0.1921	0.3390	-0.6927	-1.6635
RK	-0.0425	-0.1203	0.4293	0.8232	-0.6836	-1.6222

Comparison of the levels (incidence) of primary oncological diseases (Table 2) with the indicators of well water samples exceeding the MPC in terms of chemical indicators (Table 7) is shown on Table 8. In the Table light green is used for cases accepted on 0.8 probability level (the value of t exceeds 1.397), darker green shows the cases, which are accepted on 0.9 probability level (the value of t exceeds 1.806), while the darkest green shows those cases, which could have been accepted on 0.95 probability level (the value of t exceeds 2.306).

According to the results, the correlation seems to be stronger by time in every district of the Western region, in contrary, when the average values for the Western region are analysed, the tendency is opposite: the correlation is stronger in the 2009-2013 period.

In the Northern region correlation at 0.8 probability level can be observed at several districts during the 2009-2013 period, which has been absent for the 2014-2018 period, apart from Karauzyak, where the correlation became notably stronger.

In the Central region there is an obvious correlation (at least at 0.8 probability level) for both 5 year periods, but it cannot be detected for the whole 10 year long time series.

Not any dependence in the Southern region of the RK has been observed.

Table 7. Specific gravity of non-normative well water samples by chemical indicators (in%)

№	Zones, districts	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	Muynak	100.0	100.0	98.8	97.8	97.7	80.7	94.2	99.0	100.0	100.0
2	Kungrad	31.0	42.2	40.0	33.8	21.8	40.0	23.2	38.0	21.6	47.0
3	Kanlykul	62.6	50.0	55.0	52.2	64.0	53.6	70.9	65.4	73.2	94.3
4	Shumanay	39.6	40.8	40.6	41.7	50.8	51.7	43.7	40.7	33.5	40.4
	Western Zone	58.3	58.3	58.6	56.4	58.6	56.5	58.0	60.8	57.1	70.4
5	Takhtakupyr	100.0	80.0	100.0	100.0	100.0	99.2	99.2	100.0	100.0	99.4
6	Karauzyak	54.1	33.8	33.6	34.4	50.3	53.8	93.2	87.8	93.1	92.8
7	Chimbay	34.4	34.9	25.9	25.5	16.5	16.2	25.5	22.2	11.2	19.5
8	Kegeyli	40.5	42.0	13.2	8.9	16.7	38.8	69.0	35.9	46.9	55.6
	Northern Zone	57.3	47.7	43.2	42.2	45.9	52	71.7	61.5	62.8	66.8
10	Nukus city	89.9	82.6	95.0	100.0	98.9	99.7	95.7	100.0	99.7	99.4
11	Khodjeyli	72.6	86.5	92.4	92.1	69.4	84.8	92.9	80.6	70.3	85.2
	Central Zone	81.3	84.6	93.7	96.1	84.2	92.3	94.3	90.3	85	92.3
13	Amudarya	88.7	76.2	55.9	44.8	57.7	54.0	68.6	65.1	67.2	56.3
14	Beruni	58.6	57.1	80.5	69.0	54.2	72.5	65.1	58.0	51.6	92.4
15	Ellikkala	88.2	76.6	82.8	26.2	34.3	27.5	33.8	45.0	37.2	72.6
16	Turtkul	100.0	100.0	100.0	90.9	100.0	78.6	63.7	80.0	100.0	100.0
	Southern Zone	83.9	77.5	79.8	57.7	61.6	58.2	57.8	62.0	64.0	80.3
	RK	63.1	60.6	60.5	49.5	54.4	46.5	60.5	59.9	55.0	67.2

Note: there are no wells in Nukus district and Takhtiatash

4 Conclusions

The present investigation has made use of spatial and statistical analysis tools, so establishment of an analytical relation between the causes of high mortality from MN and the mentioned environmental factors would require further studies.

According to Tables 4, the strong relation between the incidence rates of MN in the RK per 100 000 population (Table 2) and the percentage of open water reservoirs samples, which found the maximum permissible concentration (MPC) of chemical substances and chemical indicators could have been established for the 10 year (2009-2018) period in Ellikkala and Chimbay. In both cases the correlation is stronger in the first half of the period (2009-2013). For the second period (2014-2018), strong correlation was observed in Muinak and Amudarya.

