Analysis of Parasitic Contamination in Wastewater at the Sewage Treatment Plant in the City of Yakutsk

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***Abstract*--Municipal-domestic wastewater containing propagative forms of bio- and geohelminths which drains into and contaminates the Lena river, represents a health and epidemiological safety hazard in the Sakha Republic.**

This paper presents the results of a study into the parasitic contamination in the sewage of the city of Yakutsk. Data show that in the collected wastewater taken prior to treatment, as well as in the sediments recovered from the grit chambers of the water treatment plant, 100% of samples were contaminated with eggs of the *Ascaris* and the *Diphyllobothrium* species. Even after UV irradiation treatment, viable roundworm and tapeworm eggs were observed in 18% and 9% of samples, respectively.

We conclude that the wastewater desinvasion methods employed in Yakutsk are ineffective at fully eradicating the causative agents of ascariasis (roundworm) and diphyllobothriasis (tapeworm), and as such are insufficient for the purposes of epidemiological safety with regards to the aforementioned forms of helminthiasis.

Keywords-propagative helminth forms; diphyllobothriasis; contamination of the environment's objects; sanitary parasitological monitoring of wastewater; sanitary parasitological indices of water quality.

I. INTRODUCTION

Diphyllobothriasis risk is present in the Northern parts of the USA, in Canada, France, Denmark, Sweden, Holland, Finland, Germany and other countries. Infestation rate has been linked to the prevalence of rivers and lakes situated in temperate and cooler climates [1].

Up to 10 thousand cases of diphyllobothriasis are reported annually in Russia. At 16.8% of all cases of biohelminthiasis, it is the second most common parasitic worm infection after opisthorchiasis (79.7% of cases) [2].

Diphyllobothriasis is the primary parasitic worm threat in the Sakha Republic, responsible for 97.1% of biohelminth-caused infections. Data for 2016 showed a population-wide infection rate of 112.2 $^{0}/_{0000}$. This region occupies a leading position among the subjects of the RF with intensive incidence rates, such as Khakassia (103.56), Yamalo-Nenets District (54.83), Krasnoyarsk Territory (40.79), the Komi Republic (20.96) and Buryatia (15.78) [3]. Diphyllobothriasis is today the most widespread biohelminth infection in the northernmost parts of Russia, and presents a particularly potent public health issue for the Sakha Republic (Yakutia). Local epidemiological factors for diphyllobothriasis include anthropogenic water pollution and the traditional consumption of insufficiently cooked fish by the indigenous population.

Combating the spread of infectious diseases and safeguarding bodies of surface water from being contaminated by parasitic worm eggs and larvae requires effective sewage disinfestation treatment [4]. Modern water treatment infrastructure in large part succeeds in purifying water of mechanical detritus, chemical pollutants and pathogenic microorganisms. Improving water purification technology allows treatment facilities to reduce the concentration of particulates and organic matter, bacterial pollution to improve water quality. However, even the most efficient water cleaning technology cannot guarantee that all potential forms of invasion are removed from sewage [5].

The purpose of our work was to conduct - on the premises of the Yakutsk biological water treatment plant – an analysis of an ecological and sanitary parasitological monitoring of wastewater and its sediments for the existence and extent of contamination by helminth eggs.

Materials and methods. Data collection, sampling, and dynamic tests were conducted in 2015-2017, on the premises of the Yakutsk station for biological treatment of wastewater. Analyses of water samples and their sediments were carried out at the city's chemical-bacteriological laboratory *GUP Vodokanal* (where 'GUP' stands for 'state unitary enterprise'). In the course of the undertaken research study, the following methods were used - epidemiological, sanitary parasitological, and statistical.

II. Results and Discussion

The station for biological treatment of wastewater is a major ecological facility in the city of Yakutsk. Received municipal and domestic sewage waters undergo mechanical and biological treatments here. The uniqueness of the facility lies in the fact that, due to the severe climatic conditions of Yakutia and permafrost, all structures are located in closed heated rooms on a pile foundation.

