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THE ROLE OF THE IMAGES OF JAPAN AND ITS PREFECTURES IN THE ATTRACTIVENESS OF JAPAN AS A TOURIST DESTINATION

ABSTRACT. The article deals with the analysis of the tourist destination images of Japan and its prefectures and contains the results of the research carried out both based on examination of official Japanese statistics and tourist literature in Japanese, English and Russian and social polls in Russia and field studies in Japan. In this paper we present the results of the research conducted by the specially created for this work original method of tourist literature review that allowed us to select prefectures most rich in different tourist images and to develop a typology of Japanese prefectures. To present day the research of such kind is a unique one not only about Japan but on the whole as well.

INTRODUCTION

In the postindustrial economy the role of tourist destination images (TDI) in the development of the territories has been increasing greatly. According to Lawson and Baud-Bovy (1977) tourist destination image is the expression of all objective knowledge, impressions, prejudice, imaginations and emotional thoughts an individual or group might have of a particular place. It encompasses both the personal images and the stereotyped images shared by groups."To some extent images as a territory resource have become as important as natural resources and industrial capacities. Tourism is quickly turning into a driver of Japanese economy. In terms of the contribution to the GDP (which rose from 2% at the beginning of 2000-s to 4,9 % in 2014) (Economic Impact of Travel on Japan, 2014 it is competing with automobile industry and is higher than that of electronics industry (Cool Japan Strategy 2012). Though for the most part it is due to domestic tourism gains, in recent years foreign inbound tourism has been developing successfully. The amount of spending by foreign tourists has jumped greatly, especially due to the nearly doubled number of the prosperous Chinese visitors, who spend much more than travelers from other countries.

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Still, despite the fact that Japan can boast by a lot of things that could not be seen anywhere else it is not such a popular destination among people travelling to foreign countries. In 2014 it was 22nd in the world and 7th in Asia though in 2015 in Asia it moved to the 5th place and in the world to the 16th (White Paper on Tourism 2016). There are 3-5 times more foreign visitors in Turkey, Italy, China, Spain, USA and France than in Japan. And in comparison with Great Britain, Germany and France Japan's gains from tourism are 3-5 times lower (Japan Today 2015)

Meanwhile, Japan has a high touristic potential and many people throughout the world perceive Japan as a very attractive country for travelling. Yet for a whole host of reasons consider such a trip to be unrealistic. In our research we aimed at analyzing the stereotypes of the perception of Japan, the problems that hinder more intensive inward tourism and measures aiming at overcoming them and improving the appeal of the country (Tihotskaya and Stegnienko 2015).

MATERIALS AND METHODS

The main object of this research paper is analysis of the destination images and stereotypes that exist about Japan and its prefectures and their role in attractiveness of Japan for foreign tourists. In the course of our research the sociological poll was carried out by Alexandra Stegnienko in Moscow (from December 2014 to March 2015) to find out the images that transform into negative factors determining negative perception of Japan as a tourist destination. Methods we used include statistical method, social polls and interviews, as well as specially developed for this research original system of analyzing tourist literature. More than 12 top guidebooks and websites were analyzed: «Lonely Planet», «Dorling Kindersley», «Tomas Cook», «National Geographic Traveler», «Vokrug Sveta», Japanese editions introducing Japan to foreigners (Sato 2008; Takayuki 2009). We have also analyzed the articles about all prefectures in Wikipedia and Wikitravel in English, Japanese and Russian languages. Also we have conducted field studies in Japan and composed mind maps.

RESULTS AND DISCUSSION

The main summarized results concerning obstacles for travel to Japan we presented in the table consisting of two parts: according to potential and according to actual tourists (Table 1). We have interviewed 100 tourists who had visited Japan and compared their answers with destination images of 900 Russian citizens who had never been in Japan (both by questioning, mainly students, personally or by asking to fill in a survey and through the Internet where all people despite age, sex, etc. could answer). People wishing to visit Japan but considering it unlikely fear high traffic costs and general burden most of all. One third of all respondents consider visa acquisition quite difficult and fear the language barrier (Visa regime for Russian citizens was soften only

Table 1. Obstacles for travel to Japan according to potential tourists, %

Difficulty level	Orientation difficulty	Not enough guide signs in English	High prices	Language barrier	Inhospitable people
No problem	29	38	22	20	71
Could be some inconviniences	29	23	17	25	13
Casual difficulty	11	13	26	17	1
Could be a problem	13	8	16	16	
A serious problem	3	4	5	7	
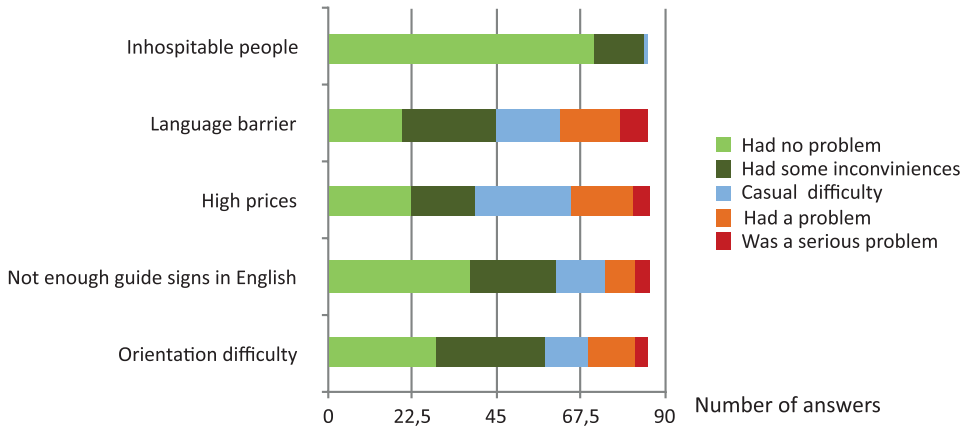
Fig. 1. Obstacles for travel to Japan according to actual tourists

in 2017. The applicants, who pay for their trips themselves, will not have to provide any statement from a guarantor, and more people will be entitled to multiple-entry business visas under the reworked criteria). At the same time tourists that visited Japan noticed that they had no difficulties despite some language problems and considered the prices rather high.

The Japanese tourist industry is rather well developed and suitable for various kinds of trip (Tikhotskaya 2016). Still, unlike domestic tourists feeling comfortable being taken good care of, foreign visitors not understanding the Japanese language experience panic from mere looking at Japanese characters (Tikhotskaya 2018). Our analysis of the main tourist campaigns and measures to create comfortable environment for foreign travelers undertaken in Japan shows that carrying out the active tourist policy favored the rapid recovery of foreign tourist arrivals that decreased greatly after the 2011 Great Tohoku earthquake. According to Japan Tourism Agency data in 2013 Japan achieved the goal which was set at the beginning of 2000-s for the year 2010 – the number of foreign tourist arrivals for the first time exceeded 10 million. Number of foreign tourists in 2015 increased to 20 million (doubled since 2011), spending increased to 3.5 trillion yen; nearly as much as the role of automobile parts export. The government has set a new set of targets for the tourist industry: the number of international visitors to Japan should increase to 40 million by year 2020

and to 60 million by 2030 (Ministry of Land, Infrastructure, Transport and Tourism 2016).

The most effective step was the simplification of the visa system for a number of the countries of South-East Asian countries that led to the increasing stream of tourists. The programs aimed at environment improvement for foreign travelers also brought in good results. It included widening tourist information network, free Wi-Fi destinations extension, introduction of foreign languages signs, credit card acceptance widening, broadening of tax free shops, promotion of volunteer movement.

Every prefecture, every community aspires to position itself as an attractive tourist destination using the images that exist about Japan on the whole and supplementing them with something unique. As a result of the activation of local efforts the attractiveness of Japan's image as a popular tourist destination is growing. What is even more important, it is taking shape owing to the Japanese people considerable culture as well. According to the U.S.travel magazine Conder Nast Traveler, in 2016 Tokyo and Kyoto were picked as the world's best cities outside United States, while in 2015 they ranked 15-th and 9-th (in 2017 Tokyo was the first and Kyoto – the third).

One of the distinctive features of recent tourist policy in Japan is diversification of the tourist flows. As it can be seen in the Table 2 most tourists visit 3 regions: Tokyo, Hokkaido and the heart of the Kansai region

that is Kyoto and Osaka. These destinations are equally popular among Japanese and foreign travelers. But while the fifth place in domestic travels occupies situated rather close to Tokyo Shizuoka prefecture, with its spectacular natural landscapes, foreign tourists visit it more rarely and prefer more close to Tokyo Chiba prefecture (Table 2).

Based on statistical data it is difficult to trace one-day tourist trips, such as to Tokyo Disneyland, Kamakura or Hakone and Fujiyama from Tokyo and inaccuracy of statistics inspired us to develop original method of analyzing.

A. Stegnienko has analyzed guide-books in English and Russian languages as well as most popular internet travel sites (Wikipedia and Wikitravel) in English, Russian and Japanese. In the total 12 sources were analyzed. From them for all prefectures were taken various characteristics: toponyms, definitions, names of temples, handicrafts as well as personalias and so on. Depending on the degree of every characteristic disclosure

the prefectures received value from one to three points and the appropriate category – historical, cultural, natural, et cetera. If there is a whole section in a guidebook TDI received 3 points, if a short description – 2 points and if only short mentioning – 1 point. For example, in the case of Hokkaido a lot is said about ainu, so this image is given 3 points while about Shiretoko there are only 2 paragraphs (2 points) and about ice diving only one sentence (1 point). All the points received by every image in every guidebook were summarized and it allowed us to create the rating of most significant images and the rating of prefectures most detailed described in the tourist literature.

