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STUDY OF THE EFFECT OF DROUGHT ON THE ECONOMIC PARAMETERS AND HEIGHT DYNAMICS OF FABA BEAN VARIETIES INTRODUCED FROM ICARDA

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Global climate change in today's world has caused environmental degradation on Earth. Stress factors such as drought can affect the growth, development and productivity of many valuable crops, causing them to die. As one of the priority crops of the modern era, pulses are an important part of the food basket of the population. They are considered one of the most important alternative foods for meeting the daily protein requirements. The minimal use of animal protein and the widespread use of legumes, which are rich in plant protein, to replace it, leads to a reduction in the need for animal husbandry and the replacement of pasture with arable land. This helps to increase the area sown to legumes and other crops in the country. The faba bean is the cheapest food crop in the agricultural sector. The Turgoromer-1 instrument was used to determine the water retention capacity of the leaves of the horsebean varieties, and an infrared thermometer was used to determine the temperature change at plant level due to leaf transpiration. According to the results of the researches, the most promising varieties for the Absheron district are Rebeya 40; FLIP17-010FB; FLIP17-008FB; FLIP17-032FB; FLIP16-202; FLIP17-055FB; FLIP17-033FB; FLIP16-200; Misir-3. Height to 1st bean and plant length (r=0.854*), number of seeds and beans per plant (r=0.982**), bean length and number of seeds per plant (r=0.986**), grain weight per plant and plant height (r=0. 939*), grain weight per plant and number of seeds per plant (r=0.886*), grain weight per plant and bean length (r=-0.885*), grain yield and plant height (r=0.950*), positive reliable relationships between grain yield and number of seeds per plant (r=0.947*) and seed weight (r=0.885*), hundred seed weight and number of beans (r=0.894*).

Keywords: faba bean, cultivar, introduction, drought, water retention capacity, correlation

In our country the area sown with legume crops is almost insignificant. In order to increase the production of these plants in our country the main task is to create new productive varieties, mechanization of their harvesting and introduction in farms. Considering the diversity of soil and climatic conditions, it is necessary to create varieties of intensive type by selecting high yielding, disease resistant, mechanized varieties for the regions. Therefore, it is necessary to conduct ecological experiments of the faba bean plant in different regions of our republic, determine the superior characteristics and create by breeding suitable varieties for each region [1; 2].

More recently, simpler devices have been used to study drought tolerance. For example, the water-holding capacity of the leaves can be determined with the «Turgorometer-1», and the change in temperature at planting level due to transpiration in the leaves with an infrared thermometer. The drought tolerance of wheat and ramson has been evaluated using these devices [3]. Other methods are used to determine the weight of the root system of faba bean plants [4], grain yield, number of days to flowering, shortening of the growing season, etc. [5]. to nozzle permeability, product index [6]. The effects of drought on plant height and development, 100 seed weight, yield, chlorophyll content [7], root system and dry biomass of 40 faba bean samples cultivated under different conditions of water supply were studied [6].

Drought adversely affects plant growth and productivity. The resilience of plants to drought stress depends on their species and the degree of water loss. Some varieties can withstand drought stress because they use water more efficiently.

As a result of drought stress, oil, starch and carbohydrates, various oils, esters and synthesis of specific substances are impaired. Conversely, the amount of protein starts to increase. Literature reviews show that varieties grown in arid regions have higher protein and starch content than varieties grown in humid and irrigated areas. A high protein content increases the energy of the plant and reduces water loss, preventing plant mortality.

Materials and methods of research

Research work was carried out at Absheron experimental base of RICH in 2017-2018, 2018-2019, 2019-2020 and 2020-2021. The Apsheron Peninsula is located on the western coast of the Caspian Sea near the 40th parallel, N400 31.957' north latitude and E49052.525' east longitude, at 6 m above sea level. The area has hot and dry summers and mild winters. Average annual temperature in the area is 10-140C, the average temperature in January is -10C to 50C, and the average temperature in June is 21-270C. The average annual wind speed, typical for the region, is 4-8 m/s. Mostly northern winds dry out the soil, which increases the water demand of plants. The average annual precipitation on Apsheron Peninsula is 311 mm and is distributed unevenly. Most precipitation falls in autumn and winter and 10% falls in spring.

Soil in Apsheron peninsula is heterogeneous, mainly greyish-brown, poorly nutrient-depleted, alkaline and carbonatised. In terms of mechanical composition, soils are mainly clayey, sandy and poorly structured. The amount of total humus in arable layer is small and amounts to 1.27-1.32%. There are very few readily available forms of nutrients in the soil. In this soil type, the faba bean plant has a high demand for nutrients. Three nurseries containing 234 varieties of faba bean from the ICARDA International Centre were taken as research material. These include the International Ascochytosis Immunity Nursery (FBIABN), the International Brown Spots Immunity Nursery (FBICSN) and the International Mechanical Harvest Nursery (FBIMHN).

The International Classification of cultivated Vicia faba species, URBI of the All-Russian Institute of Botany, State Variety Testing of Agricultural Plants (1989), International Biodiversity Institute Methodology for determining a key set of characteristic and evaluation descriptors of faba bean (Vicia faba) – methodology were used to examine samples [7].

During the study, phenological observations of plants were made, and the resistance of samples to diseases and the dormancy period, the duration of the growing season of plants, height, position in the field, height of lowest pod –bearing node were evaluated. Height, number of grains in the pod, width, length of the pod, weight of 100 grains and yield were determined on a Turgonometer-1 device (Fig. 1,2).

As can be seen from the Table, drought stress had a negative effect on plant growth and productivity. The response of the varieties we studied to the drought was different. In this regard, the effect of drought on the design elements was different (Table 1). The drought-tolerant varieties had growing season of 210-217 days, height of 1 pod 10-40 cm, plant height 35.6-76.0 cm, number of seeds in pod 3, pod width 1.0-1.4 cm, length 6, 8-9.3 cm, yield varied from 60-471 g/m 2. The growing season for moderately drought resistant varieties was 211-217 days, the height of 1 pod 15-38 cm, plant height 31.3-76.3 cm, the number of seeds in a pod 3-4 pcs, pod size – width 1.0-1.3 cm, length 6.7-9.8 cm , the yield varied between 139-513 g/m 2 . In less drought-resistant varieties growing season 211-217 days, height of 1 pod 10-40 cm, height of the plant 31,3-86,3 cm, the number of seeds in a pod 3, pod width 1,0-1,3 cm, length 6,7-9,4 cm, the yield varied in the range 100-509 g/m2.

Fig. 1. Faba bean – Vicia faba.L (inflorescence)

Fig. 2. Faba bean – Vicia Faba.L (height measuring)

St. VIFA2-93 was moderately drought-tolerant according to the turgor index measured by the Turgorometer-1 in a local variety sample of 0.6. In the variety samples presented in Table 2, the drought tolerance was in the range (0.8-0.9). As a result of the research we can say that these varieties are suitable for the Absheron zone as drought tolerant and promising varieties (Table 2).

During the growing season, the height of the faba bean plant was measured during germination and emergence, vegetative, reproductive, pod senescence and stem senescence stages.

Table 1

Turgor and morphobiological indices of varieties
of faba bean belonging to different nurseries

Sowing №	Accession name	Drought-resistance	Growing season, days	Crop height, cm	Height of lowest pod –bearing node, cm	Pod length		Number of Beans per pod, pc	100 seeds weight, gr	Yield, gr/m^2
						Width, mm	Length, cm			
FBİABN										
1	Rebeya 40	0,9	210	65	25	10	7,2	3	88	296
14	FLİP16-190	0,5	216	61	25	10	7,7	3	100	423
16	Rebeya 40	0,4	217	70	31	12	7,8	3	73	420
17	FLİP17-007FB	0,5	217	74	10	13	8,8	3	90	390
18	FLİP17-045FB	0,6	217	68	15	12	7,7	3	90	454
19	Rebeya 40	0,5	217	63	25	13	8,3	3	88	475
20	FLİP17-016FB	0,6	217	75	20	11	8,5	3	80	431
29	St.VİFA-2-93	0,4	216	73	40	15	9,0	3	90	460
30	FLİP16-199	0,4	215	86	35	11	8,2	3	93	493
31	Rebeya 40	0,6	214	77	25	13	9,0	3	74	513
32	FLİP17-022FB	0,4	213	82	38	13	9,0	3	90	425
33	FLİP17-039FB	0,4	216	74	35	12	8,0	3	95	359
34	Rebeya 40	0,6	216	72	38	12	9,8	3	85	455
35	FLİP17-010FB	0,8	217	66	35	13	9,4	4	94	471
37	Rebeya 40	0,4	217	74	38	11	7,8	3	74	509
38	FLİP17-018 FB	0,7	217	73	28	11	7,8	3	87	305
44	FLİP17-008FB	0,9	216	70	26	13	8,0	3	82	359
36	VİFA2-93(st)	0,5	217	75	35	10	9,4	3	118	466
FBİCSN										
2	FLİP17-038FB	0,5	211	53	27	13	9,1	3	94	100
12	FLİP17-032FB	0,9	211	52	20	13	7,7	3	83	384
14	FLİP16-202	0,9	214	65	25	12	7,8	3	94	263
15	FLİP17-041FB	0,5	213	59	15	10	7,0	3	67	313
17	FLİP16-215	0,6	217	63	23	15	12,0	4	90	364
23	FLİP17-055FB	0,8	212	58	19	10	6,8	3	93	326
24	FLİP17-033 FB	0,8	210	54	20	11	7,7	3	74	399
26	FLİP17-043FB	0,7	217	52	25	13	6,7	3	86	366
27	FLİP17-045FB	0,6	217	53	20	13	8,5	3	94	354
30	FLİP17-035FB	0,6	217	54	20	14	7,5	3	100	371
31	Rebeya 40	0,7	217	43	25	20	8,8	3	94	100
32	FLİP17-031FB	0,7	216	54	20	13	9,0	3	100	213
34	Rebeya 40	0,6	215	56	20	13	8,6	3	95	213
39	FLİP17-059FB165	0,5	217	49	27	15	7,3	2	95	304
42	FLİP16-200	0,9	213	56	25	14	8,1	3	78	286
29	VİFA2-93(st)	0,4	217	60	20	10	8,5	3	122	353

End of table 1

Sowing №	Accession name	Drought-resistance	Growing season, days	Crop height, cm	Height of lowest pod –bearing node, cm	Pod length		Number of Beans per pod, pc	100 seeds weight, gr	Yield, gr/m²
						Width, mm	Length, cm			
FBİMHN										
1	ELİZAR	0,9	217	53	10	13	9,3	3	110	219
2	FLİP16-205	0,5	216	63	17	14	8,8	3	86	260
7	FLİP16-217	0,7	210	41	30	10	8,6	3	78	330
8	FLİP16-214	0,6	216	47	15	13	8,8	3	100	375
10	FLİP16-012	0,6	211	47	19	12	6,8	3	64	287
11	FLİP17-055FB	0,6	212	59	17	12	8,1	3	87	263
13	FLİP16-206	0,5	213	43	15	13	7,8	2	82	286
14	FLİP16-213	0,6	216	31	12	12	8,8	3	81	209
15	Misir-3	0,8	215	36	10	12	8,6	3	80	60
21	FLİP16-211	0,5	213	31	10	10	6,7	3	80	188
22	FLİP16-014	0,5	214	37	20	12	8,0	3	70	126
25	FLİP16-011	0,6	217	45	15	12	7,8	3	90	139
18	St.VİFA-2-93	0,6	217	31	15	10	6,8	3	95	199

Table 2

Drought tolerance of faba bean varieties

Accession name	T_1	T_2	T_2/T_1
FBİABN			
Rebeya 40	102	88	0,9
FLİP17-010FB	74	57	0,8
FLİP17-008FB	90	81	0,9
FBİCSN			
FLİP17-032FB	102	88	0,9
FLİP16-202	110	100	0,9
FLİP17-055FB	96	75	0,8
FLİP17-033 FB	102	78	0,8
FLİP16-200	80	73	0,9
FBİMHN			
Misir-3	106	91	0,8
St.VİFA 2-93	112	70	0,6

The observation shows that the resistance to Ashichytosis in the nursery (FBIABN-18) increased with plant height and varied between 65 and 104 cm. In St. VIFA-2-93, the plant height index was 87-88 cm. The lowest index was 65 cm in sample FLIP16-190 and the highest index was 104 cm in sample FLIP17-022FB.