The correlation between the primary incidence rates of MN and the percentage of tap water samples exceeding the MPC of chemical substances and indicators (see in Table 6) was not convincing on 0.95 confidence level for the 10 year long period (2009-2013), but for the half periods, there have been relevant correlations in Amudarya and Beruni (2009-2013) and Muinak, Kanlykul, Karauzyak and Amudarya (2014-2018).

Table 8. Correlation between the primary incidence rates of MN in the RK per 100 000 population (Table 2) and the percentage of tap water samples exceeding the MPC of chemical substances and indicators (Table 5)

Zones, district	rx _y (2009-2018)	\bar{t} (2009-2018)	rx _y (2009-2013)	\bar{t} (2009-2013)	rx _y (2014-2018)	\bar{t} (2014-2018)
Muinak	-0.2940	-0.8701	-0.3195	-0.5841	-0.7659	-2.0632
Kungrad	-0.5124	-1.6876	-0.2989	-0.5425	-0.8571	-2.8820
Kanlykul	0.1690	0.4849	0.1457	0.2551	0.2350	0.4187
Shumanai	-0.2400	-0.6993	-0.1301	-0.2273	-0.3058	-0.5564
Western	-0.1835	-0.5279	-0.7673	-2.0724	-0.2246	-0.3993
Takhtakupyr	0.3655	1.1108	0.6401	1.4432	-0.2296	-0.4085
Karauzyak	0.3497	1.0557	-0.7162	-1.7776	0.8024	2.3286
Chimbay	-0.1128	-0.3211	0.6338	1.4193	-0.0209	-0.0362
Kegeyli	-0.3897	-1.1968	-0.6064	-1.3208	-0.0464	-0.0804
Northern	0.4817	1.5549	-0.2714	-0.4884	0.6020	1.3058
Nukus city	-0.3438	-1.0355	-0.4819	-0.9525	-0.6054	-1.3175
Khojeli	0.1164	0.3315	0.6422	1.4512	-0.3801	-0.7119
Central	0.1234	0.3516	0.6840	1.6242	-0.6312	-1.4096
Amudarya	0.2027	0.5855	0.3835	0.7193	-0.0355	-0.0615
Beruni	0.1029	0.2927	-0.1043	-0.1816	0.5210	1.0572
Ellikkala	-0.0573	-0.1625	0.2468	0.4411	-0.0347	-0.0602
Turtkul	-0.1565	-0.4481	0.5204	1.0555	0.0920	0.1600
Southern	0.1262	0.3598	0.2029	0.3588	0.3247	0.5945
RK	0.2444	0.7127	0.3993	0.7544	0.1654	0.2904

As it can be observed in Table 8, the correlation between the primary incidence rates of MN and the percentage of tap water samples exceeding the MPC of chemical substances and indicators shows strong correlation (at 0.95 confidence level) only occasionally, in Kungrad and Karauzyak. A very favorable feature is that there is no correlation at all in the Southern region of RK.

Since the small number of samples distorts the results, also lower confidence level should be considered. At 0.8 confidence level, the correlation between primary incidence rates of MN and non-normative water samples of open reservoirs by chemical parameters (Table 4) and also for the tap water samples (Table 6) was established at several districts and regions of the RK. Therefore, it is reasonable to search for a dependence analytically as well. The results for the well water samples (Table 8) are not that convincing, but as open reservoirs may more properly reflect the actual water quality (as in open reservoirs the water is more homogeneous due to the diffusion of the chemical particles than in the water supply system), the source of the dependence is worth for an analytical investigation.

All in all, the results obtained allow us to conclude that the higher the proportion of non-normative water samples, i.e. chemical contamination of water in open reservoirs and non-normative samples of tap water and atmospheric air in specified districts, the higher primary malignant oncological incidence rates. The solution to the problem of the consumption of contaminated water by the population for drinking purposes is to maximize the coverage of the population of the allocated districts with centralized water supply and bring the quality indicators of the tap water supplied to the population in accordance with the state standard. Our results can contribute to planning the reduction of the pollution of

the environment, providing a measure for a differential approach for specific territories of the RK.

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