Then the total value was summarized and the most important characteristics and prefectures with most detailed information were identified; their tourist specialization was discovered (Stegnienko 2013). After that we calculated the share of each prefecture in all tourist destination images (Fig. 2). On the map in deep brown are shown prefectures with high value and in beige – with low

**Table 2. Number of tourists by prefecture and prefectures rating, 2015
(White Paper on Tourism 2016)**

Prefecture	Rating among all tourists	Total number of tourists	Rating among foreign tourists	Number of foreign tourists
Tokyo	1	51480	1	9980
Hokkaido	2	30390	3	3050
Osaka	3	24090	2	4310
Kyoto	4	20690	4	2990
Shizuoka	5	20300	10	540
Kanagawa	6	14620	8	920
Chiba	7	19790	5	1990
Okinawa	8	18520	6	1360
Nagano	9	16850	11	530
Aichi	10	14620	7	1060
Fukuoka	11	14560	9	560
Hyogo	12	13080	12	490
Miyagi	13	10170	29	100
Yamanashi	23	6910	13	480

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value. If the prefectures TDI found in tourist literature are considered we receive more reliable rating of each tourist destination. In this case the second place occupies Kyoto prefecture, the cultural capital of Japan, where 16% of all cultural heritage objects of the country are concentrated. Not coincidentally Kyoto is called the city of thousand temples. In addition to important sacral objects there are lots of historical and cultural sites (to begin with shogun's castle Nijo and emperor palace), temples as well

as national parks. Besides, Kyoto prefecture hosts the largest manga museum which is also a center of modern culture. Tourism plays a key role in the prefecture's economy. For example, in 2010 while there were less than 3 million residents it was visited by 76 million domestic and 1 million foreign tourists.

If we take into account TDI, Okinawa prefecture, often called Japanese Hawaii, comes the third. Then also appears Nagasaki prefecture. Despite not belonging to top
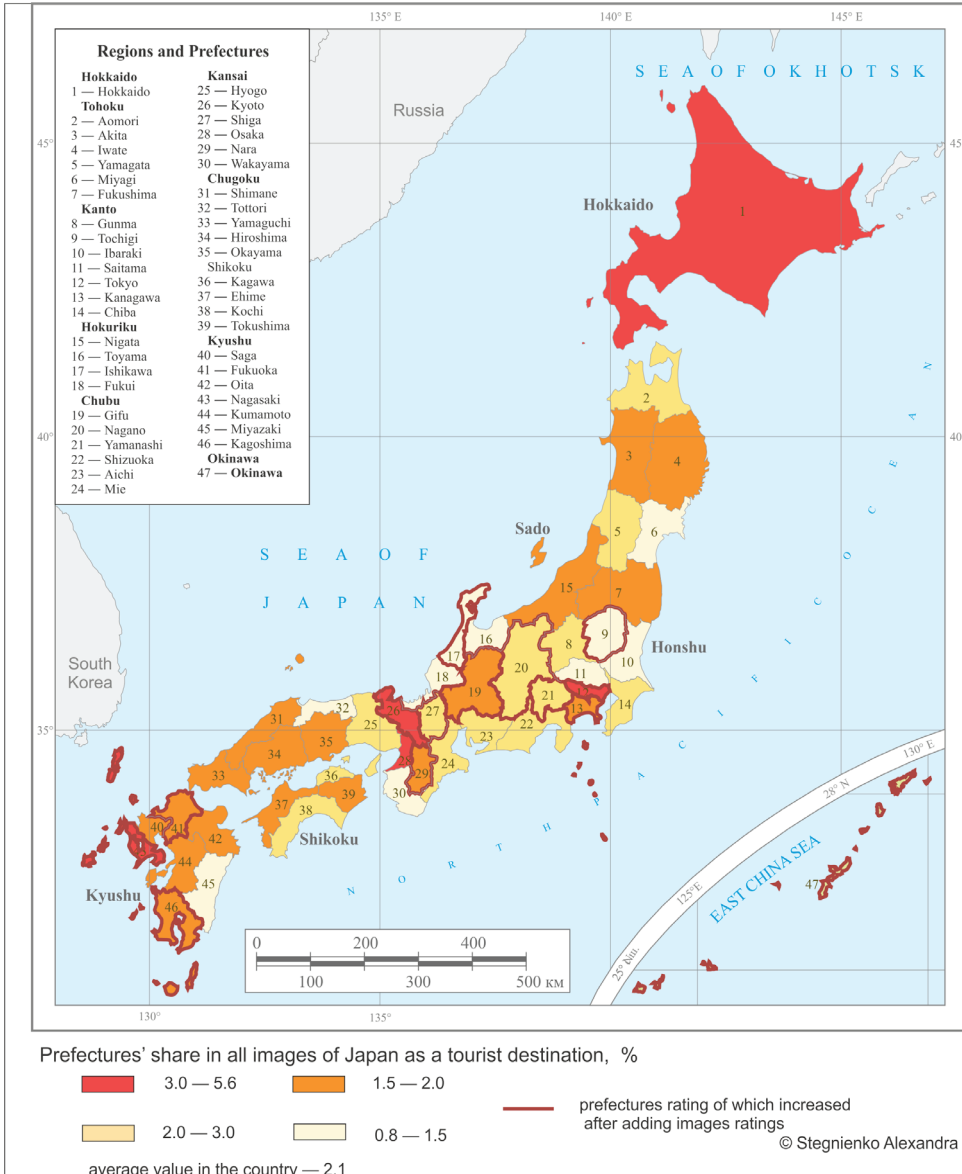
Fig. 2. Prefectures share in all images of Japan as a tourist destination

10 by the number of tourists, it is famous around the world no less than Kyoto and Tokyo due to nuclear bombing during WWII as well as Hiroshima. In the case of considering images Nara prefecture also hits the top 10, because it is very popular as one-day travel destination from Kyoto. Among foreign tourists it gained success not only as the first capital of Japan, where the Todaiji and Horyuji temples and other famous historical sites are situated but also because of the possibility of close contact with deer strolling with ease through the city parks, shrines and temples.

Outlined are prefectures value of which increased after adding TDI rating. (This is a composite score received by prefectures due to every image depending on the details of its description). It means that these prefectures have some significant TDI and are popular destinations among domestic travelers. They are not once mentioned before Tokyo, Kyoto, Nara, Kanagawa and Osaka prefectures. Yamanashi prefecture, with the symbol of the country, Fuji-san (Fujiyama is situated in both Yamanashi and Shizuoka prefectures and the two are debating about its location), and Tochigi prefecture with Nikko about which there is a popular saying "who has not seen Nikko does not know what a beauty does mean".

Also we tried to identify the factors that are forming the TDI of Japan and prefectures most rich in them (Fig. 3). In the course of analyzing the formation factors of prefectures images we divided them into key and secondary ones and developed the classification of prefectures' images by their formation factors. We found out that cultural factor is the dominant one – 31% of all images were formed this way. Japan is primarily famous for its cultural heritage though this factor includes very diverse groups of images. They are literal and cultural masterpieces, mentality features, traditional festivals and rites, gardens, crafts, modern architecture, thematic parks.

While the beaches of Japan don't account even for 1% of images the second place is occupied by the natural factor and climatic factor (22%). It is particularly important for Japan taking into consideration on the one hand unpredictability of its nature and common natural disasters and on the other hand sacral perception of nature inherent to Shinto religion and uncommon environment friendliness, the cult of nature beauty. Not in many countries in the world one can find the tradition of mass group enjoying of sakura blossom, full moon or autumn leaves.

The third place by the input into the formation of Japan's images occupies economic factor that is 16%. This group contains any images that are characterizing agriculture, industry and service sector. Thus, Nagoya city with Toyota headquarters, together with surrounding cities, is famous as Japanese capital of automobile industry. Anyone can go to a special excursion at the Toyota demonstrative hall though an advance order is necessary.

At last, typology of prefectures was made – we chose main, major and significant tourist destination images centers as well as image semi-periphery, periphery and deep periphery (Fig. 4). The main tourist destination image centers are those the total rating of which is more than 800 images and they are mentioned in all analyzed information sources. This type includes 3 prefectures: Tokyo, Kyoto, Hokkaido. Not less important for understanding of the image of Japan are 5 major image centers: Kanagawa, Osaka, Hiroshima, Fukuoka, Nagasaki prefectures. (Other type's criteria are explained in the map legend).

And finally mind maps for all kinds of tourist destination images types for most prefectures were composed. Mind map allows representing visually the place image. We shall explain it on the example of Hokkaido (Fig. 5). On the mind map of this prefecture are clearly seen the two key groups of this prefecture image formation, that is North and Nature. All other images are related to them. The Northern geographical position determined the otherness of this prefecture from the center of Japan. Northern landscapes and large open spaces remind more of Russia (One nickname of Hokkaido prefecture is "Japanese Siberia"). Vegetables,

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not common for Japan, are cultivated here. Northern position and remoteness explain later developing and cultural differences. While there are no famous ancient temples the national minority ainu villages culture of whom is now added to Japan's heritage objects are preserved. The Northern position is also related to sport development that

is Olympic Games, ski resorts as well as to popular snow festival that takes place in Sapporo.