The observation shows that resistance to brown spot disease in the nursery (FLIP18) gradually increased with plant height, the plant height varied between 47 and 76 cm. In VIFA2-93, plant height ranged from 62-71 cm. The minimum value was 47 cm for FLIP16-200 and the maximum value was 76 cm for FLIP17-038FB.

Table 3

Correlation between morphobiological parameters of faba bean varieties

	PH	HLPN	BPS	NSP	PL	100SW	SY
PH	1						
HLPN	0,854**	1					
BPS	0,071	-0,392	1				
NSP	0,923*	-0,534	0,982**	1			
PL	-0,713	0,755	-0,573	0,986**	1		
100SW	-0,251	0,245	0, 894*	-0,529	0,248	1	
SY	0,950*	-0,229	0,241	0,947*	-0,944*	-0,490	1

NOTE: PH – plant height, **HLPN –** height of lowest pod –bearing node, **NBP** – Number of Beans per pod, **NSP** –number of seeds per plant, **PL** –pod length, **100SW** – 100 seeds weight, **SY –** seed yield.

The height of the plants in the nursery suitable for mechanized harvesting (FLIP18) gradually increased, the height of the plants varying between 51 and 72 cm. The plant height of VIFA2-93 was 58 cm. The lowest value was 51 cm for FLIP16-211 and the highest was 72 cm for FLIP16-210 (Table 3).

A correlation between morphobiological indices in the studied faba bean cultivars was established.

Conclusion

1. 10 promising drought tolerant (0,8-0,9) variety samples were selected from the nurseries of the faba bean for various purposes, introduced from the International Breeding Center ICARDA, and used for creation of a source material for breeding.

2. During the growing season the height of the faba bean plants during the germination and emergence, vegetative, reproductive, pod senescence and stem senescence stages was measured in 12 varieties of resistance to ashichytosis disease in nursery (FBIABN), resistance to brown spot disease in nursery (FBIKSN) in 3 mechanized harvesting conditions in nursery (FBIIMHN) in 11 varieties was higher than in local varieties St.VIFA-2-93.

3. Rebeya 40; FLIP17-010FB; FLIP-008FB; FLIP-032FB; FLIP16-202; FLIP17-055FB; FLIP17-033FB; FLIP16-200; ELIZAR; It was determined that the samples of variety Egypt-3 are important as a donor form in future breeding work. The recommended optimum biometric dimensions of plants to create a model variety of horse bean with high grain yield under the irrigation conditions of Absheron : plant height 65-100 cm, height of lowest pod –bearing node 18-25 cm, number of beans per plant 25-35, number of beans in 1 plant 9-15 cm, length 8-10 cm, bean width15-19 mm, weight of 100 grains 80-130 grams..

4. The positive correlation was ovserved between height of lowest pod –bearing node (r=0,854*), number of grains per plant and number of beans per plant (r=0,982**), length of pod and number of grains per plant (r=0,986**), grain yield and height of plant (r=0,950*), grain yield and number of grains per plant (r=0,947*) and number of pods (r=0,894*).

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ARTICLE

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THE INCIDENCE OF COVID-19 AMONG HOSPITAL WORKERS AT THE BEGINNING OF THE PANDEMIC IN THE KYRGYZ REPUBLIC

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In Kyrgyzstan, the period when the COVID-19 pandemic began to develop from April to June 2020 was characterized by a high infection rate of medical workers. Almost 20% of the total number of COVID-19 patients were infected with the disease by employees of medical organizations. Data from the Department of Disease Prevention and State Sanitary and Epidemiological Surveillance (DDPSSES) were analyzed. Evaluation of the implementation of infection control measures in 9 hospitals where COVID-19 outbreaks were investigated among employees. We also conducted a survey of 289 employees of healthcare organizations who underwent COVID-19. The main factor of doctors ‘ infection was the low implementation of administrative measures (69%) aimed at organizing safety at the workplace and in places of residence in observatories, and protecting medical personnel (40%). The analysis of the data of the DDPSSES showed that the key risk factor is contact at work with colleagues (35%), since the work was not organized in such a way that employees who provide services to patients with COVID-19 did not overlap with employees who provide services to the rest of the population. Also one of the likely risk factors for infection for health workers there was a stay in observatories, after the completion of a 14-day shift, where medical workers were placed with negative PCR results, but on the 12-14 day of their stay there at the same time, from 5 to 17 medical workers from one observatory were tested positive for PCR. The survey showed that medical workers ‘ illnesses were related to their professional activities: 41% worked in hospitals providing COVID-19 treatment services; 30% of medical workers worked in observatories and mobile teams, and 13% – at patient sorting points in polyclinics and ambulance stations. SOPs were developed to eliminate these factors which prescribe procedures for organizing the safety of work and rest of medical teams in a pandemic COVID-19.

Key words: COVID-19, health workers, administrative measures of infection control, nosocomial infection, pandemic.

Introduction

According to WHO data, from January 2020 to May 2021, according to the most conservative estimates, from COVID-19 115 thousand doctors died. [1]

As of September 5, 44,316 cases of laboratory-confirmed coronavirus infection were registered in Kyrgyzstan, which is 681.7 cases per 100 thousand population. According to official statistics of the Ministry of Health of the Kyrgyz Republic, as of the beginning of September 2020, more than three thousand cases of COVID-19 were registered in the republic among medical workers, which is almost 20% of the incidence among the population. The highest rates were registered in Osh, Chui oblast, and Bishkek. In the city of Osh outbreaks of coronavirus infection were registered in the Osh Inter-regional Clinical Hospital (OIRCH), in The City Perinatal Center (CPC), in the children’s infectious diseases hospital of The Osh City Clinical Hospital [2, 3].

Materials and methods of research

The data of the Department of Disease Prevention and State Sanitary and Epidemiological Surveillance (DDPSSES) was analyzed from the beginning of the pandemic to 08.05.2020. Also, employees of the Republican scientific and practical Center for infection Control conducted an epidemiological study of COVID-19 outbreaks among employees in 9 hospitals (Bishkek, Osh, Jalalabad and Naryn regions). The implementation of infection control measures in these hospitals was evaluated during the epidemiological studies. Assessment sheets/tools were developed by the Republican Scientific and Practical Center for Infection Control staff to conduct an epidemiological survey [4-6]. Preliminary work was carried out to assess the Infection prevention and infection control in healthcare organizations, the availability of personal protective equipment for healthcare organizations, and other safety factors at the workplace of employees of healthcare organizations. Assessment sheets were tested in the epidemiological investigation of cases of nosocomial infection of medical workers and patients in multi-specialty hospitals in Bishkek, Osh, Jalal-Abad, Osh and Naryn regions (9 hospitals).

We also conducted a survey of 289 employees of healthcare organizations who had undergone COVID-19. Selection criteria for the survey are employees (medical and non-medical personnel) working in healthcare organizations of the Kyrgyz Republic who had laboratory-confirmed infection with SARS-

CoV-2 coronavirus in the period from March 1, 2020 to June 1, 2020. Statistical data processing was carried out using a personal computer in the Microsoft Office Excel 2010 program.

Results of the research and discussions

A preliminary analysis of the epidemiological reports of the Ministry of Health of the Russian Federation on the probable factors that influenced the infection of medical workers with COVID-19 on 08.05.2020 was carried out. The first cases of COVID-19 in healthcare organizations were detected as a result of testing for: when employees have clinical manifestations of respiratory infection or pneumonia; if they have a history of contact with a confirmed case of COVID-19; after completing a 14-day shift in the red zone, and before completing the observation period after leaving the red zone.

According to the Department of Public Health, 88% of cases of infection of medical personnel are related to the provision of medical services to patients with COVID-19 (Table). A key risk factor is contact at work with colleagues (35%), which indicates that administrative infection control measures related to the organization of safety at the workplace were not implemented For example, the work was not organized in such a way that employees who provide services to patients with COVID-19 did not overlap with employees who provide services to the rest of the population. Also, one of the likely risk factors for infection for health workers was staying in observatories, after completing a 14-day shift, or after unprotected contact (without appropriate PPE) with a patient with a confirmed diagnosis of COVID-19. Medical workers were placed in observatories with negative results of PCR diagnostics, but on the 12-14 day of their stay in the observatories, 5 to 17 medical workers from one observator simultaneously received a positive PCR test. The organization of proper accommodation of employees in the observatory is also included in administrative measures [7].

If on the date of 08.05.2020 there were 223 cases of diseases among employees of medical institutions, then as of 09.08.2020 the number of ill health workers was 2948. Figure 1 shows an analysis of the incidence of health workers in the Kyrgyz Republic by region, the largest proportion of cases occurred in Osh, which is associated with an outbreak of nosocomial infections in the Osh City Perinatal Center (OCPC).

An analysis of the data provided by the DDPSSES showed that nurses are more at risk of contracting COVID-19, this is due to a variety of reasons, primarily due to the fact that nurses are in more frequent and close contact with patients and are exposed to more exposure (fig. 2).

The developed assessment tools made it possible to conduct an initial assessment of the risk factors for the occurrence of ISM and signs indicating an epidemic problem, as well as to conduct an epidemiological analysis of the collected data that is unified for all healthcare organizations of the Kyrgyz Republic.

Figure 3 shows an analysis of the infection safety system assessment by functional infection control blocks in hospitals where COVID-19 cases were detected among employees and patients for the period from April to June 2020.

The number of cases of COVID-19 among employees of health organizations by the nature of their services to the population as of 08.05.2020.