Sanitary and chemical analyses of wastewater at the inlet and outlet from the treatment facilities are systematically carried out at the station, as well as the study of its sediments for 30 sanitary-chemical and 5 sanitary-parasitological indices.

The mechanical and biological treatment of sewage carried out at the Yakutsk biological treatment station allows to reduce the content of pollutants that exceed the maximum permissible concentrations to the normative values for organoleptic, mechanical and sanitary-chemical indices. At the same time, the results of laboratory studies of wastewater samples by parasitological indicators in 2016 did not meet the norms of SanPiN (Sanitary Rules and Norms) 2.1.5.980-2000 "Hygienic requirements for the protection of surface waters" (See Table I).

TABLE I. Contamination of Municipal-Domestic Drains and the Efficiency of Their Disinvasia at teh Biological Treatment Plant in Yakutsk (2016)

Eggs of helminths of the genus	Positive samples detected (% to those examined)				
	Water samples			*Sediment samples*	
	Before treatment (n=12)	*After biologi-cal treatment (n=12)*	*After UV[a] (n=11)*	*From grit chamber (n=3)*	*After filtering (n=5)*
Ascaris	100	33,3	18,18	100	100
Diphyllo-bothrium	100	16,67	9,09	100	80
Enterobius	16,67	8,33	0	0	0

[a]UV – ultraviolet irradiation

Our evaluation of the parasite contamination of Yakutsk's sewage showed that in water samples taken prior to treatment and samples of sediments taken from the grit chambers, 100% of such samples showed Ascaris and *Diphyllobothrium* egg contamination. Mechanical filtration of grit chamber sediments failed to remove any *Ascaris* and only reduced *Diphyllobothrium* contamination to 80%. Water samples treated with secondary mechanical filtration and activated sludge showed a reduction in contamination to only 33% (*Ascaris*) and 17% (*Diphyllobothrium*). UV irradiation reduced contamination levels further to 18.18% (*Ascaris*) and 9.09% (*Diphyllobothrium*).

Enterobius eggs were found in 17% of wastewater samples taken prior to treatment. Mechanical filtration and biological treatment (with activated sludge) reduced the contaminated samples down to 8%. After UV irradiation, no viable pinworm eggs were found.

Currently utilized methods of wastewater disinvasion treatment in Yakutsk do not guarantee eradication of parasites responsible for ascariasis and diphyllobothriasis.

Elevated parasite levels in wastewater carries a negative impact on the health and sanitation levels of the local water sources.

Monitoring water quality in water bodies of primary and secondary importance in the Sakha Republic (Yakutia) between 2010 and 2016 indicates the continuing ambiguity of the sanitary-parasitological situation in the region. According to the latest official data, 2016 vs 2015 recorded a jump of 67.5% (1.14 vs 0.77) in propagative parasitic forms in the water sources of the monitored zone.

Environmental conditions in large part explain the prevalence of helminth parasitism in a human population. Taking the extant data on helminth contamination of the local environment, N.A. Romanenko proposed a model of helminth-parasitic epidemiology reflecting mutual cause and effect between the quality of the environment and the incidence of parasitological infections [6]. Official health statistics are clear on the longstanding presence of diphyllobothriasis in the Sakha Republic. Cases are recorded every year. Infection rates (IR) varied from a maximum of 241 $^{0}/_{0000}$ recorded in 2006 to a minimum of 112.2 $^{0}/_{0000}$ in 2016. Over the studied period, the regional multiyear average rate (MAR) totaled 177.5 $^{0}/_{0000}$. Even though 2006 and 2009 both saw an increase in the rates of cases more severe than MAR (by 40% and 20% respectively), subsequent years witnessed a stable, secular decline in IR.

Epidemiological analysis of the regional population showed a reduction in rates of diphyllobothriasis infection by a factor of 2.1 over 11 years. However, comparing the regional MAR rate in the Sakha Republic (177.5) to the nationwide rate (6.4), a factor of 27.7, shows just how serious the region's helminth-borne parasitic problem still remains [3].