The periphery prefectures image is often less diverse (Fig. 6). These prefectures are tourist "backwoods" of the country that are rarely mentioned in the guidebooks. However

Regions and Prefectures

Hokkaido	Kansai
1 — Hokkaido	25 — Hyogo
Tohoku	26 — Kyoto
2 — Aomori	27 — Shiga
3 — Akita	28 — Osaka
4 — Iwate	29 — Nara
5 — Yamagata	30 — Wakayama
6 — Miyagi	**Chugoku**
7 — Fukushima	31 — Shimane
Kanto	32 — Tottori
8 — Gunma	33 — Yamaguchi
9 — Tochigi	34 — Hiroshima
10 — Ibaraki	35 — Okayama
11 — Saitama	Shikoku
12 — Tokyo	36 — Kagawa
13 — Kanagawa	37 — Ehime
14 — Chiba	38 — Kochi
Hokuriku	39 — Tokushima
15 — Nigata	**Kyushu**
16 — Toyama	40 — Saga
17 — Ishikawa	41 — Fukuoka
18 — Fukui	42 — Oita
Chubu	43 — Nagasaki
19 — Gifu	44 — Kumamoto
20 — Nagano	45 — Miyazaki
21 — Yamanashi	46 — Kagoshima
22 — Shizuoka	**Okinawa**
23 — Aichi	47 — **Okinawa**
24 — Mie	

Prefectures' images by their formation factor

key-factor
- ☐ cultural
- ☐ natural and climatic
- ☐ sacral
- ☐ economical

Secondary factor
- ● historical
- ● cultural
- ● natural and climatic
- ● sacral
- ● economical

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Fig. 3. Prefectures' images by the formation factor

Regions and Prefectures

Hokkaido	Kansai
1 — Hokkaido	25 — Hyogo
Tohoku	26 — Kyoto
2 — Aomori	27 — Shiga
3 — Akita	28 — Osaka
4 — Iwate	29 — Nara
5 — Yamagata	30 — Wakayama
6 — Miyagi	**Chugoku**
7 — Fukushima	31 — Shimane
Kanto	32 — Tottori
8 — Gunma	33 — Yamaguchi
9 — Tochigi	34 — Hiroshima
10 — Ibaraki	35 — Okayama
11 — Saitama	Shikoku
12 — Tokyo	36 — Kagawa
13 — Kanagawa	37 — Ehime
14 — Chiba	38 — Kochi
Hokuriku	39 — Tokushima
15 — Nigata	**Kyushu**
16 — Toyama	40 — Saga
17 — Ishikawa	41 — Fukuoka
18 — Fukui	42 — Oita
Chubu	43 — Nagasaki
19 — Gifu	44 — Kumamoto
20 — Nagano	45 — Miyazaki
21 — Yamanashi	46 — Kagoshima
22 — Shizuoka	**Okinawa**
23 — Aichi	47 — **Okinawa**
24 — Mie	

Typology of prefectures as tourist destination image centers

Main TDI centers
(mentioned in all analyzed guide-books, total rating over 800 images)

Major TDI centers
(mentioned in all analyzed guide-books, but rating is lower - 500-800)

Significant TDI centers
(with rating 350-500 if mentioned in all, over 500 if in 11 from 12 analyzed guide-books)

Image semi-periphery
(prefectures with average presentation in travel books, with rating 200 - 350 if mentioned in 12 and 300-350 if in 11)

Image periphery
(prefectures with low presentation in travel books)

Deep image periphery
(prefectures with minimum presentation in travel books)

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Fig. 4. Typology of prefectures as tourist destination centers

it does not mean that these prefectures have nothing to boast of. Thus, in Toyama prefecture there is one of the UNESCO World Cultural Heritage List sites, Gokayama villiage, where traditional village architecture is preserved. Besides, Toyama prefecture has lots of routes through the picturesque mountains and river valleys.

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Fig. 5. The mind map of Hokkaido prefecture

Fig. 6. The mind map of Toyama prefecture

CONCLUSION

The carried out research allowed us to make the following conclusions.

1. We defined highs and lows of Japan as a tourist destination. Among highs there are cultural heritage, service, infrastructure and among lows mainly high level of prices and visa and language problems.

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2. Our method of research is more demonstrative than the analysis of the statistics of tourist flows because while studying statistical data it is difficult: to monitor one-day trips (e.g., to Disneyland, Kamakura, Fuji-san), to separate usual tourists from business tourists among domestic tourists in particular.

3. Images influence on tourism can't be underestimated. Well-known images of Japan make it an attractive destination for both Asian and Western tourists though image of expensive and difficult for independent travelers country hinders the development of tourism.

4. Images affect the distribution of tourist flows. Mostly foreign visitors go to 4 destinations which are dominant in travel literature and no less interesting but less famous prefectures remain on the margins of the international tourism.
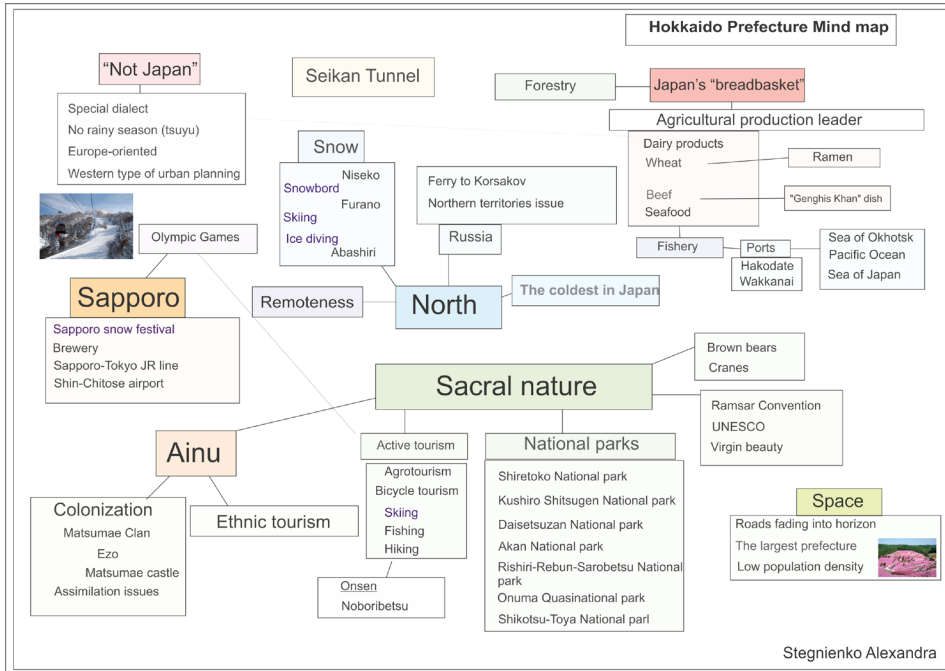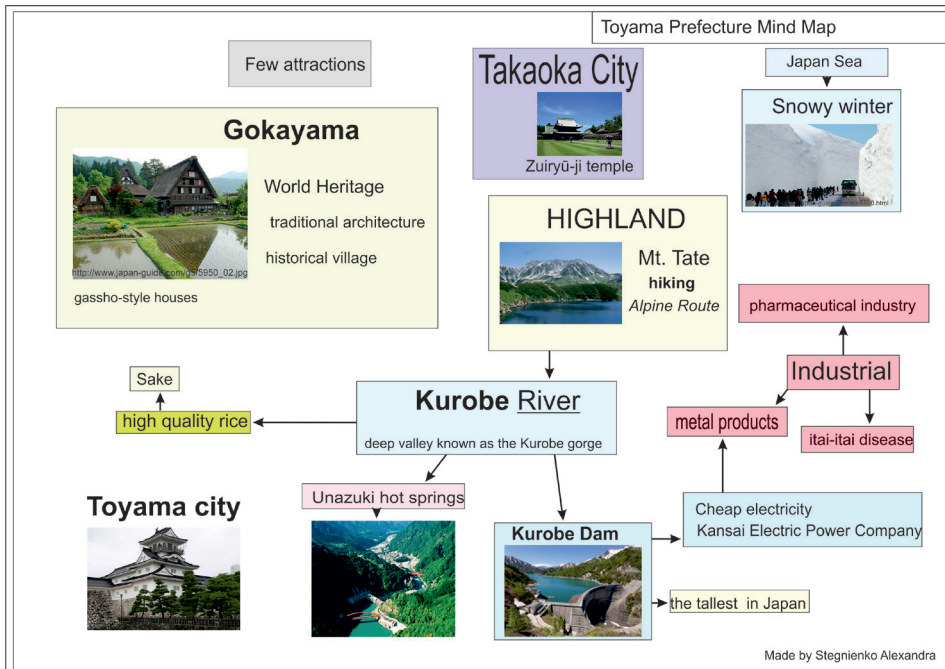
5. The measures to create comfortable environment for foreign travelers give results and it makes sense to continue this policy.

6. The policy of domestic tourist flows diversification is becoming successful but it is still only the first step in relation to foreign travelers.

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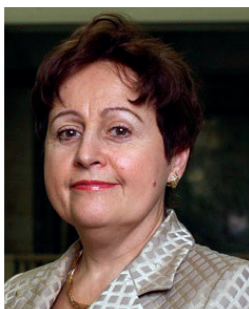
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A NOVEL METHODOLOGICAL APPROACH OF ESTIMATING URBAN POPULATION IN NIGERIA

ABSTRACT. The primary source of population data in Nigeria is the census despite its inconsistency. Consequently, efforts made to estimate population from such census figures and sometimes vital registration system has proved inadequate because of diverse problems. This study is aimed at developing a technique of population estimation in Nigeria using symptomatic data. The data for this study were collected through survey method, immunization and school enrolment data were collected from the Expanded Programme on Immunization and Ministry of Education, respectively. The average number of people per house or crowding index (CI) for Kabba was combined with immunization and school enrolment to establish a relationship which was subsequently used in regression analysis to estimate population. The results show that the population of Kabba and Kogi State were 70,870 and 4,230,382, respectively. The study recommended that the model can be used for population estimation in Nigeria and in places that have similar population data generation problems.