Probable conditions of contact with COVID-19	Number of cases	%
Infection is related to professional activities	198	88%
Contact at work with colleagues with COVID-19	79	35%
Working in hospitals for COVID-19	40	18%
Working in observatories for contact people	34	15%
Working in mobile teams	27	12%
Working in isolation centers for people with suspected COVID-19	4	2%
Epidemiological investigation of COVID-19 cases	4	2%
Services for patients with COVID-19 in primary health care	7	3%
Other health services for people infected with COVID-19	3	1%
The infection is not related to professional activity	25	12%
Family contacts with COVID-19	6	3%
Sources not installed	19	9%
Total	223	100%

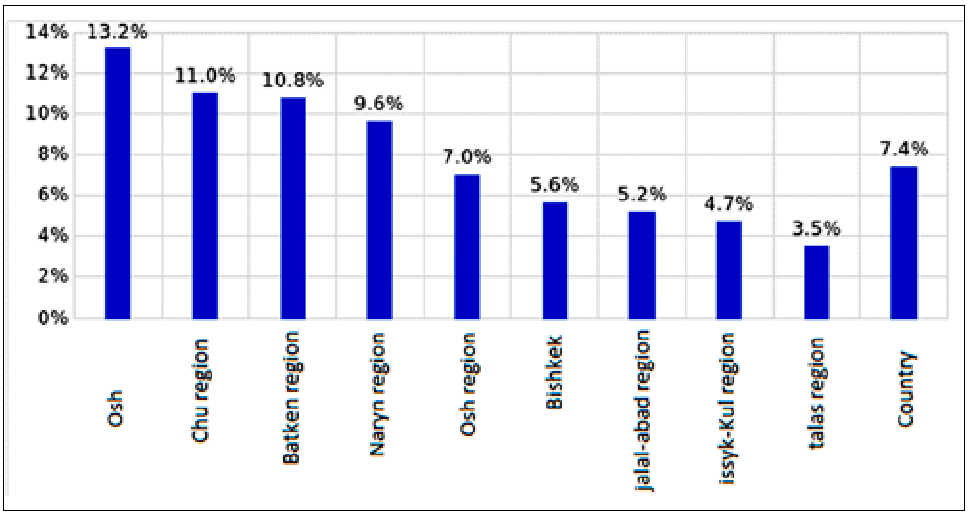

Fig. 1. Percentage of health workers infected with COVID-19 from the total number of cases by region (n=2948)

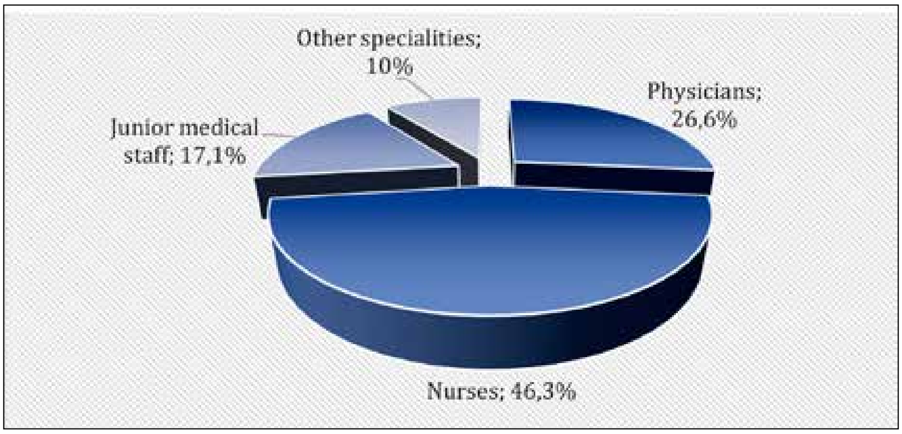

Fig. 2. Distribution of COVID-19 among medical personnel of institutions (n=2948)

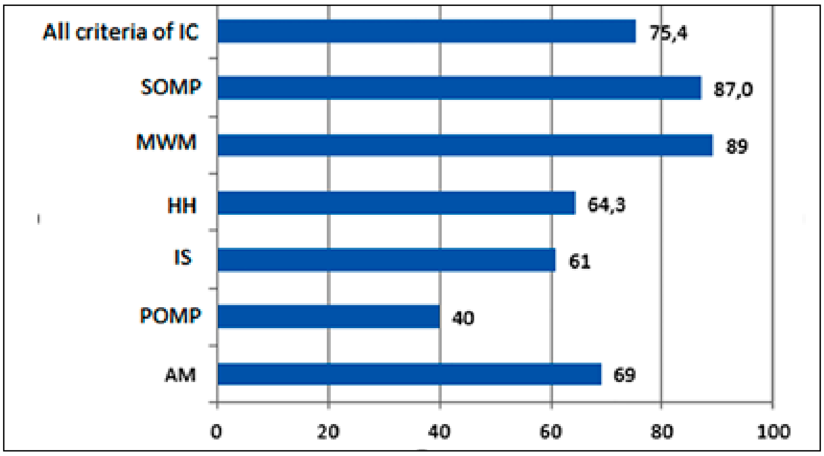

Fig. 3. Results of the analysis according to the Infection prevention and infection control criteria (average % of execution)

Note: AM – Administrative measures; POMP protection of medical personnel, AM component; ICET – infection control education and training; HH – hospital hygiene; IS – isolation system; SOMP – safety of medical procedures; SONI – surveillance of nosocomial infections; CSD – centralized sterilization department; MWM – medical waste management

As can be seen in Figure 3, not a single hospital provided the implementation of infection control measures corresponding to the high-level assessment (76-100%). On average, all activities in the studied hospitals were performed by 75.4 %, which corresponds to average level of infection control implementation (51-75%) However, this does not ensure the infectious safety of patients and medical personnel in a pandemic. A high level of implementation (corresponding to 76-100%) is observed only in the criteria of infection control: safety of medical procedures (87%) and medical waste management (89%).

At the same time, measures to ensure individual protection of medical personnel were least implemented (40%), this component is included in the criteria "administrative support of the infection control program/administrative measures" (AM). The activities carried out in hospitals meet the basic level (26-50%), which is insufficient to protect patients and medical staff.

As part of the study, 289 medical professionals were interviewed. Among the surveyed patients, 88% were female, with the maximum value in Naryn region (90%) and the minimum value in Chui region (50%). The proportion of males in different regions varied from 50% to 10%. This distribution reflects the overall distribution of health workers in the Kyrgyz Republic by gender, where the nursing profession is traditionally considered "female".

The average age of health workers in the entire sample was 45 years, the minimum age was 21 years, and the maximum age was 71 years. The median age was 47 years. More than half of the respondents (61%) are aged from 20 to 49 years. More than a quarter of respondents in the entire sample (30%) fall in the age group from 40 to 49 years, with the minimum value in Osh region (22%) and the maximum in Batken region (67%). The youngest group of patients is noted in the Chui region-with COVID-19, 100% were people under the age of 49 years. In the republic, almost 39% of ill health workers were over 50 years old, because in state health organizations, older employees predominate.

A little less than half of the respondents were average medical personnel (45%), doctors (33%) were the second largest number of sick employees of medical organizations, and junior medical personnel (nurses, distributors, laundresses, housewives, cooks, drivers, etc.) were slightly less than 22% (Figure 4). According to the eHealth Center, currently the number of nurses in the country is 2.5 times higher than the number of doctors. This sample reflects the situation with staffing in healthcare organizations, in addition, nurses are in closer contact with patients compared to other health workers and are at a higher risk of SARS-CoV-2 infection.

Of the 289 employees of medical institutions surveyed, 161 (56%) provided direct services to patients with a confirmed diagnosis/suspicion of COVID-19, among the remaining 128 health workers there are those who did not provide services to patients (engineer, procurement specialist, etc.), as well as those who work with patients with other diagnoses However, they may be potentially infected with SARS-Cov-2, without clinical manifestations.

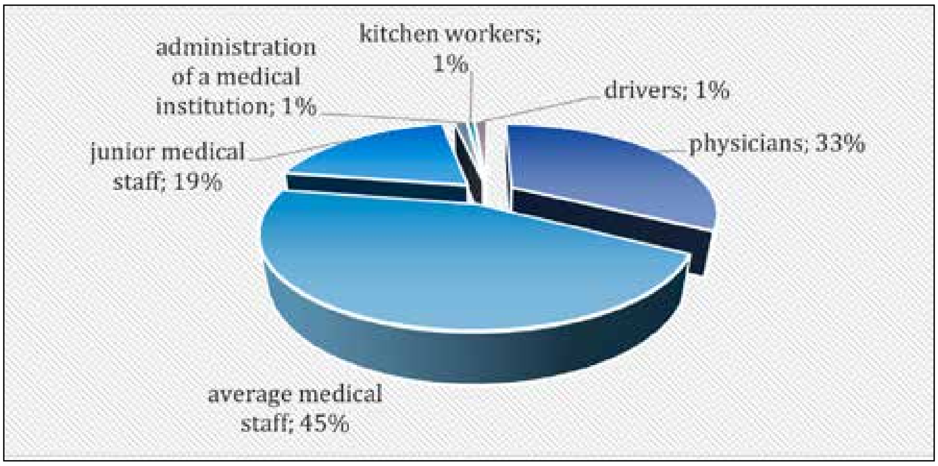

Fig. 4. Distribution of employees of healthcare organizations diagnosed withCOVID-19 by specialty, (n=289)

Among the affected physicians, the majority were attracted to work in hospitals repurposed to provide services for the treatment of COVID-19 (41%), 30% of medical workers worked in observatories and mobile teams, and 13% – in sanitary quarantine point, family medicine center, and ambulance stations.

Conclusion

Health workers are at high risk of infection due to the fact that they are engaged in work with dangerous working conditions performed in special conditions associated with the risk of infection.

To ensure safe working conditions, the heads of healthcare organizations are required to implement administrative measures. As shown by the assessment of the implementation of the infection control criteria (Figure 3), the implementation of administrative measures was insufficient-only 69%. And the implementation of the component on individual protection of medical personnel, as noted above, was very low – 40%. Therefore, SOPs were developed (Order of the Ministry of Health of the Kyrgyz Republic dated 8 May 2020, No. 297 “On approval of temporary standard operating procedures for healthcare organizations of the Republic during the COVID-19 epidemic”), where they were prescribed three levels of protection for medical personnel, depending on the level of risk of infection. Administrative measures to ensure safety for health workers in the workplace are also indicated. The main administrative measures are those that should be provided by the management of healthcare organizations:

• Provide access to personal protective equipment (PPE) for health workers involved in all services;

• Ensure availability and control of PPE stocks;

• Monitor and control PPE supply requests;

• Control the distribution of PPE from the organization's warehouses;

• Appoint a trained person responsible for the provision and use of PPE;

• Provide facilities for performing a Fit test for tightness of the respirator (to select the right shape of the respirator that provides a tight fit);

• Organize practical trainings for medical staff on prevention, diagnosis and treatment COVID-19;

• Responsible for the development and approval of internal regulations on prevention, diagnosis and treatment COVID-19.

• Arrange places for medical staff to put on and remove PPE. If possible, it is recommended to provide a full-length mirror for putting on PPE (for monitoring the putting on of PPE by health workers).

• Organize the work of personnel involved in providing health services to people with clinical symptoms COVID-19 and / or with a laboratory-confirmed case, with the provision of a full set of PPE, with conditions for rest. Organize sorting and redirection of patients.

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ARTICLES

UDC 681.5

DEVELOPMENT OF A CONTROL SYSTEM FOR THE PRODUCTION OF NICOTINAMIDE

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At present, the task of increasing the level of competitiveness of products manufactured by enterprises has become topical. And this is possible by improving quality and reducing waste. The implementation of this project will solve the problems of improving process safety, improving the quality of products and improving working conditions. Nicotinamide is an amide of nicotinic acid, a vitamin remedy. It has an anti-pellagric effect caused by vitamin PP deficiency. Vitamin B3 (pantothenic acid), as an integral part of coenzyme A, is involved in carbohydrate and fat metabolism, promotes the absorption of proteins, enhances peristalsis, and is associated with the functions of the thyroid gland and adrenal glands. They are added to premixes at premix plants, into feedstuffs at feed mills and in feed shops of farms, in accordance with the standards and technology for introducing vitamins existing in the Russian Federation. In Russia, there are no enterprises producing feed vitamin B3, the main suppliers from abroad are China, Switzerland, Germany and others. Automation of a technological process is a set of methods and tools designed to implement a system or complexes that allow you to control the technological process itself without the direct participation of a person or leave the right for a person to make the most responsible decisions. This project is aimed at the construction of a new enterprise for the production of feed vitamin B3.