Of the Sakha Republic's administrative districts, a full 85% rate as unsafe with respect to diphyllobothriasis. As table 2 shows, ten districts are particularly hard-hit, with rates of the infection there registering anywhere from 4 to 7 times the regional average (See Table II).

TABLE II. Adminstrative Districts of the Sakha Republic (Yakutia) with Elevated Rates of Diphyllobothriasis (2016)

Name	Infection rates $^{0}/_{0000}$	Exceeds by a factor of	
		Sakha Republic average	*Russian national average*
Zhigansky	729,1	6,5	175,5
Kobiaysky	468,1	4,2	113,4
Olekminsky	440,9	3,9	105,3
Khangalassky	293,9	2,6	70,2

It should be noted that a fair number of researchers estimate the real rate of *Diphyllobothrium latum* infestation of the population to be on average 3 times the reported

number, since not everyone who is subject to this parasitic invasionwill get diagnosed [1].

Helminth eggs and larvae can survive for a long time in the environment such as bodies of surface water, and as such pose persistent threat of infection to definitive (or primary), paratenic (or intermediate), and additional hosts. The widespread availability of propagative forms of *Diphyllobothrium latum* in the surface waters of the region is evidenced by the infection rates of fish by larvae. In the middle regions of the Lena river, infection rates seen in pike (*Esoxlucius)*, burbot *(Lotalota)* and perch (*Percafluviatilis*) by plerocercoids of *Diphyllobothrium latum* reached 39.1, 67.0 and 17.7% at the infestation rate of 8.29±0.81; 16.2±2.51; 1.6±0.16 respectively [7].

Hotspots for diphyllobothriasis in the republic are concentrated in the drainage areas of the Lena, Kolyma, Indigirka, and Vilyuy rivers. Central Yakutia is host to a concentration of river-borne diphyllobothriasis with freshwater copepods serving as another vector. The coastal zones of lakes and reservoirs are a biotope for *Diphyllobothrium latum*, where the parasite matures through its coracidium and procercoid stages [8].

Our contention is that the regional prevalence of parasitic infection by *Diphyllobothrium* is the result of insufficient disinfestation of wastewater and its sediments.

The situation is made worse by the natural and climatic characteristics of Yakutia. Permafrost makes the construction of a traditional system of storm drains impossible in the city of Yakutsk. This in turn leads to surface runoff from the city finding its way to nearby aquifers, bypassing any existing water treatment facilities. The resulting conveyance of parasitic worm eggs and larvae greatly increases pollution of the Lena river with propagative parasite forms and aggravates the epidemiological threat.

We believe the reason for the insufficient ovicidal effects of UV irradiation, and also for the reduced effectiveness of UV lamps is the fact that their surfaces are rapidly dirtied when in use.

One of the possible environmentally friendly (non-chemical) solutions to the problem of UV lamps getting dirty, and also to the issue of cleaning wastewater of parasites is the simultaneous pairing up of ultrasound with UV lamps. Ultrasound keeps the lamps clean while simultaneously weakening the cell membranes of helminth eggs, making them more susceptible to destruction by UV irradiation.

III. Conclusion

Municipal-domestic wastewater contaminated with propagative forms of bio- and geohelminths are one of the factors responsible for the unfavorable sanitary-parasitologic condition of the Lena river, which in turn degrades the epidemiological conditions of the entire region.

The wastewater treatment methods currently employed at the Yakutsk sewage cleaning facilities do not guarantee a full elimination of the parasites responsible for ascariasis and diphyllobothriasis, and as such cannot guarantee the epidemiological safety of the water supply.

Evaluation of parasitic contamination and continued sanitary-parasitological monitoring of wastewater serve as the starting point for regulating the parasites' ecosystem by influencing the forms, which exist outside the host organism. In turn, this should allow a greater degree of sanitary control over surface water and the optimization of public health measures to combat water borne diseases and parasites.

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