KEY WORDS: Population, Symptomatic, Census, Estimate, Crowding Index

INTRODUCTION

The census is the main source of population data. Evidence from literature suggests that population data collection dates back to 1789 in Nigeria, but there has never been any consistency in the process. Despite this, population data have remained the main ingredient on which every social, economic and spatial development planning is based. The need for population data is felt more than ever before in Nigeria because of rapid urbanization. Previous studies revealed that increases in population at various times in spatially defined areas of the world usually creates different settlement pattern on the land scape. Oftentimes, a very small village soon becomes so big, covering several hectares of land within a few decades. The inhabitants of such areas are faced with poor roads, poor/ inadequate housing, inadequate water supply, poor power supply, as well as poor dietary intake, among others.

In ameliorating such situations, researchers have concerned themselves with how to unveil population distribution pattern, dynamics, as well as the composition and structure of the population. These and many

other effects that often result from man environment-relation have constituted the geographers' domain of study. Most often, data on the number of people living at such places are generated through the census and where not available through indirect techniques.

The usual and most common method is through projections that are based on the application of the annual growth rate index and through the use of indirect techniques of population estimation (Ekanem 1972; Afolayan 1978; Ayeni 1980; Olorunfemi 1981, 1984, 2005; Mba 2006; Akanbi 2006). Nigeria's total population figures had been estimated from tax records at various times in the past (Adediji 2011). About the middle of the 20th century, the method of generating population data shifted to making estimates from fertility and mortality records. This shift can best be illustrated by Ayeni's work on Katsina (Ayeni 1980). But, as at 2014, registration of births in Nigeria covered only 42% of the rural dwellers (NPC 2014). Thus, using data from this source would appear unsuitable because of low coverage.

The challenges of the techniques above require that research must continue to find improved techniques of population estimation in the absence of the actual census. It is for this reason that the possibility of using immunization and school enrolment data becomes relevant in Nigeria because immunization of children has a wide coverage and its documentation since it was introduced in 1979 has been good. It should be recalled that immunization was introduced to address the prevalent high death rate of children in Nigeria. Among a number of vaccines that were injected on both children and pregnant women is BCG. The BCG usually has the highest coverage because it is first injected at birth, while others are injected at various stages of life thereafter.

Primary and secondary school enrolments in Nigeria have received wider coverage and good documentation in recent times because of the several efforts made by government to encourage secondary school education. Government's quest to encourage education through school enrolment made attendance of primary school and junior secondary school free and compulsory for children of school age. Hence, the enrolment rate improved and actually increased. The present effort is an attempt at evolving a population estimation model based on immunization and school enrolment. If successful, it could become a source of population data generation for local and urban development planning purposes in Nigeria.

THE STUDY AREA

This study was carried out in Kabba, a town in Kabba/Bunu Local Government Area (LGA). The LGA is located on Latitudes of 70 45' and 8028' North and Longitudes of 60 5' and 60 30' East. The Local Government is bounded by Yagba West, Mopamuro and some parts of Ijumu Local Government to the West, the southern part of Ijumu Local Government and Okehi Local Government to the South, Lokoja Local Government to the East, Kogi Local Government and Kwara State to the North (Fig. 1, 2). Kabba in recent times has merged with some of the settlements in its suburbs and a number of people from the settlements in the neighborhood migrated to the town. This has substantially increased the physical expansion of the town to make it worthy of study.

Kabba has three political districts (Kabba, Odolu and Aofin) and seven political wards namely: Aiyetuju/Kakola, Odolu/Fehinti, Ayewa, Asuta, Oke-koko Bolorunduro and Otugunbe. The town is situated at about 78km away from Lokoja, the Capital of Kogi State and about 130km from Abuja, the Federal Capital Territory of Nigeria. Kabba people are Yoruba by tribe. They are believed to have migrated from Ife in Osun State over 900 years ago. Kabba, being the primate town in the Kabba/Bunu Local Government Area, has attracted several other tribes from other settlements. The emigrants are mostly Ebira, Igbo, Tikfi and Hausa.

The 1991 population of Kabba was 36,124, while that of the local government was 79,276 (NPC 1991). However, the 2006 population census did not release the total
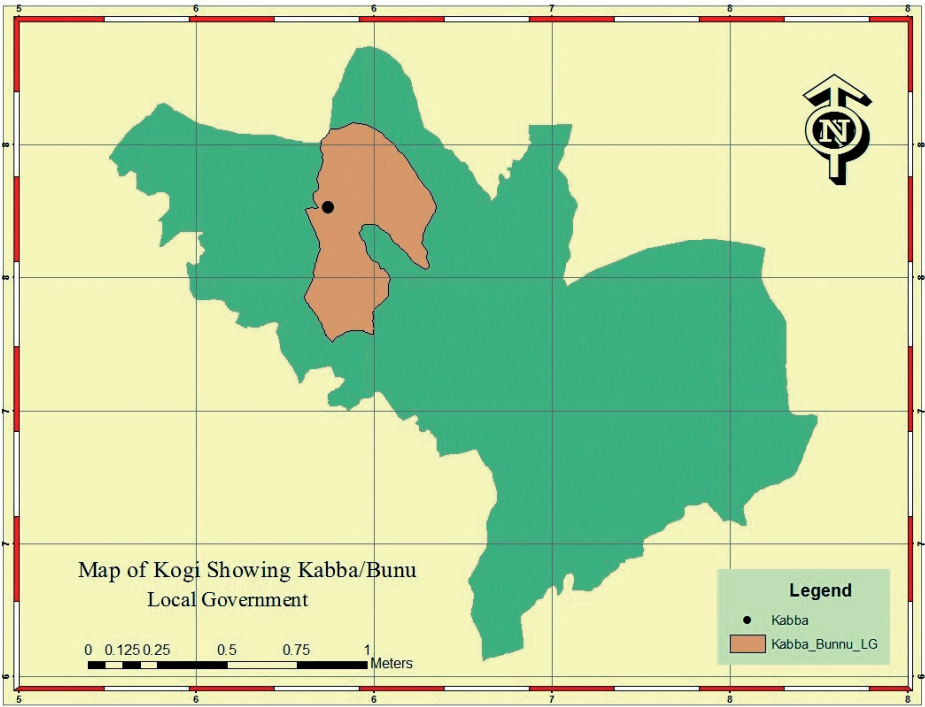
Fig. 1. Map of Kogi State Showing Kabba/Bunu Local Government Area (Kogi State Lands and Survey 2014)
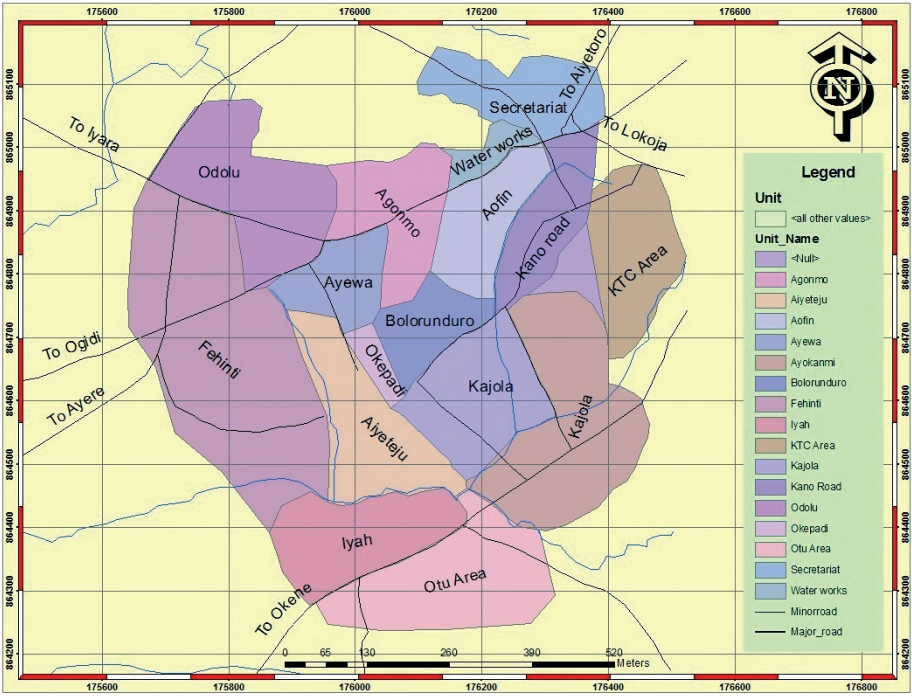

Fig. 2. Map of Kogi State Showing Kabba/Bunu Local Government Area (Kogi State Lands and Survey 2014)

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population of Kabba, rather it gave the total population of the local government as 144,579 (NPC 2006). Even at this, evidence of the spatial expansion of Kabba suggests that the population has greatly increased. All the hitherto undeveloped spaces in the South, South-West, West and North-West axes of Kabba have been developed and occupied by residential houses.

Kabba is strategically situated in a low land, but surrounded by hills (Fig. 3). These hills are low-high lands of 305-610 meters in height. Kabba is underlain by Igneous and Metamorphic rocks of the basement complex with Out-crops as massive ridges and rocky hills extended over a greater part of the area (Udo 1975). This landform is characterized by smooth and rounded Inselberg hill particularly, in the West and North of Kabba.

MATERIALS AND METHODS

Both primary and secondary data were used for this study. Data on immunization were collected from the Expanded Programme on Immunization (EPI), the National Programme on Immunization (NPI), and the Ministry of Health. Also, data on primary school and junior secondary school enrolments were collected from the Ministry of Education, National Bureau of Statistics and United Nations Education's Fund (UNICEF). The primary data that includes demographic characteristics, number of houses and household structure were collected through the survey method using questionnaire administration.