Keywords: hydrolysis, automation system, control object, automation levels, parametric optimization, adjustable parameters

The production of feed vitamin B3 is a newly designed production, which will be part of the Azot branch of JSC UCC Uralchem, Berezniki, Perm Territory.

The design capacity of the production of feed vitamin B3 (nicotinamide) for the finished product is 0.13 t/hour (1000 tons/year). The number of hours of work per year is 8016 [1].

Based on the features of the technological process, taking into account regulatory restrictions and the requirements of regulatory documents, an assessment was made of the main technical solutions for process automation. Based on the results of the analysis of the evaluation results, it was proposed to use computer technology and automation at the level of process control systems, since at this stage of production there are such automation functions as regulation, signaling and blocking. The implementation of the technological process without computers will require a large number of technological personnel. To automate the technological process, it is necessary to select not only the means of grass–roots automation, but also the controller by selecting input / output modules. The controller is located in the control panel. Data from the controller must be transmitted to the operator's station, which will be responsible for monitoring all stages of production. At the operator's station, information about the production process is output.

The aim of the study is to analyze the technological process for the production of nicotinamide as a control object in order to select a control system.

Process hydrolysis of 3–cyanopyridine in the presence of sodium hydroxide. The duration of the stage is 30 minutes.

By supplying nitrogen from a receiver with a temperature T = 18÷36°C and a pressure P = 0.1 MPa at a maximum rate to the reactor with a stirrer pos. R–3 is supplied with a solution of 3–cyanopyridine. Further, with the help of squeezing with nitrogen from the receiver with temperature T = –52 ÷ +45 ° C and pressure P = 0.1 MPa, with a maximum speed into the reactor pos. R–3 is supplied with sodium hydroxide solution. The valves on the supply of raw materials are closed (to prevent reverse operation, since the release of gases begins from the reactor). The amount of sodium hydroxide is small compared to the amount of 3–cyanopyridine (in this case, it acts only as a catalyst that promotes the hydrolysis reaction of 3–cyanopyridine).

The reactor is heated through the jacket with steam at pressure P = 0.6 MPa and temperature T = 152 ÷ 165 °C to a temperature T = 100 ÷ –110 °C. Heating is done to initiate reactions. Two reactions take place in the reactor. The main one is the hydrolysis of 3–cyanopyridine to nicotinamide:

$$C_6H_4N_2 + H_2O = C_6H_6N_2O + Q$$

Secondary – the formation of sodium nicotinate with the release of ammonia:

$$C_6H_4N_2 + NaOH + H_2O = C_6H_4NNaO_2 + NH_3.$$

During the reaction, heat is released and the mixture is heated by about 10 ÷ 20 °C (maximum up to a temperature of T = 120 ÷ 130 °C). The released ammonia and evaporating water increase the pressure in the reactor pos. R–3.

The maximum allowable pressure is P = 0.5 MPa. The reactor is equipped with a line with gas phase withdrawal through a trap (expansion pipeline 740 mm long) – in case of an excessively violent hydrolysis reaction with the release of the main phase from the reactor (and subsequent discharge back).

The resulting nicotinamide and sodium nicotinate are dissolved in the mixture. Reactions are fast. The process can be considered completed within a few minutes.

After that, the valve for issuing the gas phase to the absorption unit is gradually opened to capture the released ammonia (until the pressure drops to atmospheric pressure within 20 minutes). The gas phase enters the heat exchange part, where it is condensed and cooled with the help of recycled water to a temperature of about 35 °C. Further, the gas passes through the nozzle part of the absorber, which is irrigated by a pump with a circulation solution of ammonia water with a temperature T = +30 ÷ +40 °C and a pressure P = 0.3 ÷ 0.6 MPa. Ammonia is absorbed by water with the release of heat. The purified gas phase is released into the atmosphere.

In the circulation circuit T–1–> V–2–> P–1–>C–1, the concentration of ammonia water is gradually accumulated. Upon reaching the ammonia concentration of at least 25% (monitored by the density meter), in the period between ammonia discharge cycles from pos. R–3, a solution of ammonia water is pumped out of pos. V–2 using a pump (about 1 time per day).

If the ammonia concentration starts to exceed 25% during the ammonia purge cycle from pos. R–3, water supply for irrigation is provided with a correction for the density of the solution. Pressure in the reactor system pos. R–3 is gradually reduced to atmospheric, and the temperature is down to ≈100 °C [1].

Analysis of the technological process as a control object. The production process of nicotinomide is continuous. Production is carried out in two shifts of 11.5 hours. In each shift, 2 cycles of preparation of nicotinamide are carried out. Cycle time ≈ 2 hours 50 minutes for shift 1, ≈ 3 hours 10 minutes for shift 2. The product is centrifuged and dried continuously for 11 hours shift.

The main apparatus in the technological scheme is a capacitive–type reactor with an R–3 stirrer. Therefore, we will consider it as an analyzed technological control object. In the reactor (Fig. 1), the reaction of hydrolysis of the initial substance of a solution of 3–cyanopyridine and a solution of sodium hydroxide into a solution of nicotinamide is carried out. The control object is multidimensional with distributed parameters. The purpose of the functioning of the object is to obtain nicotinamide with a given concentration [2–3].

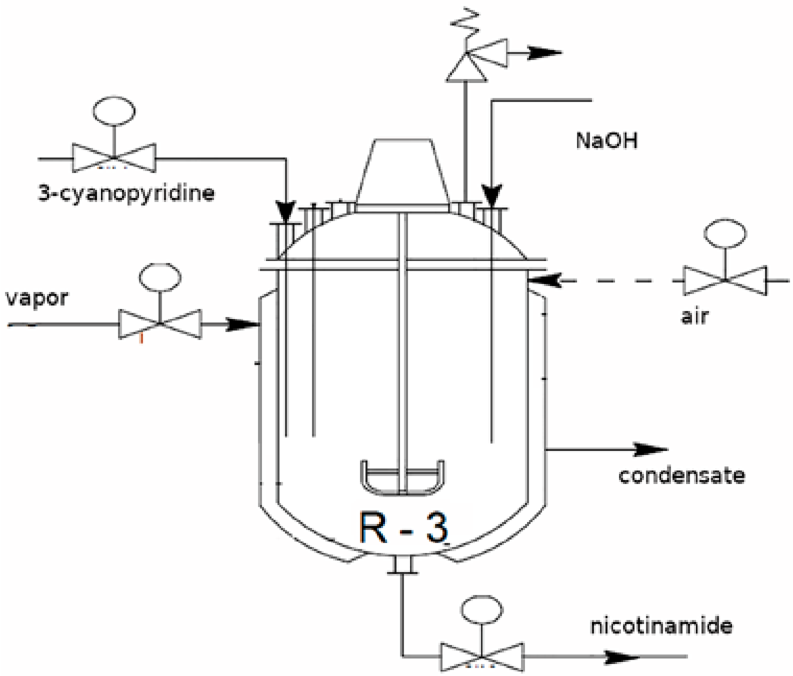

Fig. 1. Flow chart R–3

Consider the R–3 reactor temperature control loop:

– possible control actions – coolant consumption $F_{П}$, condensate consumption $F_{К}$, consumption nicotinamide $F_{пр}$;

– possible controlled disturbing influences – initial temperatures of the coolant $t_{ТН0}$ and initial substances t_0;

– possible uncontrollable disturbing influences – specific heat capacities of steam, initial substances.

The priority control action, to maintain the temperature at a given level, is the flow rate of the coolant through a control valve installed on the steam supply line to the reactor jacket.

Let us also analyze the control loop of nicotinamide concentration:

– controlled parameter – nicotinamide concentration;

– possible control actions – the consumption of 3–cyanopyridine, water, NaOH at the inlet to the reactor pos. R–3.

– possible controlled disturbances – composition 3–cyanopyridine and NaOH entering the reactor.

The priority control action, to maintain the concentration at a given level, is the flow of 3–cyanopyridine a control valve installed on the hydrochloric acid supply line to the reactor.

Results of the research and discussions

Analysis of the technological process as a control object showed that the process requires control and management of numerous parameters. In the production of nicotinamide, it is necessary to use computer technology and automation at the level of process control systems.

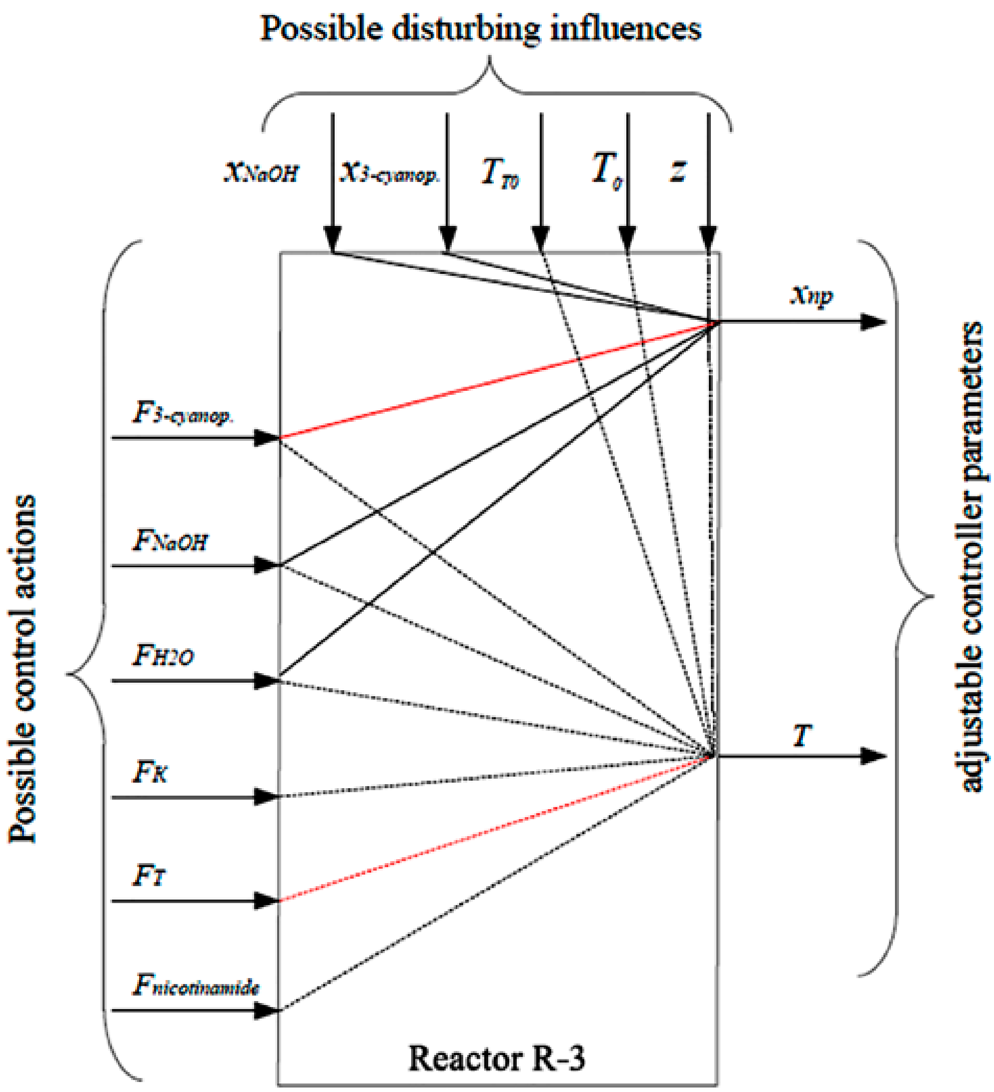

Fig. 2. Information scheme of the control object

The main purpose of using the process control system is to increase the reliability and safety of the process and its economic efficiency. The automation system in the production of nicotinamide should perform the following functions:

1. control functions – stabilization of technological parameters, ensuring a constant value specified by the regulations; implementation of blocking in case of emergencies and incorrect actions of operational personnel;

2. information functions: centralized collection and processing of information on the course of the technological process by reading it from measuring instruments and subsequent processing; providing the operator with information about the current values of technological parameters; warning and emergency light and sound alarms;

3. auxiliary functions: registration of the actions of operational personnel; archiving of received information.

