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Hygienic significance of high colour of drinking water after its primary disinfection by the use of chlorine-containing compounds for the population health of Mirny, the Republic of Sakha.**N.V. Frank, O.A. Uschkareva, N.A.Shainova, A.P.Gusev, L.S.Borhonova**

Summary. The article is devoted to the burning problem of high colour of drinking water after its primary disinfection by the use of chlorine-containing compounds. Statistic data testify to evident influence of residual colour of drinking water and by-products of chlorination on the health of people in Mirny, which results in carcinogenic effect and pregnancy failure. It is shown that the primary disinfection method aimed at reduction of colour of water is inadmissible.

Key words: drinking water, colour of water, disinfection by the use of chlorine-containing compounds, the population health.

Colour is a natural quality of water determined by humic substances which appear in the soil as a result of microbiological destruction of organic compounds and due to synthesis by soil microorganisms of its new forms coming out from soil to water. The number of these substances is influenced by geological conditions, waterbearing formation, the soil character, swamps and peat bogs in the basin of rivers. To measure the level of colour a chromium-cobalt scale imitating the colour of natural water is invented, and the colour of water is measured in degrees. Water can be considered as almost colourless only if its colour is not visual and is no more than 20 degrees, exactly this index is used in the state standard on drinking tap water.

For a long time the hygienic significance of colour of drinking water has been based only on aesthetic views without taking into consideration its possible injurious effect on the population health [3]. Scientific works and data of social and hygienic monitoring have proved the interdependence of indices of residual colour of drinking water and the content of chlorination by-products, which represents a certain risk for the health of people [5]. In scientific researches [4] it has been proved that there is evident interdependence of indices of residual colour of drinking water and the content of chlorination by-products, which represents a certain risk for the health of people. High colour of water (from 45 till 180 degrees) is a pre-condition for formation in water after its chlorination of such chlorine-derived compounds (such as chloroform) which have carcinogenic and mutagenic effects. A direct evident correlation with high coefficient ($r=0.96$) between cancer death rate and the colour of drinking water has been proved [8].

The research of reproductive function of women has shown that the most cases of pregnancy failure and difficult births happened to women living in cities which consumed drinking chlorinated water with high residual colour of 45-190 degrees. To the most informative proofs of connection between pregnancy failure and quality of drinking water one should refer the number of spontaneous abortions. The direct correlation between colour indices and the number of spontaneous abortions is established with coefficient equal to 0.78, which probably is explained by the fact that pregnant women are hypersensitive to drinking water containing the complex of contaminants and, first of all, chlorine-derived compounds. Besides, twofold increase of the frequency of chromosome derangement on the basis of micronucleus test has been registered among children with multifactorial pathology [1,5,4,8].

In order to prove that high colour of water is the reason of formation of chlorine-derived compounds which have carcinogenic effect and cause pregnancy failure the research has been made on the following issues: household water supply, methods of water processing, the analysis of statistics on cancer diseases, pregnancy failure and death rate in Mirny city, the Republic of Sakha [2].

For the household water supply in Mirny the Irelyach water storage basin is used. The characteristic features of the surface basin are little capacity of reservoir, small flowage, permafrost soil, long ice period, water-logged grounds neighbouring the basin, supply from river and surface run-off. Hydrochemical regime of the water storage basin predetermines the regional peculiarities of chemical water composition [6]. In its perennial form water, used for household water supply from the basin, is characterized by low salinity, high permanganate water oxidizability and colour, low turbidity factor and insignificant content of suspended material, which is typical of water storage basin in the North with its vast water-logged territories in the permafrost region.

According to the laboratory research made by “The center of hygiene and epidemiology in Mirny region, the Republic of Sakha” the average annual rate of colour of water in the basin varies from 140 to 230 degrees. The complex of water-purifying system in Mirny carries out a five-phase scheme of water purification. At the first stage water filtration is made by means of drum filter. At the second stage water disinfection by sodium hydrochloride is made with the help of water electrolysis method and water is decolourized by primary chlorination. The third stage is coagulation. The fourth phase is flocculation. The fifth stage is water clarification through contact clarifiers.

Over a period of time from 2005 till 2009 the improvement of sanitary-chemical indicators of drinking water has not been registered. The number of special tests remains high – 71,2%, generally conditioned by high indices of colour 100% (**table 1**).