The existing 34 quarters in Kabba town were grouped into 16 quarters. Some of the new and smaller quarters were merged

Fig. 3. Oblique Aerial Photo of Kabba Taken by the researcher at the eastern side, the highest point of one of those mountains surrounding Kabba

to have some fairly big ones for this study. The total number of houses in the study area was obtained from direct house counting conducted in all the quarters. Although the approach was cumbersome, it was the available option. Besides, direct counting of house may be the most appropriate technique of population estimation in an emerging urban centre such as Kabba, especially at the modeling level. Ordinarily if town planning records were reliable, this would have been a faster source of house number. Aerial photographs or large-scale satellite data if available would also have provided a faster source of data on house numbers.

In selecting the samples, 420 copies of a questionnaire were administered on the household heads. Of these, 411 which accounted for 10% of the household heads in Kabba (NPC 2010) were returned valid. The 10% sample, of course, satisfies the required percentage for social science research particularly, in demographic studies (Oludoyi 2007; Oriola 2002). A systematic sampling technique was employed to select the samples from the sixteen quarters. The first sample was randomly selected in every first street in the quarter, while subsequent samples were selected from every fourteenth house until the last sample in each quarter was secured. The Product Moment Correlation Coefficient was used to determine the degree of association among the paired dependent (population) and the independent variables (immunization, primary school and junior secondary school

$$\bar{Y} = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + e .... \qquad (1)$$

enrolments), while the multiple regression analysis was employed to estimate population. The multiple regression formulae adopted is of the form:
Where:
Y = The population of Kabba obtained from average number of people per house;
X_1 = (BCG) Immunization coverage of Kabba;
X_2 = Primary schools enrolment data of Kabba;
X_3 = Junior secondary enrolment data of Kabba;

a = Intercept;
b = Slope of regression; and
e = error term.

RESULTS AND DISCUSSION

Data on population distribution, average number of people per house in the quarters and wards were generated from the questionnaire administered during the field survey.

Crowding Index Pattern in Kabba and Population per Quarter in Kabba

The crowding index of Kabba is 12.2. Expectedly, spatial variation exists between the quarters. Table 1 shows that Ayewa quarter has the highest crowding index of 20.9, while KTC has the lowest of 8.6. The crowding index for the sixteen quarters in Kabba is presented in Table 1.

Using this index, the population per quarter in Kabba was calculated and also presented in Table 1. The data provided the raw material for regression analysis used to establish the relationship between population and the symptomatic data.

Population, Immunization, Primary School Enrolment (PSE) and Junior Secondary School Enrolment (JSSE).

The relationship between population and the selected symptomatic data of immunization, primary school enrolment and junior secondary school enrolment was determined, fitting the collected data into Equation 1. When population was regressed against immunization, primary school enrolment and junior secondary school enrolment data, population correlates strongly and positively with immunization (0.840) and only fairly but positively with primary school enrolment (0.638), and

Table 1. Crowding Index per Quarter in Kabba

S/No	Quarter	C I per Quarters	No of People per Quarter
1	Agonmo	10.2	2,468
2	Aiyeteju	14.9	7,331
3	Aofin	15.5	4,049
4	Ayewa	20.9	3,386
5	Ayokanmi	9.2	2,158
6	Bolorunduro	16.4	3,887
7	Fehinti	9.1	6,834
8	Iyah	9.5	3,620
9	Kajola	16.1	7,052
10	Kano Road	14.7	5,851
11	KTC	8.6	2,245
12	Odolu	10.0	4,550
13	Okepadi	15.5	5,647
14	Otuegunbe	9.3	2,297
15	Secretariat	9.5	4,399
16	Water work	10.3	4,439
	Average	12.2	-

poorly and inversely with junior secondary school enrolment (-0.052) (Table 2a). This suggests that, while immunization and primary school enrolment increase as population increases, junior secondary school Enrolment decreases. The positive correlation with immunization and primary school enrolment is perhaps not surprising, while the low and negative correlation of population and junior secondary enrolment is surprising. Indeed, this development should be a source of major concern for policy makers, because it may be due to mass drop out in the area. The model is:

$$Y = 1413.225 + 28.975x_1 + 0.136x_2 - 2.235x_3...$$

$$(2)$$

with a coefficient of determination 0.72.

Further effort to examine the feasibility of having an improved relationship between population and the symptomatic data led to per ward relationship. In Kabba, a number of quarters are usually found within a ward. Thus, when population per ward was regressed against immunization, primary school enrolment and junior secondary school enrolment data, population strongly and positively correlates with immunization (0.817); and it fairly and positively correlates with primary school enrolment (0.657) (Table 2b). Just like the previous relationship between population and junior secondary school enrolment determined in Table 2a, population correlates negatively with junior secondary school enrolment (-0.320) (Table 2b). The table also shows a coefficient of determination of 0.674. This thus implies that 67% of the variation in the population can jointly be explained by immunization, primary school enrolment and junior secondary school. The equation of the regression model is of the form:

$$Y = 3201.609 + 30.182x_1 + 0.101x_2 - 1.808x_3...$$

$$(3)$$

Table 2c reveals that the relationship between population and immunization and primary school enrolment in this analysis is the same with the relationship observed in Tables 2a when the three independents variables of immunization, primary school enrolment

and junior secondary school enrolment were used. The regression coefficient (0.841) and the coefficient of determination (0.707) for this regression are also the same with that of Table 2a. This indicates that about 71% of the variation in population can be explained by immunization and primary school enrolments only. This suggests that junior secondary school enrolment data has little or no contribution to the value observed in Table 2a. Perhaps, this is why the regression between population and JSSE has continuously indicated an inverse relationship. The equation for the model is

$$Y = 719.746 + 31.465x_1 + 0.141x_2...$$ $$(4)$$

Having regressed immunization and primary school enrolment data against population per quarter, each of the two symptomatic data was singly regressed against population to determine their individual relationship. Table 2d shows that, population correlates strongly and positively with immunization (0.840). The regression indicates a coefficient of determination of 0.706. In other words, about 71% of the variation in population can be explained by immunization data alone. It would be observed that, this was the same value observed when immunization and primary school enrolment data were regressed against population Table 2c.

When primary school enrolment data were regressed against population, it indicated that population fairly and positively correlates with primary school enrolment (0.637), with a coefficient of determination is 0.406. This thus suggests that primary school enrolment explained only about 41% of the variation in population. This is by far smaller than the coefficient of determination recorded between population and immunization (0.706) in Table 2d. The results of these two linear regression analyses suggest that immunization data alone can be used to estimate population without losing its quality. Based on the results in Table 2, the immunization derived model

$$Y = 748.865 + 30.014x_1...$$ $$(5)$$

would appear the best in the present situation. The implication of the result is

Table 2. Population and Symptomatic Data

A. Population per Quarters, Immunization, Primary School and JSSE				
Variable	Y	x_1	x_2	x_3
Population	-	.840	.637	-.052
Imm. x_1		-	.782	.076
Pri. Sch x_2			-	.360
JSSE. x_3				-
Regression				.849
Coefficient				.720
B. Population per Ward, Immunization, Primary School and JSSE				
	Y	x_1	x_2	x_3
Population Y	-	.817	.657	-.320
Imm. x1		-	.823	-.301
PriSch x2			-	-.173
JSSE. x3				-
Regression				.821[a]
Coefficient				.673
C. Population per Quarter, Immunization and Primary School Enrolment				
	Y	x_1	x_2	
Y	1.000	.840	.637	
x1		1,000	.782	
x2			1.000	
Regression			0.841	
Coefficient			0.707	
D. Linear Regression of Population and Each Symptomatic Data				
Variable	Regression coefficient		Coefficient of determination	
Immunization	0.840		0.706	
Primary school	0.637		0.406	

that population of an area can be estimated based on the immunization data alone. Consequently, model (5) was employed to estimate the population of Kabba town and Kogi State.

The Population of Kabba

$$Y = 748.865 + 30.014x_1 \ldots \tag{5}$$

Using the model developed from the immunization data, the population of Kabba was estimated and put at 70,870 (Table 3).

Further, the model was used to estimate the population of the 21 local government areas in Kogi State and the results are as presented in Table 4. The estimated population for the State is 4,230,359, while the NPC projected

Table 3. Population Estimate Using Immunization Data

S/No	Quarter	Population Estimate
1	Agonmo	3,510
2	Aiyeteju	7,592
3	Aofin	3,450
4	Ayewa	3,480
5	Ayokanmi	4,441
6	Bolorunduro	3,990
7	Fehinti	7,831
8	Iyah	4,621
9	Kajola	7,261
10	Kano Rd.	5,581
11	KTC Area	2,520
12	Odolu	3,450
13	Okepadi	5,311
14	Secretariat	3,900
15	Otuegunbe	3,270
16	Water-work	3,660
	Total	70,870

population is 4,238,836. The estimated population is slightly lower than the NPC by 0.20%. This suggests that the difference is insignificant. Thus, it may be concluded that the model is good for population estimation.

CONCLUSION

The crowding index of Kabba generated through field survey was combined with symptomatic data of immunization, primary school enrolment and junior secondary school enrolment to establish a relationship. The model evolved was used to estimate the population of Kabba as 70,870 and that of Kogi State as 4,230,382. The estimated population of the State is slightly lower than the projected NPC population by 0.20%.

Based on this study, it is recommended that reliable population estimate can be generated using immunization data. This

is most especially because immunization programme in Nigeria is universal. This will surely provide quick and reliable source of population for planning purposes, especially at the local level. In addition, immunization data is not sensitive as may not be exposed to the political restitutes of the census. The effort made at developing alternative population estimation techniques, notwithstanding, efforts must continually be made to ensure regular conduct of censuses in Nigeria. In spite of the contribution of the present study, data from the National Identity Management Commission (NIMC), Tax Identification Number in Nigeria (TIN), GSM service provider, Independent National Electoral Commission (INEC) and the present bank verification numbers (BVN) are areas that demand and deserve further research.