To perform the listed functions of the process control system, the interaction of its following components is necessary: technical, software, information and organizational support, as well as operational personnel.

The technical support of the process control system is a set (complex) of technical means, which includes computing and control devices; means of obtaining (sensors), transformation, storage, display and registration of information; signal transmission devices and actuators [4-6].

For this process, at the field level of automation, it is necessary to select valves, sensors for level, temperature, pressure, composition. The unit is located in the production area in close proximity to the staff. The development of an automation system implies the integration of all parameters coming from the lower automation to the controller, located in the control cabinet and transmitting information for registration and display to the engineer's station.

The use of a software logic controller will reduce the risk of systems failure in the absence of human control, as well as reduce human participation in the process itself [7].

The staff of the production site has a position of a process engineer who is able to conduct operational control of the operation of the installation during the technological process, as well as to carry out sampling in various parts of the system to recheck the quality and chemical composition of the product. The system constantly monitors and records data from the lower level of automation. The data is accumulated and stored on the organization's server for 14 days. This measure allows you to analyze the operation of the installation in the absence of an engineer. Errors that occur in the operation of the installation are also stored on the server, but for 1 year. Data output and analysis is carried out from the engineer's station.

The decisions made ensure that the technological process for obtaining nicotinamide is carried out in accordance with the regulations with a minimum participation of personnel with a high degree of safety and productivity.

Conclusion

In the above study, a set of measures was developed and technical solutions were proposed to create a system for automating the production of nicotinamide, which made it possible to bring the level of safety in line with regulatory requirements and improve the quality of automatic control of an existing technological facility.

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ARTICLE

UDC 669-1

TO THE CHOICE OF TECHNOLOGY FOR PROCESSING LEAD DUST OF COPPER PRODUCTION: ANALYSIS OF METHODS OF DUST RECYCLING

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Among the most important priorities for the innovative development of the mining and metallurgical industry of Kazakhstan the industrial development of technologies for processing lead converter dust from copper and lead production is included. An important prerequisite for the organization of a separate production for the processing of lead dusts of Kazakhmys Corporation LLP and Kazzinc LLP is their multicomponent nature and value, which, along with non-ferrous metals, contain dual-use metals such as rhenium, osmium, selenium and others. The content of rhenium in Zhezkazgan dust reaches 120 g/t and serves as a source of its extraction into commercial ammonium perrhenate. To organize production for the processing of arsenic-containing lead dust of Kazakhmys Corporation LLP with the production of targeted products from them, cost-effective and environmentally friendly technologies are needed that increase the technical level of production of marketable and intermediate products. Finding a rational technology for their processing is one of the key problems that need to be addressed. An increase in the content of arsenic in dust (up to 10%) makes a challenge to the development of new highly efficient technologies for processing dust with the extraction of valuable metals. In this paper, based on a brief analysis of the known pyro- and hydrometallurgical methods of dust processing, the main problems and possible solutions are shown. The review allows us to develop a general concept and outline new directions for the complex processing of dust.

Keywords: lead dust, pyrometallurgical methods, hydrometallurgy, arsenic, lead cake, rhenium, precious metals

The research was carried out within the framework of grant funding from the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan for 2023-2025 in the priority area «Geology, mining and processing of mineral and hydrocarbon raw materials, new materials, technologies, safe products and designs» of the project AP19676951 «Development of resource saving, combined technology for the complex processing of multicomponent non-ferrous metallurgy dust with the production of marketable products.

One of the urgent tasks of the sustainable development of non-ferrous metallurgy in Kazakhstan is the organization of new industries (technologies) aimed at the complex processing of substandard intermediate products and recycling materials of copper and lead production with the maximum extraction of non-ferrous and associated valuable metals.

Among the most important priorities for the innovative development of the mining and metallurgical industry of Kazakhstan the industrial development of technologies for processing lead converter dust from copper and lead production is listed.

An important prerequisite for organizing a separate lead dust processing technology of Kazakhmys Corporation LLP is their multicomponent nature and value. Lead dust, along with non-ferrous metals (Pb, Zn, Cu, etc.), also contains a number of other strategically important dual-use valuable metals: rare metals, in particular, rhenium, osmium, selenium, tellurium, thallium, and others [1].

To organize production for the processing of lead dust of Kazakhmys Corporation LLP with the production of commercial and targeted products from them, cost-effective and environmentally friendly technologies are needed that would improve the technical level of production of commercial and intermediate products obtained from lead dust, taking into account known trends and new areas of technology development.

The importance of the task of organizing technology for the processing of lead dust is pronounced by the fact that recently, due to the complication of their composition (increase in the content of copper, arsenic, antimony, etc.), large volumes of them began to accumulate on the territory of factories and enterprises without finding proper sales. The lack of a rational technology for their processing is one of the key problems that need to be addressed.

An analysis of literature sources shows that attempts to rationally solve this problem are in the focus of attention of a number of large research institutes and organizations. However, the issue of processing lead dust, both copper smelting and lead production, remains open to this day [2-4].

In this article, based on the analysis of the results of the most promising pyro- and hydrometallurgical technologies for the disposal of dust from copper smelters and lead production, possible ways of their integrated use are shown, which have the greatest interest to the processing of lead dust of Kazakhmys Corporation LLP.

Pyrometallurgical methods of lead dust processing. Pyrometallurgical technologies for the processing of lead dust include the use of *smelting* and *roasting processes*.

Smelting processes. The most common is the method of melting dust in an electric furnace with sodium sulfate and soda in a reducing atmosphere [5]. For melting, a three-phase electric furnace with a power of 2300 kVA with a hearth area of 5 m^2 is usually used. The main smelting products are lead metal, cadmium fumes and sodium slag, accumulating zinc, arsenic, selenium and other trace elements. The average composition of the dust supplied for processing, %: 52-60 Pb; 11-19 Zn; 0.8-1.5 Cd; 5-6 S; Sb and As 0.1-1.5. The costs of soda and reducing agent are 20-25% and 8-12%, respectively. Exhaust gases (826-1026 °C) after the afterburner are fed to bag filters for cleaning.

Melting of granular dust from copper smelters is also carried out in electric furnaces in a reducing atmosphere at a temperature of 800–1000 °C [6]. The mixture contains, %: Na_2CO_3 – 1-5, coke – 4-8, slag – 10-25. Electrosmelting slag containing 25% Zn is processed by leaching. When processing a mixture of dust after copper removal (Pb – 60%; Zn – 15%) and converting dust (Pb – 80%, Zn – 4%), rough lead is obtained containing less than 5% impurities and slag (Pb – 5%) which has about 97% of the Zn contained in the initial dust. The efficiency of electrothermy can be increased mainly due to the high-quality preparation of the initial charge [7].

Fine lead dust from electric filters of the converter section of copper smelters in the Ural region, along with valuable components, contains a significant amount of arsenic [8]. For the processing of these dusts, a combined method is proposed, including their reduction smelting with sulfate lead cake, sodium sulfate, soda and coke. As a next step, arsenic is extracted from the matte-slag melt by aqueous leaching. Sulfide-alkaline aqueous leaching solutions are used as a reagent for the precipitation of arsenic from acid washing solutions of the sulfuric acid plant. When the solutions are combined, 98-99% As precipitates as As_2S_3. The advantages of this technology include: increasing the complexity of the use of raw materials by increasing the extraction of lead, bismuth and precious metals into rough lead; the possibility of joint processing of converter dust and sulphate intermediate products (cake, sludge); favorable conditions for the removal of arsenic from the technological process of copper smelters in the form of a low-toxic compound – arsenic trisulfide (As_2S_3).

The work [9] presents the results of factory practice of Mitsui Kinzoku (Japan) processing zinc dust briquetted with coal in a shaft furnace. During smelting, slag and matte are obtained in the sump, and rough zinc oxide (Zn – 50%, Pb – 20%) is obtained in the condenser, which is mixed with zinc slag, rolled and roasted in a tube furnace. The cinder, containing up to 65% zinc, is reduced in a vertical retort and rough zinc and rimming are obtained. Both products are returned to blast smelting.

In Poland, a method was proposed [10] for processing lead-containing dust from shaft copper-smelting furnaces and converters. The melting of the briquetted charge is carried out in a shaft furnace with the addition of fine iron scrap (3-12% by weight of dust), lime (2-6%) and converter slag (10-12%). In this case, rough lead (Pb 92-94%), matte (Cu 10-12%, Pb 10-25%, S 28-30%) and slag (Pb < 5 %, Cu ~1%) are obtained. The dust concentrates rhenium and other rare earth elements. Separation of liquid phases is carried out in a sump, and scrap iron is introduced to reduce the sulfur concentration in rough lead.

The technology for processing lead-containing dusts at the plant of Preussag AG Metal (Germany) [11] is an interesting one, which produces zinc by the New Jersey method. Processing is subjected to the dust of roasting sulfide zinc concentrates, %: 45-50 Pb; 10-12 Zn; 2.5-3.2 Cd; 9-10 S; 250-350 g/t Ag and Waelz process dust, %: 53-55 Pb; 13-15 Zn; 0.3-0.5 Cd; 5-6 S; 0.5-1 Cl; 80-120 g/t Ag. Processing is carried out in rotary kilns with the addition of barite concentrate or soda. In both cases, rough lead is produced, which accumulates silver, and dust, which contains most of the zinc and cadmium. This dust is also processed in a rotary kiln to produce clinker and separate dust which contains lead and cadmium. Lead- and cadmium-containing dust is processed in a rotary kiln to produce rough lead and dust containing up to 50% cadmium. The resulting dust is leached with sulfuric acid and cadmium is cemented from the sulfate solution with zinc powder. Further, vacuum refining produces zinc with a purity of 99.995%. A by-product of the process is zinc sulfate. Extraction of lead into rough lead is 96%, silver into rough lead – 92%, zinc in clinker – 62%, in barite slag – 30%, in zinc sulfate – 1%. Extraction of cadmium is about 90%.

In Germany, a method has been implemented for processing sulfate cakes, sludges and dusts containing lead by reduction smelting in a rotary kiln. The material is mixed with lime (5-30%) and coke (5-20%) and loaded into a rotary kiln at 1000-1200 °C, which makes it possible to continuously produce rough lead containing: 0.25% Sb; 0.14% As; 0.047% Bi; 0.011% Cu [12].