The authors of the article made the analysis of cancer diseases and death rate over the period of 5 years in Mirny in comparison with Udachny where the indices of residual colour of drinking water deviate from hygienic norms insignificantly and an average annual index isn't higher than 30 degrees. It is necessary to note that over period of time from 1976 till 1987 on the territory of Sakha republic 12 underground nuclear explosions were made and 9 of them were made on the territory of Mirny region in Udachny city and settlement Aichal. Two of these explosions were emergent, “Chrystal” and “Craton-3”, and they were accompanied by radioactive waste release, which resulted in radioactive pollution of the environment. Therefore making comparative sickness rate assessment in Udachny one should take into account a stochastic effect in form of high level of oncology in this city. Judging from statistic data and comparative diagrams (**table 1, picture 1, table 3, table 4, picture 2, picture 3**) one can note a significant, almost twofold, increase of cancer diseases and death rate in Mirny in comparison with Udachny. The given data confirm the research results of other scientists and allow us to make a conclusion that high colour of water (from 45 till 220 degrees) is the reason of formation of chlorine-derived compounds with carcinogenic effect after the primary chlorination of water and the increased number of cancer diseases and death rate of Mirny population is connected with high colour of drinking water.

Statistic data on the number of spontaneous abortions and recurrent miscarriages of women of childbearing age in Mirny differ from the data in Udachny (**table 4, picture 4**). The number of spontaneous abortions of women of childbearing age in Mirny is 2-3 times greater than the analogous indices in Udachny, and is 10 times greater than the same indices in the Russian Federation. The research of reproductive function of women of childbearing age in Mirny has shown that the most cases of pregnancy failure and pathology in form of spontaneous abortions are caused by consuming drinking chlorinated water with high residual colour, which is explained by the fact that pregnant women are hypersensitive to drinking water containing the complex of contaminants and, first of all, chlorine-derived compounds.

Above mentioned information should be considered in the program of high quality water supply in Mirny, which needs to include a duplexed system of water supply [7]. Supply of drinking water conforming to norm by quality in respect of its colour [1] can be guaranteed by complex technological scheme without primary chlorination (**picture 5**).

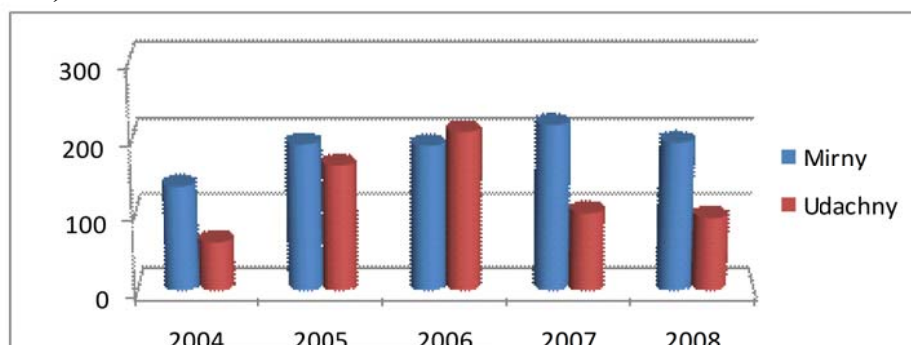
Table 1. Data of research on drinking water quality according to sanitary-chemical indices in Mirny.

Year	The number of water samples		
	total	Including special tests	Percentage of special tests
2005	421	300	71,25
2006	709	486	68,5
2007	1034	779	75,3
2008	1078	799	74,1
2009	505	360	71,2

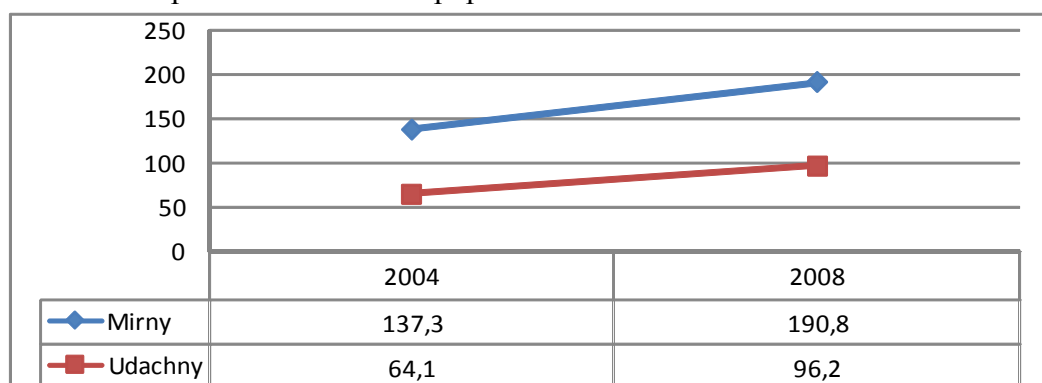
Table 2. Dynamics of cancer rate

Mirny city	2004	2005	2006	2007	2008
The number of sick persons	54	76	73	82	73
Index per 100 thousand population	137,3	193,2	191,5	218,5	195,8
Udachny city	2004	2005	2006	2007	2008
The number of sick persons	10	26	32	15	14
Index per 100 thousand population	64,1	165,7	209,6	102,7	96,2