Table 4. Population Estimate of Kogi State

S/No	LG Name	Population Estimate	NPC Projection
1	Adavi	277,988	279,778
2	Ajaokuta	157,002	157,697
3	Ankpa	340,477	342,884
4	Bassa	179,032	179,917
5	Dekina	333,814	336,127
6	Ibaji	163,575	164,313
7	Idah	102,526	102,724
8	Igalamelo	188,426	189,395
9	Ijumu	152,110	152,748
10	Kabba/Bunu	185,275	186,218
11	Kogi	147,637	148,249
12	Lokoja	251,726	253,576
13	Mopamuro	56,605	56,863
14	Ofu	245,123	245,626
15	Ogori/Magongo	51,563	51,771
16	Okehi	286,092	287,963
17	Okene	416,323	416,402
18	Olamaboro	203,013	204,135
19	Omola	138,543	139,063
20	Yagba East	189,177	190,162
21	Yagba West	179,332	180,227
Total		4,230,359	4,238,836

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EX-MARE - FORECASTING SYSTEM OF NATURAL HAZARDS IN THE AZOV SEA REGION

ABSTRACT. The paper presents approach used for the development of the forecasting system of extreme hydro-meteorological events in the region of the Sea of Azov. Due to numerous dangerous extreme events that occurred in the beginning of XXI century the issue of creation such system has become very relevant and important. The forecasting system, named EX-MARE, was started developing in 2014 as a complex of mathematical models. For each type of hydro-meteorological events, the modeling component was designed. The EX-MARE system is based on a scenario approach implied the consideration a variety of possible futures taking into account the existing uncertainty. Accurate extreme events estimation requires automated monitoring systems and long-term database application. In the paper, the detail description of the system components and the data sources is examined. Three case studies about the sea surges, flash flood and ice conditions researches demonstrate the application of the EX-MARE system and the benefits of its using. Further development of the EX-MARE system assumes adding data on exposure and vulnerability to perform the risk assessment, as well as focusing on multi-hazards exploring methodology.

INTRODUCTION

Extreme hydro-meteorological events – a major threat to the safe interactions between nature and society. The assessment of the extreme events (natural hazards) impacts and their consequences is important in spatial planning and resource management.

The beginning of XXI century was marked by a number of notable disasters connected with weather in the Sea of Azov and the adjacent region:
- flash floods on the rivers of the Western Caucasus (the Adagum River, 2012; Dagomys, Khosta, Kudepsta, Mzymta rivers, 2015) with high damages and losses (Matishov et al. 2012; Matishov et al. 2014c);
- strong storm in the Kerch Strait (November

11, 2007) when 11 ships wrecked and there was an oil spill (1,200 tons) (Matishov et al. 2013);

- two extreme sea surges in the delta of the Don River in March 2013 and September 2014 (strongest flooding in a century, the similar flooding in the delta of the Don River was recorded in September 1914) when 20 and 26 settlements respectively were affected (Matishov and Berdnikov 2015);

- extremely cold winters and vast areas of ice in the southern seas – anomalous situation similar to a large-scale degradation of the ice in the Arctic. The extremal ice conditions in 2006, 2008, 2012 years in the Sea of Azov caused significant harm to navigation (Matishov et al. 2014b);

- "blooming" of water as a result of the algae mass reproduction is extremely actual and typical phenomenon of the Sea of Azov region. An excess amount of organic matter can cause a dramatic deterioration of the water oxygen regime that can be accompanied by the aquatic organisms massive death (so-called hypoxia phenomena), especially fish and benthic. Moreover, in areas with high algae concentration microorganisms can produce toxins posing a threat to human health (Matishov and Kovaleva 2010);

- during the recent decades the Sea of Azov coast has been destroying intensively by both natural and anthropogenic factors. More than 50% of the Taganrog Bay coastal zone is the area having high risk of landslide (Ivlieva and Berdnikov 2005).

Localization of such natural hazards in the region of the Azov Sea requires the development of a forecasting system based on the experience of domestic studies taking into account regional specifics. Many foreign hazards forecast systems are designed for completely different landscape and climatic conditions and are aimed at one type of extreme events, while in the region of the Sea of Azov there is a need to predict different, but interconnected hazards.

To address these issues, we started the development of the forecasting system of extreme hydro-meteorological events in the region of the Sea of Azov (EX-MARE) in summer 2014.

Currently for the Sea of Azov there is only one publicly available forecasts for wind waves. This is a product of system for operational wind wave forecasting in the World Ocean and seas of Russia developed at the Russian Hydrometeorological Centre since 2010 (Zelen'ko et al. 2014). The forecasting is performed through the computations with wind wave spectral models WAVEWATCH III v.3.14. Forecasts are available through the ESIMO operational module (http://hmc.meteorf.ru/sea/).

Many articles are devoted to storm surges modeling in the Sea of Azov (Tikhonova et al. 1995; Ivanov et al. 2008; Krukier et al. 2009; Sukhinov et al. 2011; Datsyuk et al. 2014; Fomin et al. 2015; Popov and Lobov 2016; Popov and Lobov 2017; etc.). Immediately after the catastrophic flood on September 24, 2014, in Russian Hydrometeorological Centre started work on creating an operational model for level and currents in the Sea of Azov (Popov and Lobov 2016). In the spring of 2015, this model was implemented into the ASOOI system (Popov and Lobov 2017), but in public access forecasts are still not available. The mean absolute error of sea level for comparison with observations at coast stations is in the range of 5-11 cm.

There is a much less articles devoted to forecasting the ice conditions of the Sea of Azov. In (Dumanskaya 2013) presents a long-term forecast (two to eight months) of ice conditions in the ports of the non-arctic Russian seas, based on physic-statistical dependencies. The model from (Dashkevich et al. 2016), which allows perform historical reanalysis as well as operational forecasting, is used in the EX-MARE system.

Forecasting of floods in the Sea of Azov region is connected with the Kuban River. The flood forecasting and early warning system for floods on the rivers of the Caucasus Black Sea coast and the Kuban basin is described in (Borsch et at. 2015). The automated system developed for this region includes methods for obtaining a every day forecast of flows and water levels on three day for 30 river sites (but it not include sites on the Adagum River).

Detailed modeled reconstruction of extreme storm in the Kerch Strait (November 11, 2007) and it consequences are presented in (Oil spill accident... 2011).

The practical absence of public forecasts for the Sea of Azov (with the exception of wind waves) confirms the importance of developing such a system. At the same time, the main task of developing EX-MARE was not so much the development of new models (since the most of them was already developed and tested), how much joining them into a single system. The EX-MARE system runs in test operational mode since 2015, so there is still not enough data to fully assess the quality of all forecast models.

In this paper, we describe the system configuration, the approaches used while it was developing, and the examples of its use.

MATERIALS AND METHODS

EX-MARE development is based on a system approach. It implies a design of unified concept and architecture that allow incorporate models and techniques developed to predict and assess a risk of natural hazards into integrated software package.

The EX-MARE system has created as a decision support tool, thereby allowing user to specify "issue", receive a response and use it in the decision making process. A question addressing to the system is formulated as a scenario. In context of natural hazards risk assessment, a scenario can be defined as a possible events sequence built to research cause-effect relationships.

The key idea of a scenario approach is to consider a variety of possible futures: to make alternative calculations with data corresponding to different situations. The focus on accommodating uncertainty is fundamental to the scenario as a methodology (Selyutin at al. 2009). Such an approach yields good results under conditions of high uncertainty, where traditional prediction methods give errors due to differences in the evaluation of input

data. Scenarios allow us to understand under what conditions an unfavorable situation may arise, and help to assess how it is possible to influence the processes leading to acceptable and unacceptable outcomes. Scenarios can provide a possibility to use different forecasts, the same forecast, but with different model parameters, and the synthetic situations – not predictable, but potentially possible cases characterizing the "worst" situation, etc.

In the EX-MARE framework, we examined the following extreme hydro-meteorological events:

1. Flash floods on the rivers of the Western Caucasus.
2. Extreme storm surges in the delta of the Don River.
3. Strong storms: wave loads and ships wrecks.
4. Cold winters and extreme ice condition.
5. Algal blooms and oxygen depletion (hypoxia and fish kill).

The EX-MARE system was designed to assess the natural extreme events risk in the basin, the coastal zone and the water area of the Sea of Azov to warn local governments, households and businesses. A prerequisite for such forecast system creating is the presence of the following components:

- automated monitoring system;
- regular field studies;
- long-term databases;
- good-quality regional meteorological forecasts;
- models validated on regional observational data.

In Fig. 1, the architecture of EX-MARE system is presented. It consists of the subsystem for the data load, the scenarios constructor, the modeling subsystem, the data processing subsystem, the visualization subsystem, and the data storage.