The disadvantages of rotary kilns are:

– large dust loss, which significantly complicates the equipment scheme and reduces the environmental friendliness of the process;

– a large number of processing stages and products that require their further processing, and, associated with this, the loss of metal;

− high power consumption;

− difficulties of complex mechanization and automation of the process;

– the use of complex and expensive dust-collecting devices.

For the processing of lead converter dust from copper smelting production, composition, %: 60.5 Pb, 1.6 Cu, 3.35 As, 1.12 Zn, 1.77 Sb, 8.1 S, 121 g/t Ag, 87.5 g/t In prepare a charge containing NaOH and a reducing agent (coke). During the smelting in a short drum furnace, an extraction of lead into the rough metal is 97–99%. Alkaline slag after treatment with water contained up to 340 g/t In. The method is characterized by high extraction of indium (above 95%) and low consumption of reagents.

Roasting processes. The authors of [13] granulated lead dust from a copper smelter, and then coated the granules with a particulate refractory material (silicon oxide or high-silicon ore, or cement). Next, the mixture was roasted at a temperature of 550-700 ºC for 0.5-2 hours. The consumption of coatings was 5-30% of the mass of dust. Roasting was carried out in a shaft furnace in a continuous mode, which significantly increased the productivity of the process and facilitated the solution of tasks for its mechanization and automation. Despite these advantages of the method, its implementation is possible with the addition of a refractory material, which significantly increases the cost of the technology.

In [14], lead dust from converting copper matte was mixed with crushed Fe-Si-Al alloy, which was added in an amount of 2-10% by weight of the dust. The initial mixture was rolled, dried and roasted at 500-750 ºC, blowing air at a speed of 0.4-1 m/s. The method makes it possible to extract rhenium into the gas phase at the level of 90-95 %, to organize a continuous process, to use a calciner having a higher specific productivity with smaller dimensions. This technology is associated with the cost of the alloy, which leads to an increase in the cost of technology.

In [15], a highly dispersed product (converter dust) is mixed with coarse-grained material (part of crushed granules roasted at 550-700 ºC), taken in an amount of 5-40% by weight of the charge. The initial mixture is granulated, the granules are dried and roasted at a temperature of 400-700 ºC. The process fails to achieve a high extraction of arsenic into dust, gases, so the resulting lead cake containing arsenic experiences certain difficulties in further smelting process.

In [16], fine lead dust (0-63 μm) is mixed with coarse-grained material (0-2000 μm in size) in an amount of 5-20% by weight of the mixture, and the resulting mixture is granulated. After drying, the granules are roasted in a shaft-type reactor. Water is fed into the reactor at a temperature of 570-670 ºC. This method fails to achieve a high removal of arsenic from the dust. The resulting cake, although it contains a high lead content, is heavily contaminated with arsenic, and therefore encounters difficulties with further processing. In addition, the supply of water to a hot reactor leads to the formation of elemental hydrogen, which makes the process explosive.

In [17], dispersed lead dust is granulated with calcium oxide in an amount of 15-40% by weight of the granules, and roasted at a temperature of 570-670 ºC in the presence of water vapor. This technique reduces the volume of material flows at the stage of hydrometallurgical processing and increases the specific productivity of the equipment at this stage.

An analysis of the considered works shows that carrying out the dust roasting process without the addition of an oxidizing agent [14, 15] is inefficient, since the extraction of arsenic into the gas phase reaches only 85%. This is due to the fact that the higher sulfide and lower oxide of arsenic (As^{5+}) are not oxidized to their volatile compounds – As^{3+}.

Granulation of lead dust and sludge is carried out in order to filter the gas phase through the product layer in a laminar mode, reduce dust formation, which makes it possible to achieve high kinetic characteristics during the roasting process and increase the degree of extraction of arsenic, rhenium and osmium into the gas phase [14, 18, 19]. At the same time, to loosen the structure of the granules without destroying them, to increase the reaction surface of the solid product, to expand the gas outlet channels inside the granules and improve the access of oxygen to the active sites, the addition of coarse-grained and coarse-grained materials to the fired material is required [16].

The addition of refractory substances to the roasting charge [14, 20, 21] has the following advantages: it prevents the granules from melting and sticking together; raises their melting temperature and thus allows distillation of arsenic, rhenium and osmium at high temperatures, which allows sufficiently complete extraction of rhenium and osmium into the gas phase.

Despite the advantages described above, pyrometallurgical technologies are characterized by the complexity of equipment design, high costs of energy, material and labor resources, as well as equipment investment. In addition, the use of pyrometallurgical technologies is accompanied by significant volumes of dust and gas mixtures that require their purification and disposal.

Hydrometallurgical processing methods of lead dust. Recently, in the world, special attention has been paid to hydrometallurgical technologies for the production of non-ferrous, rare and rare earth metals. Unlike pyrometallurgical methods, they are cost-effective, environmentally cleaner and include rational methods for processing technogenic raw materials and intermediate products.

There are various hydrometallurgical methods for processing lead dust. As a rule, the main operation in their processing by hydrometallurgical methods is leaching. Leaching is carried out in solutions of different acids (H_2SO_4, HNO_3, HCl), alkalis (NaOH, NH_4OH) or acidified salts ($FeCl_3$, $Fe_2(SO_4)_3$).

All of these methods are described in sufficient detail in the technical literature and do not require special commentary. Still it is important to mention essential basic shortcomings of each of them.

The disadvantages of alkaline leaching are:

– loss of expensive alkali;

– precious metals and copper, which remain in cakes from leaching, are not extracted into marketable products;

– high yield of semi-finished products and production wastes;

– the presence of effluents containing harmful impurities.

Sulphate hydrometallurgical schemes for the processing of lead dust are the most well studied, which is associated with the cheapness and availability of sulfuric acid. In addition, the lower solubility of lead sulfate compared to other non-ferrous sulfates provides greater selectivity in hydrometallurgical schemes based on sulfuric acid. However, such schemes have significant drawbacks:

– there are problems associated with the need to utilize SO_4^{2-};

– regeneration of solutions is accompanied by significant losses of expensive reagents (up to 20% in each turn).

Perspective directions of development of lead dust processing technologies. Promising areas of lead dust processing include various options for bacterial leaching. In Iran, a method has been implemented for processing dust from copper plants containing, %: 36 Cu, 22.2 Fe, 12.2 S, obtained from dust collectors during the operation of converters and reverberatory furnaces. The experiments were carried out in an Erlenmeyer flask with a solution acidity of 1.8, a pulp density of 7%, a process temperature of 31°C, and a stirring speed of 150 rpm [22]. An increase in pulp density indicates an increase in bacterial growth in the initial phase of microorganism growth (lag phase), an increase in acid consumption, metal ion toxicity, copper concentration and tangential stress. As a result, the redox potential and copper recovery are reduced. According to the obtained curves, the maximum extraction of copper from biological conditions for densities of 2, 3, 4 and 7% was 42.2%, 45.9% and 83.1%, respectively. The obtained data indicate the possibility of recovering copper from copper-containing dust using natural mesophilic bacteria. This technology can be an alternative and promising process to cope with the problem of dust accumulation in enterprises.

The authors of [23] use the method of bacterial leaching with the help of Acidithiobacillus ferrooxidans and Acidithiobacillus thiooxidans, which oxidize iron and sulfur, to process lead dust from a copper smelter. Particle sizes less than 80 microns. The average content of copper in the dust is 30%. The basis of sulfide copper minerals is chalcocite, chalcopyrite, bornite and covelin. Since a significant amount of copper is in oxide form, chemical leaching with dilute sulfuric acid is carried out before the bioleaching process. The process is carried out in a 500 ml specialized vessel at a process temperature of 31°C and a stirring speed of 150 rpm. To increase the density of the pulp, special conditions were created with higher toxicity, tangential stress and a decrease in mass transfer, which, in turn, led to a slowdown in the process rate and copper recovery. To avoid this, much more microorganisms and a richer nutrient medium are needed, an increase in the percentage of solids in the pulp.

Under optimal conditions, up to 91% of copper is recovered from the dust.

Biotechnologies can be applied to solve environmental problems by converting hazardous materials into safe or valuable products as a powerful and cost-effective technology. This technology has a number of advantages over pyrometallurgical processes:

– relative simplicity;

– mild operating conditions;

– low capital costs;

– low energy consumption and environmental safety;

– the processing scheme is closed loop;

– circulating solutions after partial or complete regeneration are used as a nutrient medium for bacteria and a leaching solution.

Along with the listed advantages, bacterial leaching has a number of significant disadvantages: intensification of leaching is achieved by activating the vital activity of bacteria adapted to specific environmental conditions (type of ore, chemical composition of solutions, temperature, etc.). This requires a pH of 1.5-2.5, a high redox potential (Eh 600-750 mV), a favorable and stable chemical composition of the solutions, which is achieved by their regeneration and the mode of aerating and moistening (irrigation) of the ore. In some cases, nitrogen and phosphorus salts should be added, as well as bacteria grown on recycled solutions in regenerator ponds. The number of bacterial cells in the leaching solution and ore should be at least 106-107 per 1 ml or 1 g, respectively. The cost of 1 ton of copper obtained by bioleaching is 1.5-2 times lower than with conventional hydro- and/or pyrometallurgical methods.

The relevance of research on the search for a new technology for processing fine dusts of copper smelters is due to the following reasons:

• these products are valuable raw materials and must be subjected to self-processing, which is relevant for both economic and environmental reasons;

• utilization of copper smelter dust prevents potential damage to nature and human health and increases the complexity of the use of ore raw materials.

The disadvantages of pyrometallurgical schemes are the low quality of the products obtained, the need for purification and neutralization of gases. Products obtained from the processing of man-made waste in pyrometallurgical units, in most cases, require additional (more often hydrometallurgical) refinement, which significantly reduces the efficiency of pyrometallurgical schemes.

In the hydrometallurgical processing (leaching) of lead dust, solutions of acids, alkalis, salts, as well as organic solvents are used as solvents.

The use of acids is associated with an additional consumption of reagents for the selective separation of metals from solutions. In addition, it is necessary to create special acid-resistant equipment, often operating at elevated temperatures.

When using alkaline solvents for the extraction of copper, zinc and lead, difficulties arise with the recovery of solvents and their subsequent disposal, as well as the processing of the resulting products. Most often, they are contaminated with other heavy non-ferrous metals, which leads to the need for their further selective separation.

The use of amine-containing solvents makes it possible to achieve high selectivity in the extraction of metals into solution. Moreover, some solvents quite selectively affect lead compounds. Organic solvents are characterized by a high capacity for non-ferrous metals, as well as the possibility of their regeneration and return to the leaching stage. In addition, they do not require special construction materials.

Thus, the developed technology must comply with modern environmental requirements, be completely closed to sewage and solid waste, and fit into the overall production cycle of the enterprise.

Based on the analysis, it follows that the most effective technology for the processing of lead dust, which ensures its complex use, are combined methods that combine pyro- and hydrometallurgical methods. This approach will allow the selective extraction of valuable metals into marketable products with the removal of harmful impurities and their further utilization.