Picture 1. Comparative dynamics of cancer sickness rate in years (per 100 thousand population)



Picture 2. Comparative dynamics of cancer sickness rate increase sickness rate per 100 thousand of population



Increase of cancer diseases in Mirny from 2004 till 2008 is from 137,3 till 190,8 per 100 thousand of population, while in Udachny it is from 64,1 till 96,2 per 100 thousand of population. Rate of growth of diseases in Mirny is 42,6%, while in the Russian Federation it is 6,7%.

Table 3. – Death rate caused by malignant neoplasms in Mirny in comparison with Udachny

The number of died	2004	2005	2006	2007	2008
Mirny	56	43	45	54	29
Udachny	10	9	12	4	6
Index of per 100 thousand of population					
Mirny	142,4	109,3	118,1	143,9	77,8
Udachny	64,1	57,4	78,6	27,4	41,2

Picture 3. Comparative dynamics of death rate caused by malignant neoplasms per 100 thousand of population

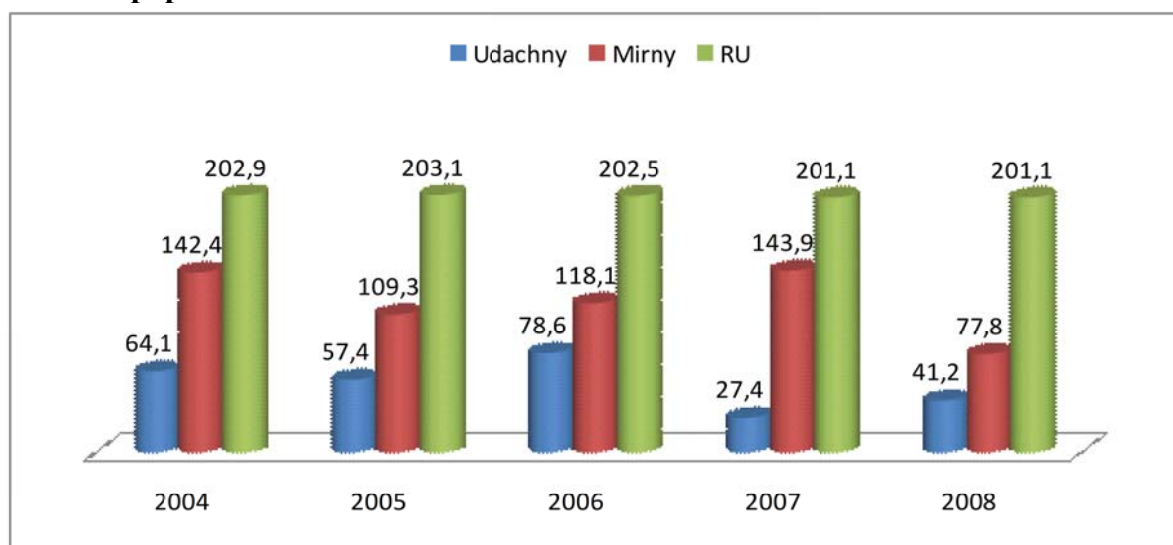
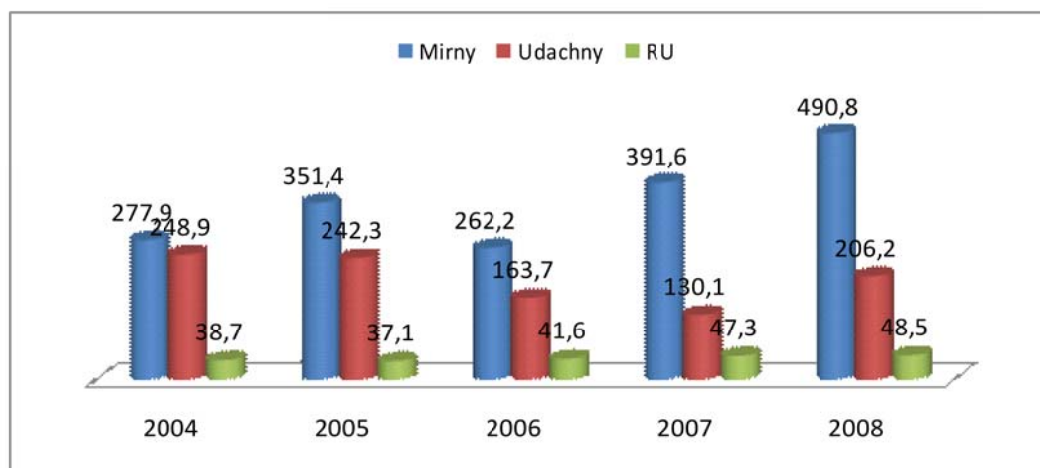