The Modeling subsystem is based on a modular principle of models system forming, allowing a sequential simulation when the output of one module is the input of another one. EX-MARE includes the several model components implementing specific methods of the extreme hydro-meteorological events forecasting. Each model component comprises one or several numerical models and the
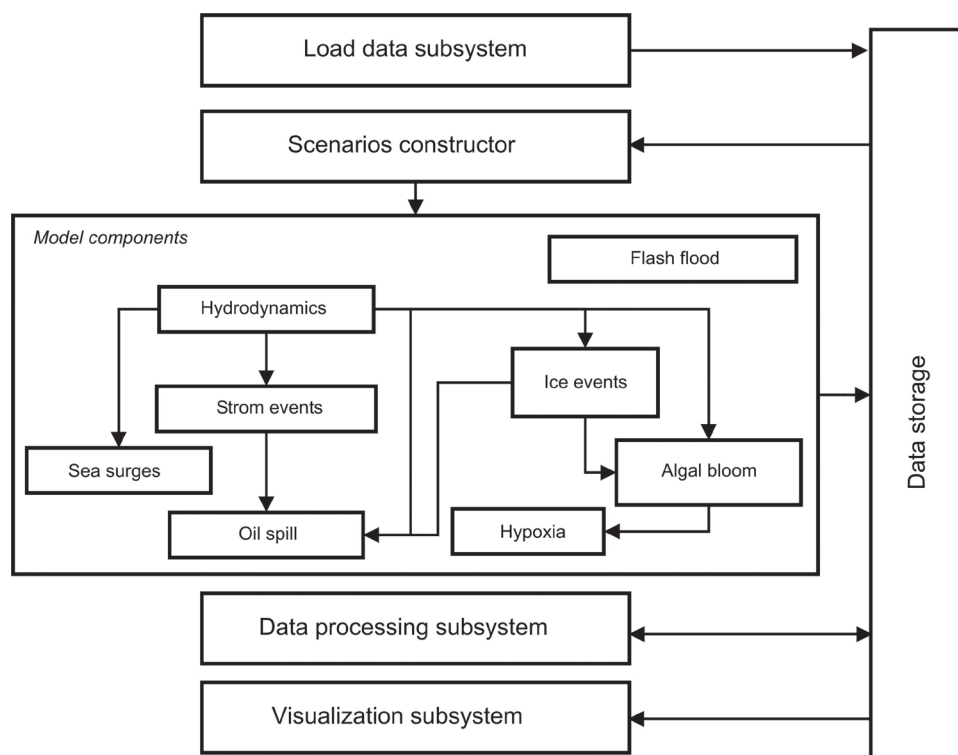
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Fig. 1. Architecture of EX-MARE system

controller responsible for running the model and the data processing procedures in the desired order. It should be noted that the using models are independent software with their own formats of input and output files. Data processing procedures are designed to perform the necessary file format conversions to interact with the data storage.

The "Flash flood" component uses two hydrological software packages: HEC-HMS (Hydrologic Modeling System) and HEC-RAS (River Analysis System), which are is products of the Hydrologic Engineering Center within the U.S. Army Corps of Engineers (www.hec.usace.army.mil/software/). HEC-HMS is designed to describe the physical properties of river basins and to simulate the precipitation-runoff processes. HEC-RAS models the hydraulics of water flow through natural rivers and other channels. HEC-RAS implements one- and two-dimensional modeling of flow as well as sediment transfer modeling capabilities. In "Flash flood" component the Adagum River was chosen as test object.

To model currents and surface level the three-dimensional hydrological model "The Sea of Azov Surge Model" (SASMO) was used. It was developed in SSC RAS (Chikin 2009; Datsyuk et al. 2014). For a numerical realization of SASMO the decomposition of the simulation area into the shallow-water and the deep water layers and finite-difference methods were used. Parallelization is performed in the paradigm of "shared memory" using the communication MPI library. The spatial resolution of the model in latitude and longitude is 685 m and 660 m, respectively. Vertically it has 30 uniformly distributed levels. Integration time step is 2 min. The input data include bathymetry of the Sea of Azov and the wind fields with 3 hours time step.

In the "Sea surges" component SASMO is coupled with HEC-RAS. The flood area in the Don River delta is calculated in HEC-RAS using a sea level (the SASMO output data) as the input data.

In the "Storm events" component the model SWAN developed at the Delft University of Technology is used. SWAN is a wave model for obtaining of realistic wave parameters in coastal areas, lakes and estuaries at given wind, bathymetry and currents conditions. It was customized to the Sea of Azov conditions (Tretyakova and Yaitskaya 2015; Yaitskaya 2017).

SWAN allows implementing the nested grids technology. Scheme with three levels of nested grids is applied for the Sea of Azov. The coarsest grid (first level - meshes size is 0.1°×0.1°) is used for both the Black Sea and the Sea of Azov. The fine grid (second level - meshes size is 0.01°×0.01°) is used for the Sea of Azov only. The finest grids (third level) are used for some coastal areas especially prone to abrasion with meshes size 0.001°×0.001°. Time step is 15 min in according to recommendations of developers and our computer experiments (Yaitskaya 2017). The input data are the following: wind fields (from meteorogical forecast) and sea currents fields (from the "Hydrodynamics" component). The wind wave forecasts perform for the ice-free period.

The "Storm events" component also uses the methodology of the Marine Hydrophysical Institute of RAS, Sevastopol (Kushnir et al. 2013) to assess the wave load in the coastal areas.

The "Ice events" component implements methods forecasting ice cover and ice thickness in the Sea of Azov. It includes the compartmental hydrological model of the Sea of Azov developed in SSC RAS (Berdnikov 2006). This model allows carrying out retrospective and predictive simulation of the ice regime based on the equations of water, salts and heat balances. The simulation results are compared with the the remote sensing data processing results. Detection of areas with the presence of sea ice is based on the Normalized Difference Snow Index (NDSI) (Hall 2014). To calculate NDSI the MODIS Terra/Aqua data are used.

NPZD (nutrient-phytoplankton-zooplankton-detritus) model of the Sea of Azov is used in the "Algal bloom" component to allocate zones with high level of harmfull algae concentrations. Depending on the time step, the NPZD model explores short-term, seasonal or interannual variability of primary production and nutrient balance associated with river runoff variations and meteorological characteristics. The model output data are primary production and biomass of phytoplankton. The model input data are the river runoff, water exchange with the Black Sea, precipitation, solar radiation and concentration of allochthonous dissolved and suspended organic matter and nutrients in river runoff. The "Algal bloom" component uses one more method to assess primary production. It is based on the chlorophyll-a concentration estimation using satellite images. It should be noted that the highly productive waters of the Sea of Azov are characterized by the high turbidity reducing the accuracy of proven methods for chlorophyll-a concentration estimation by satellite images. Therefore the NIR–Red algorithm (Moses et al. 2009; Moses et al. 2012; Moses et al. 2014; Gitelson et al. 2011) for the estimation of chlorophyll-a concentration in the productive and turbidity waters was used.

The "Hypoxia" component carries out the forecasts of the dissolved oxygen concentration in sea and generates the dissolved oxygen depletion maps. It contains 1D mathematical model of oxygen regime, describing the seasonal variation of the oxygen concentration, its vertical distribution and interaction with sediments (Kulygin et al. 2016). The input data of the "Hypoxia" component include the wind speed, water temperature, primary production and reservoir bathymetry (digital elevation model (DEM)). The output data are vertical distribution of oxygen and the labile organic material in each point of DEM. Based on this information the maps of the oxygen depletion areas and, accordingly, of the hypoxia risk are created. The risk of oxygen depletion is calculated as the frequency (probability) of situations reducing the oxygen concentration at a certain depth below a specified critical threshold.

The "Oil spill" component implements methods of the Sea of Azov oil pollution forecasting in case of the emergency spills during transportation by ships. The component includes two models: MEDSLIK (Oceanography Center of the University of Cyprus) (http://www.oceanography.ucy.ac.cy/medslik/) and the SSC RAS oil spill model (Kulygin and Berdnikov 2013). The input data are the following: wind fields (from meteorogical forecast), sea currents fields (from the "Hydrodynamics" component), wave parameters fields (from «Storm events» component). To perform simulation the spill conditions are set: spill location and time, volume, composition of oil fractions. The models output is the distribution of the oil products concentration in the sea area and the coastal zone. It allows building maps with the probable location of oil spills in the water area, as well as a risk map of the coastal zone pollution.

The input variables of all components are exogenous hydrometeorological factors, as well as control (scenario) parameters.

For performing numerical experiments, it is necessary to have a set of scenarios characterized by a certain probability. The scenario constructor is an algorithm used to create various scenarios. It includes the environmental conditions generator simulating stochasticity effect. The constructor core is the scenario assembly module. Scenario within the EX-MARE, in addition to the description, contains a set of the input data, model parameters, initial and boundary conditions values. Thus, scenarios constructor provides input data sets for specific model calculations. One type of scenario can be used during the model validation, the other in retrospective simulations, and the third for operational practice.

The scenario approach allows to use of a group of forecasts (ensemble) for a number of slightly different initial conditions and/or different meteorological forecasts. The ensemble mean gives a better (in comparison with a single deterministic forecast) estimate of the predicted characteristic, and the variance of the prognostic characteristics in the ensemble can be considered as a measure of the uncertainty of the forecast.

Main goal of the load data subsystem is collecting of all available observations and weather forecasts for the region of interest. Retrieving data from the databases is performed in automatic regime. The load data subsystem is a set of scripts providing timely preparation of all environmental parameters necessary for initialization of the modeling subsystem. In fact, for each data source (observations, forecasts, remote sensing data), a specialized procedure for automatic or semi-automatic data loading is implemented.

Data processing subsystem is a set of procedures performing the aggregation of the information to compare it with available observation data, convert it into spatial formats and so on. The comparison with the observational data provides a quantitative measure of the models quality as well as a possibility to identify the models parameters changes that need to be done. Visualization subsystem is based on ArcGIS (ESRI) software and consists of the projects with predefined structure of layers and its data sources.

The data storage is a hub providing the interaction between all functional components that not communicating directly, and use storage to record or retrieve data. Metadata catalog service is designed to search available datasets in the data storage. Whenever new dataset enters the data storage, the information about them is automatically added to the metadata catalog. The data storage accumulates datasets obtained as a result of computational experiments, along with data collected by monitoring systems.

The data storage includes: database, containing the service information; catalog of datasets which presented files in netCDF format containing forecasts, observing systems data and results of scenario calculations; catalog of satellite images; and spatial database.

Data sources

The meteorological forecasts are considered as "input" information for the EX-MARE system. The global and regional forecasts available for free are preferable. The main forecasts sources are the following.