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МАТЕРИАЛЫ XV МЕЖДУНАРОДНОЙ СТУДЕНЧЕСКОЙ НАУЧНОЙ КОНФЕРЕНЦИИ «СТУДЕНЧЕСКИЙ НАУЧНЫЙ ФОРУМ 2023»

СТАТЬЯ

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ОЦЕНКА ВНУТРИГОДОВОЙ ИЗМЕНЧИВОСТИ ОСНОВНЫХ КОМПОНЕНТОВ ЭКОСИСТЕМЫ НЕВСКОЙ ГУБЫ ФИНСКОГО ЗАЛИВА И ВЛИЯНИЕ ФАКТОРОВ НА СКОРОСТИ ПРОЦЕССОВ МАССООБМЕНА В ВОДНОЙ ЭКОСИСТЕМЕ

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Невская губа Финского залива по своим гидрохимическим и гидробиологическим характеристикам, а также по уровню загрязнения вод подразделяется на три района: северный, центральный и южный. Проблемой мониторинга состояния водной экосистемы Невской губы являются ледовые условия, которые препятствуют проведению гидробиологических исследований в акватории. Для решения данной проблемы идеальным инструментом является имитационное моделирования массообменных процессов. Имитационное моделирование также позволяет оценить реакцию водной системы на внутренние и внешние воздействия и спрогнозировать их изменение во времени. Целью данного исследования является оценка скоростей процессов массообмена в водной экосистеме Невской губы с помощью методов имитационного моделирования. Авторами были поставлены задачи исследования: обобщить и оценить влияние физических факторов на скорость первичного биосинтеза планктонных водорослей с помощью моделирования и оценить данные гидробиологических наблюдений на акватории Невской губы в 2022 году. В проведённом исследовании было акцентировано внимание на изменчивость скоростей массообмена в водном фитоценозе под воздействием внешних факторов и внутрисистемных особенностей функционирования водной экосистемы, в которой учитывались только агрегированные фито- (F) и зоопланктон (Z); процессы первичного продуцирования и ассимиляции пищи, выедания фитопланктона зоопланктоном, траты на обмен и естественное отмирание организмов.

Ключевые слова: Невская губа, фитопланктон, влияние факторов среды, имитационное моделирование, продукция, скорости массообмена

Работа выполнена при финансовой поддержке Российского научного фонда, грант № 23-27-10011, и при финансовой поддержке Санкт-Петербургского научного фонда.

ASSESSMENT OF THE INTRA-ANNUAL VARIABILITY OF THE MAIN COMPONENTS OF THE NEVA BAY ECOSYSTEM OF THE GULF OF FINLAND AND THE INFLUENCE OF FACTORS ON THE SPEED OF MASS EXCHANGE PROCESSES IN THE WATER ECOSYSTEM

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The Neva Bay of the Gulf of Finland is divided into three regions, North, Central and South, by its hydrochemical and hydrobiological characteristics and by the level of water pollution. The problem of monitoring the state of the aquatic ecosystem of the Neva Bay are ice conditions that hinder hydrobiological research in the water area. To solve this problem, the ideal tool is simulation of mass exchange processes. Simulation simulations also allow to assess the response of the water system to internal and external effects and to predict their change over time. The aim of this study is to assess the velocities of mass transfer processes in the aquatic ecosystem of the Neva Bay using simulation methods. The authors set the tasks of the study: to generalize and assess the influence of physical factors on the rate of primary biosynthesis of planktonic algae with the help of modelling and to evaluate hydrobiological observations on the Neva Bay in 2022. The study focused on the variability of mass transfer velocities in aquatic phytocenosis under the influence of external factors and intrasystemic features of the aquatic ecosystem functioning, which considered only aggregated phyto-(F) and zooplankton (Z); processes of primary production and assimilation of food, phytoplankton removal by zooplankton, exchanging and natural extinction of organisms.

Keywords: Neva Bay, phytoplankton, influence of environmental factors, simulation modeling, primary productivity, mass exchange rates

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Водная экосистема представляет собой сложную многокомпонентную систему, которая включает в себя химические компоненты (азот, фосфор, загрязнители различного вида и состава и др.), биологические компоненты (фито-, зоо-, бактериопланктон и т.д.), физические условия и особенности среды. Все компоненты взаимодействуют друг с другом посредством прямых и обратных и/или множественных связей. Одним из инструментов изучения процессов массообмена в водных экосистемах является имитационное моделирование. Моделирование позволяет выражать процессы в водных экосистемах на основании математических закономерностей между участниками данных процессов. Положительными сторонами имитационных моделей являются возможность более глубже познать процессы, спрогнозировать реакцию системы на воздействия на уровне отдельных процессов и интегративных свойств экосистемы в целом, провести различные эксперименты без больших временных трудозатрат [1,2].

Целью исследования было провести оценку скоростей процессов массообмена с помощью методов имитационного моделирования в водной экосистеме Невской губы.

Задачами исследования было:

1. Обобщить данные гидробиологических наблюдений на акватории Невской губы в 2022 году;

2. Оценить влияние освещенности, температуры воды, содержания в воде биогенных элементов (минерального фосфора и азота) на скорость первичного биосинтеза планктонных водорослей;

3. Оценить скорости балансового уравнения водного фитоценоза по трем моделям совместного влияния факторов для вегетационного периода развития водной экосистемы;

4. Оценить по результатам моделирования первичную продукцию в различных частях Невской губы.

Материалы и методы исследований

В проведенном исследовании для оценки удельных скоростей процессов массообмена использовались 2 первых уравнения баланса скоростей из точечной (пространственно – однородной) модели водной экосистемы [1]:

$$dF / dt = Б_F - G_{FZ} - S_F - R_F \pm Q_F,$$

$$dZ / dt = A_Z - S_Z - R_Z \pm Q_Z,$$

где $Б_F$ – скорость валового первичного биосинтеза фитопланктона, G_{FZ} – скорость выедания фитопланктона зоопланктоном, S_F, S_Z – скорости естественной смертности фитопланктона и зоопланктона, R_F, R_Z – скорости трат на обмен фито- и зоопланктона, A_Z – скорость ассимиляции пищи зоопланктоном, Q_F, Q_Z – скорости внешнего поступления вещества в систему. Все скорости в выполненных расчетах имеют размерность мг сух. веса $_*$ л$^{-1}$ $_*$ сут$^{-1}$. Важнейшим компонентом имитационной модели является первое слагаемое в первом уравнении $Б_F$ – скорость первичного валового биосинтеза фитопланктона, эта составляющая баланса скоростей описывает преобразование вещества и энергии (минеральное питание, свет, температура) в живое вещество, синтезируемое водорослями, поэтому выбор и обоснование моделей учета влияния факторов, правильность их расчёта определяют адекватное изменение F в водоеме и успешность модели в целом.

Скорость валового первичного биосинтеза в модели определяется как:

$$Б_F = (\mu_F + r_F)\, F,$$

где μ_F – интенсивность чистого первичного биосинтеза фитопланктона, r_F – интенсивность трат на обмен, F – биомасса фитопланктона.

Интенсивность чистого первичного биосинтеза μ_F, является основополагающим параметром системы балансовых уравнений, т.к. она является основой для вычисления первичного биосинтеза, трат на обмен фитопланктона и чистой продукции. В данной работе она может рассчитываться на основе трех моделей:

1. Модель Либиха. Концепция лимитирующего фактора.

$$\mu_F = f(T)\, min\{f(I), f(N), f(P), ..\}$$

«Л-модель»

2. Модель Митчерлиха. Многофакторная зависимость.

$$\mu_F = f(T) * f(I) * f(N), f(P) * \ldots$$

«М-модель»

3. Модель Митчерлиха-Либиха.

$$\mu_F = f(T) * f(I)\, min\{f(N), f(P), ..\}$$

«МЛ-модель»

где $f(T)$ – зависимость удельной скорости роста от температуры (максимальная удельная скорость роста), рассчитывается по формуле Lehman et al [3], $f(I)$ – влияние освещенности на удельную скорость роста фитопланктона, её рассчитывали по формуле Райтера и Дж. Стила; $f(N)$, $f(P)$ – влияние биогенов на удельную скорость роста, расчёт выполнен по формуле Михаэлиса – Ментен – Монó. В проведенном исследовании использовались все три модели и сравнивались полученные результаты с данными наблюдений.

Для оценки изменчивости основных компонентов водного фитоценоза были использованы данные ФГБУ “Северо-Западное УГМС”, полученные при натурных исследованиях на станциях в Невской губе (НГ) в 2022 году. Наблюдения проводились неравномерно по времени, так для химических и гидрофизических параметров наблюдения выполнялись на протяжении всего года раз в месяц, а данные по численности и биомассе фитопланктона и зоопланктона исследовались лишь в мае, августе и октябре. В ходе исследований [4,5], было показано, что Невская губа по гидробиологическим и гидрохимическим показателям разделяется на три части, северную и южную, где происходит контакт воды с берегом и транзитную (центральную) со свободным водообменом. Это обусловливает внутригодовое изменение гидрохимических компонентов в эстуарии р. Невы и определяет загрязнение водного объекта в целом.

Результаты исследования и их обсуждение

На рис. 1а приведен внутригодовой ход температуры воды в поверхностном слое воды в водоеме. В июле – августе температура превышала 20°C, что является аномальным для Невской губы. Так в 2018-20 года температура воды в поверхностном слое не превышала 20°C, а в 2022 максимальная температура воды достигла 25°C, что оказывало угнетающее воздействие на фитопланктон, так как каждый вид фитопланктона имеет свой интервал толерантности с оптимальной температурой воды. При превышении оптимальной температуры воды и при стремлении к границам интервала рост фитопланктона будет угнетаться.

На рис.1б приведено изменение биомассы фитопланктона в вегетационный период. Для возможности сравнения биомасс фитопланктона проводимыми другими авторами в своих исследованиях, на рис.1б и 1в биомассы приведены в мг сыр.веса/л. Интересно отметить, что в майскую вспышку максимум биомассы наблюдался в центральной части Невской губы – 2,6 мг сыр. веса/л, довольно близко и северная часть – 2,3 мг сыр. веса/л, а на юге всего 1,6 мг сыр. веса/л. В октябре ситуация диаметральна, максимум приходится на южную часть – 1,13 мг сыр. веса/л, а биомассы центрального и северного районов совпадают. В работах [4,5] авторами приведены схожие показатели биомассы фитопланктона в целом для весны.