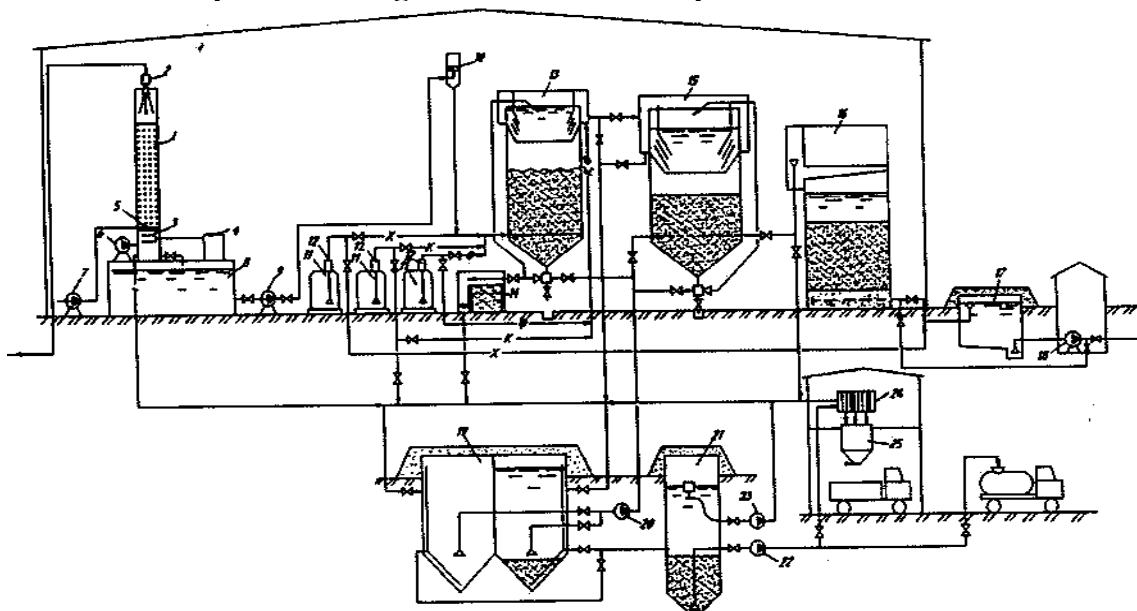
Table 4. Dynamics of spontaneous abortions of women of childbearing age in Mirny

The number of spontaneous abortions and miscarriages	2004	2005	2006	2007	2008
Mirny	106	134	100	147	183
Index per 100 thousand population	277,9	351,4	262,2	391,6	490,8
Udachny	38	37	25	19	30
Index per 100 thousand population	248,9	242,3	163,7	130,1	206,2
Russian Federation	55705	53207	59365	67279	68864
Index per 100 thousand population	38,7	37,1	41,6	47,3	48,5

Picture 4. Comparative dynamics of spontaneous abortions per 100 thousand of population



Picture 5. Complex technological scheme of water purification



The given scheme includes 9 units of different function. Unit 1 (position 1-7) is used for degasification, aeration, impurity oxidation by ozone-aerial mixture. Unit 2 (position 10-14) – the 1st stage of water clearing. Unit 3 (position 16) – water coagulation. Unit 4 (position 16) – water filtration. Unit 5 (position 17,18) – collection and storage of purified water. Unit 6 (position 11,12) – chlorination, coagulation, flocculation of water. Unit 7 (position 19, 20) – reagent purification, storage and recycling of rinsing water. Unit 8 (position 21-22) – sediment condensation and its delivery to dehydration and utilization. Unit 9 (position 24, 25) – utilization of water sediment.

Conclusion

Comparative analysis of cancer rate and pregnancy failure of women of childbearing age has shown a stable dynamics of increase of these pathologies and accordingly the physical impairment of population health of Mirny for the latest years. Prognosis will stay unfavorable if the old technological scheme of water purification is used and no measures are taken to improve the quality of drinking water according to its colour index.

Thus, the colour index of water for settlements of Mirny region of Sakha republic is at the same time the index of contamination by chlorine-organic compounds.



The research data testify to the necessity of providing the population with drinking water which has no more than 20 degrees of colour index in order to reduce the risks of damage to the population health by co-products of water chlorination.

A duplexed system of water supply without primary chlorination should be regarded as one of the variants of water supply system in Mirny.

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