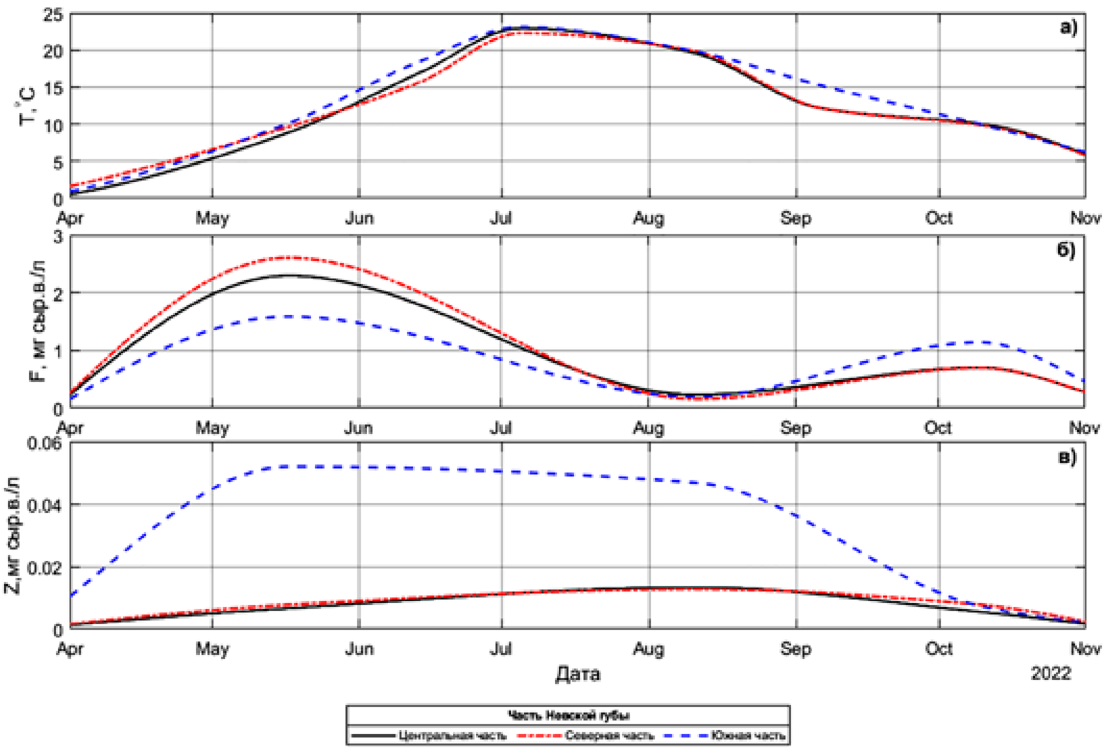

Рис. 1. Годовой ход температуры воды (а), биомассы фитопланктона (б) и зоопланктона (в) для районов Невской губы в 2022 году

Биомасса зоопланктона (рис.1в) в южной части Невской губы сильно превышала аналогичные показатели для центральной и северных частей: 0,05 – 0,04 мг сыр. веса/л в летний сезон против 0,006-0,013 мг сыр. веса/л в северной и центральных частях. Интересно отметить, что максимум биомассы зоопланктона для южной части наступает в мае, а в центральной и северных частях в августе. В дальнейшем, для моделирования всех процессов массообмена и имитации поведения системы в целом, мы перейдем в расчетах от биомассы в сыром весе к биомассе в сухом весе.

Максимальные показатели μ (рис. 2) характерны для северной части, так по М–модели в пик весеннего развития фитопланктона μ имеет значение 0,27 $сут^{-1}$, а для L–модели – 0,72 $сут^{-1}$.

Во всех районах Невской губы лимитирующим фактором выступает концентрация минерального фосфора, её недостаток уменьшает μ в 11 раз весной и в 2 раза летом, особенно сильно недостаток фосфатов сказывается именно в центральной и южных частях, недостаток освещенности уменьшает μ в 2 раза весной (эффект самозатенения), а летом из-за повышения мутности, начинает быстро расти, достигая осенью уменьшения μ в 60 раз. Нехватки азота в Невской губе не наблюдается, и сильного влияния на μ он не оказывает.

Максимум μ в разных районах не достигается в одно время (рис. 2), так в северной и южных частях губы весенний пик приходится на начало июня, а в центральной части уже после середины июля, осенью пик в центральной и северных частях НГ приходится на середину августа, а на юге, ближе к сентябрю. Траты на обмен фитопланктона (единый дыхательно-выделительный процесс) в процентном соотношении от μ составили 20% летом и 60% осенью для всей Невской губы.

Скорость первичного биосинтеза по М-модели составила соответственно: для весеннего пика – северная часть НГ– 0,08 мг сух. веса/л*сут, центральная и южная части НГ – около 0,02 мг сух. веса/л, осенью максимумов скорости первичной биосинтеза не наблюдалось, что связано с высокими тратами на обмен фитопланктона. По L – модели весенний пик для севера НГ составил 0,25 мг сух. веса/л, для южной и центральных частей -0,12 мг сух. веса/л, зато для данной модели был выраженный весенний пик он составил 0,01 мг сух. веса/л для центральной части НГ и 0,03 мг сух. веса/л для южной части НГ. Скорость трат на обмен имела два выраженных пика для южной части НГ, в остальных наблюдался только выраженный весенний пик, показатели для М – модели составили от 0,003 до 0,015 мг сух. веса/л в весенний пик. Для L – модели траты на обмен составили: весенний пик – 0,02-0,045 мг сух. веса/л, осенний пик в южной части НГ – 0,008 мг сух. веса/л.

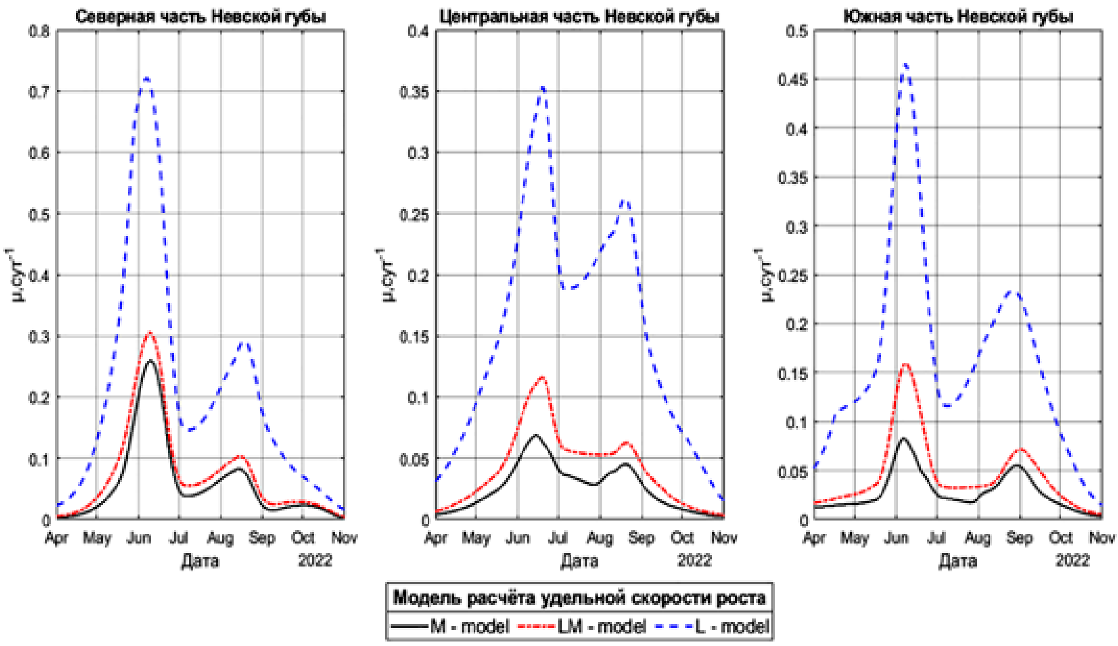

Рис. 2. Удельная скорость роста, рассчитанная по 3-м моделям для каждой части Невской губы

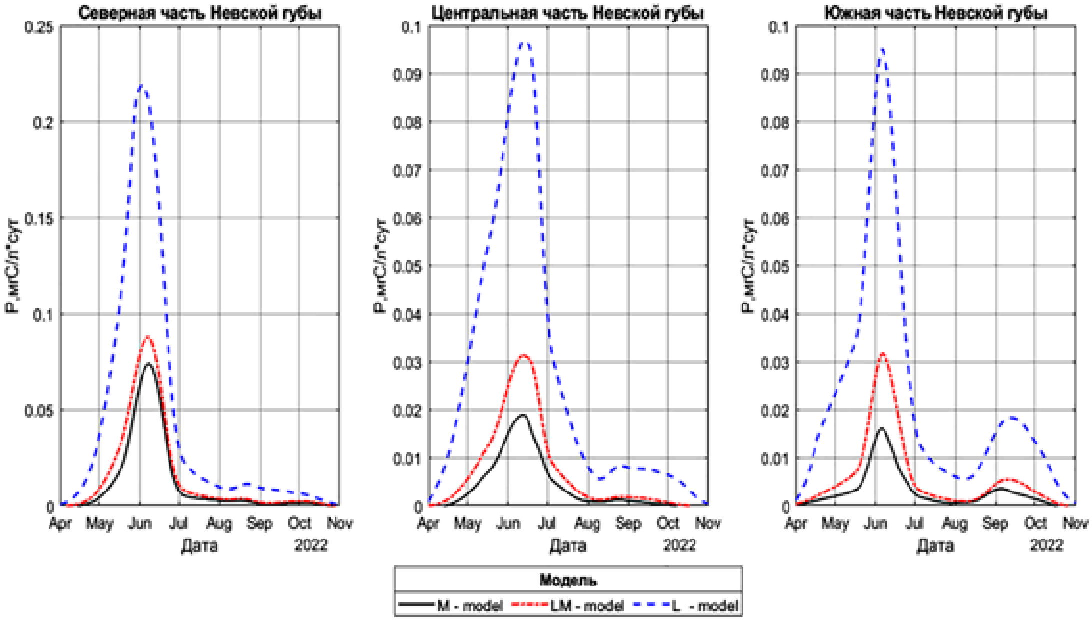

Рис. 3. Продукция фитопланктона, рассчитанная по трем моделям для Невской губы за период апрель – ноябрь 2022 года

Продукция фитопланктона (рис. 3) в 2022 году оказалась невысокой. По М-модели суточная продукция составила 0,015 – 0,019 – 0,075 мг сух. веса/л. для южной, центральной и северных частей НГ соответственно. Значимого пика, кроме южной части НГ, осенью не отмечается, на юге продукция осенью составила 0,004 мг сух. веса/л. Совсем иная картина для L – модели, так в южной и центральных частях НГ продукция в весенний пик цветения составляет около 0,1 мг сух. веса/л, а в северной части – 0,22 мг сух. веса/л., также осенью в центральной части продукция фитопланктона составляет 0,01 мг сух. веса/л., а в южной – около 0,02 мг сух. веса/л.

Интересно отметить, что по показателям продукции фитопланктона по М и LM моделям, южная и центральные части Невской губы, а также северная часть, за исключением короткого пика цветения, по всему периоду вегетации принадлежат к олиготрофному типу вод. Однако, если рассчитывать продукцию по L – модели, то в момент весеннего цветения воды трофический статус во всех 3-х районах будет соответствовать мезотрофному типу, а вне диапазона цветения – олиготрофному типу. Это также подтверждает, что L – модель дает более адекватные результаты по продуктивности водной экосистемы.

Заключение

В Невской губе биомассы фито- и зоопланктона, довольно низкие. Во время весеннего цветения максимум биомассы приходится на центральную часть НГ, минимум на южную часть. В осеннем пике цветения максимум достигается в южной части НГ. Биомасса зоопланктона южной части максимальна при весеннем пике и остается достаточно высокой до сентября, в центральной и северных областях биомасса очень низкая и максимума достигает только весной.

Исследование влияния температуры, освещенности и биогенных элементов на скорость первичного биосинтеза показало, что в весенне-летний период лимитирующим фактором для всех частей Невской губы является наличие фосфатов, а осенью, из-за повышения мутности воды – является освещенность. Показано, что максимальные значения удельной скорости первичного биосинтеза для трёх частей НГ достигаются не единовременно.

Проведенная оценка основных составляющих уравнения баланса скоростей водного фитоценоза показала, что скорости трат на обмен и первичного биосинтеза имеют выраженные максимумы для весеннего периода цветения, и для осеннего цветения выраженные пики есть только в южной части НГ.

По уравнению баланса скоростей была рассчитана продукция, где максимум продукции был получен по L – модели для весеннего цветения фитопланктона и составляет 0,22 мг сух. веса/л. По M – модели максимальная продукция была 0,075 мг сух. веса/л. В весенний пик более интенсивные массообменные процессы происходили в северной части НГ, в осенний пик – в южной части НГ.

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