Global Forecast System (GFS) is a weather forecast model produced by the National Centers for Environmental Prediction (NCEP). Gridded data (with 0.25 degree of resolution) are available for downloading through the NOAA National Operational Model Archive and Distribution System (NOMADS) (http://nomads.ncep.noaa.gov/).

COSMO-RU System of Nonhydrostatic Mesoscale Short-range Weather Forecast of the Hydrometcenter of Russia. Gridded data (with 7 km of resolution) are available on ESIMO portal (http://portal.esimo.ru).

Yr online weather service provides forecasts from Norwegian Meteorological Institute (http://www.yr.no). In public access there are available only forecasts for individual locations (34 location for the Sea of Azov region).

Weather service «Raspisaniye Pogodi» (https://rp5.ru) provides Met Office forecasts for different locations (76 location for the Sea of Azov region).

For parameterization and validation of EX-MARE model, modern and historical (for the long period) observational data are required. The following databases are used:
- database with observations at hydrometeorological stations of the Roshydromet (Federal Service for Hydrometeorology and Environmental Monitoring of Russia) network;
- database with observations at Emersit network stations;
- database with observations at SSC RAS stations;
- oceanographic database of the SSC RAS.
Database of hydrometeorological stations observations contains data published at RIHMI-WDC (All-Russian Research Institute of Hydrometeorological Information – World Data Center) and ESIMO portal as well as historical data digitized from paper archive.

The Emersit network includes about 200 stations located on the rivers of the Krasnodar and Rostov regions and on the Sea of Azov coast. Most of these stations have sensors for sea/river level observation. Some of them are equipped with sensor of the following meteorological parameters: air temperature, air humidity, atmospheric pressure, precipitation (quantity, type, intensity), wind direction and speed.

In 2016, the Southern Scientific Center of the Russian Academy of Sciences and the Institute of Arid Zones of the SSC RAS joined to the Pan-Eurasian Experiment (PEEX, https://www.atm.helsinki.fi/peex) as associate members. Since 2004, a network of meteorological and hydrological posts in the Azov-Black Sea region has been developing by SSC RAS to monitor and predict the impact of climate change and human activities on the marine environment. Four stations of the SSC RAS are included in the PEEX catalog: "Kagalnik", "Donskoy", "Vzmore", and "Manych". The first two stations are located in the Don River delta, the third one – in the Taganrog Bay, the fourth one – in the Manych River valley. The database of SSC RAS stations contains observations of the sea level, ice conditions, meteorological and hydrochemical parameters for the period 2004-2017.

The oceanographic database of the SSC RAS was formed as a result of the ecosystem researches conducted in the South of Russia by the SSC RAS and IAZ SSC RAS, as well as a result of the search and archiving of historical data. In 2014, a new version of the Atlas of Climate Change (Matishov et al. 2014a) was published. It contains the most complete publicly available oceanographic databases of the Sea of Azov (about 66 000 marine stations for the period 1891-2012).
Remote sensing data are presented by free satellite images (Landsat, MODIS, MERIS etc.) available from the following data sources:
- NASA Physical Oceanography Distributed Active Archive Center (PO.DAAC) (http://podaac.jpl.nasa.gov);

- NASA Ocean BiologyDistributed Active Archive Center (OB.DAAC) (https://oceancolor.gsfc.nasa.gov/);
- Copernicus Marine environment monitoring service (http://marine.copernicus.eu).
The EX-MARE utilizes datasets with different processing levels (L1 to L4).

Workflow of the EX-MARE system

The interaction between the components is implemented in form of the task queue with using the Advanced Message Queuing Protocol (AMQP). AMQP is a messaging protocol that enables conforming client applications to communicate with conforming messaging middleware brokers. Messaging brokers receive messages from publishers (applications that publish them, also known as producers) and route them to consumers (applications that process them).

One of the EX-MARE components (publisher) is the initiator of the task. At some point in time, it sends the task message to the queue. The other component (consumer) is in the waiting mode while there is no any message in their queue. When message is in the queue AMQP brokers deliver it to consumers subscribed to queues and consumer immediately begins task execution.

The main types of EX-MARE tasks are downloading information from external sources and starting modeling calculations. Tasks related to the first type are processed by the load subsystem, tasks of the second type - the modeling subsystem. After the completion of the task, if it was successful, the task is placed in the archive, in case of an error in a special errors queue. This allows you to restart the task (moving it back to the working queue) after finding out the cause of the error.

Since AMQP is a network protocol, the publishers, consumers and the broker can all reside on different machines.

RESULTS AND DISSCUSION

The EX-MARE computer equipment consists of 4 computers (Intel Xeon Processor 4 core, 2.80 GHz; 16GB RAM), located in the local network of the SSC RAS, and 16 virtual machines (VM), running on this computers and joining in one sub-network. Each EX-MARE component (model components, data storage, load data subsystem, etc.) is running on one of the VMs. The system organization as a private "cloud" allows, if needed, to deploy the developed software to the global "cloud" systems. The time for preparing the forecast for 72 hours is about 10 minutes.

The EX-MARE system has been running in test mode since 2015. It was used for both operational forecasts and retrospective/special case scenarios.

Operational forecasts are prepared according to the schedule. In the automated mode, the following processes are performed: loading data from external sources into the data storage; creation of basic (daily) scenarios as inputs for corresponding model components; simulation and subsequent results processing with their publication in the data storage.

Some examples of the EX-MARE using for modeling extreme hydro-meteorological events are presented below.

Modeling of the extreme storm surges in the Don River Delta

Since the launch of the EX-MARE in 2015, more than 60 calculations of storm surges have been carried out. Forecast of the water level in the delta was performed each time when the forecast wind has western component and velocity exceeded 8 m/s. The actual number of dangerous surges in the Don River delta (when the water level exceed 1.3 m in Baltic height system (BK77)) according to the data of the automatic level gauge on the "Donskoy" station was 25 for the period 2015-2017. Five of them took place in 2015, 10 in 2016 and 10 in 2017. Most dangerous surges were within the April.

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The forecast of the level dynamics (maximum value and its achievement time) in general corresponds to the observation data (Fig. 2) (Tretyakova et al. 2016). The mean absolute error (MAE) of the water level is 10 cm (mean relative error (MRE) is 12%) for the first 24 hours. MAE of time reaching the maximum level is 3 hours. The forecasting error significantly depends on the accuracy of the used wind forecast. Analysis of the calculation results and input wind fields showed that the deviation of the wind forecast from the actual within the range of up to 3 m/s slightly affects the result of the calculations. With increasing this difference, the error of level forecast becomes larger. The most frequent case is overestimate value of wind speed, which leads to a higher simulated water level.

The EX-MARE also was used to reconstruct two catastrophic surges occurred in March 2013 and September 2014. The results of the calculations showed a good coincidence of the dynamics in the water level rise and its maximum value, however, the decline of water level was inaccurate (Fig. 3) (Yaitskaya and Tretyakova 2016).

Modeling of the extreme flash flood in the Adagum River Basin

Models of "Flash flood" component were tune on the observations of July 2012 flood. The extreme intense rainfall 6-7 July 2012 in the mountain area of the northwest Caucasus caused the formation of the flash floods in the basins of the rivers Adagum, Tsemes, Yashamba, Abin. This flood has led to large property damage and numerous human deaths, especially in Krymsk town.

Since 2012 catastrophic floods in the Adagum River basin have not been observed. At the same time, "Flash flood" component was used to assess the impact of the littering of the bridge openings in Krymsk on the flood. There were considered two scenarios: open and close bridge openings. Fig. 4 shows the flood zones in the vicinity of Krymsk and the profiles of the water surface under different scenarios. Total flood areas of both scenarios are similar, but there are differences in the flooding mechanism: in case of "close" scenario, hydraulic heads are formed near the bridges. Nevertheless, we can conclude that in the case of so extremely high runoff as was in July 2012, the degree of littering of
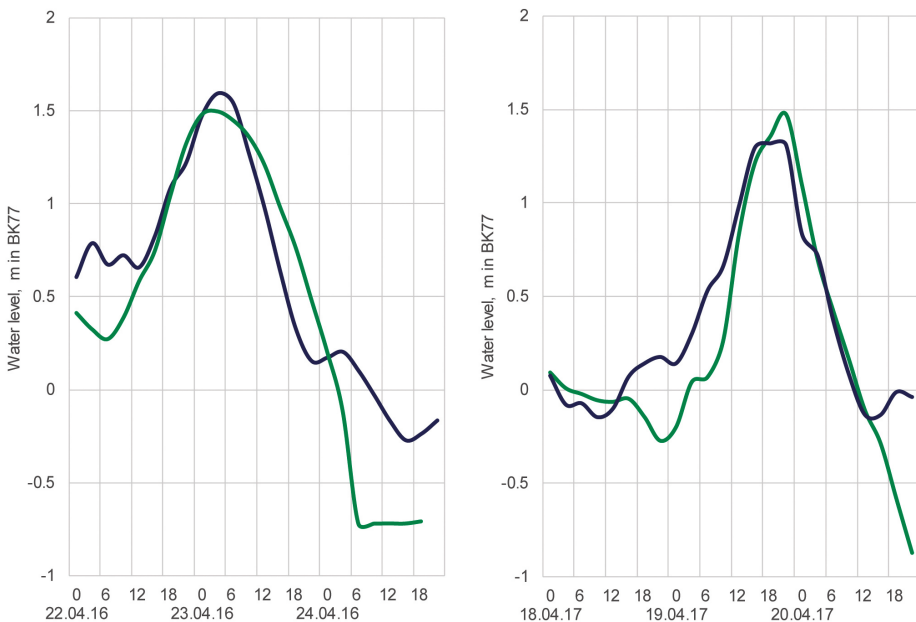

Fig. 2. Forecast of surges in April 2016 and 2017 (green line - forecast, blue line - actual values)
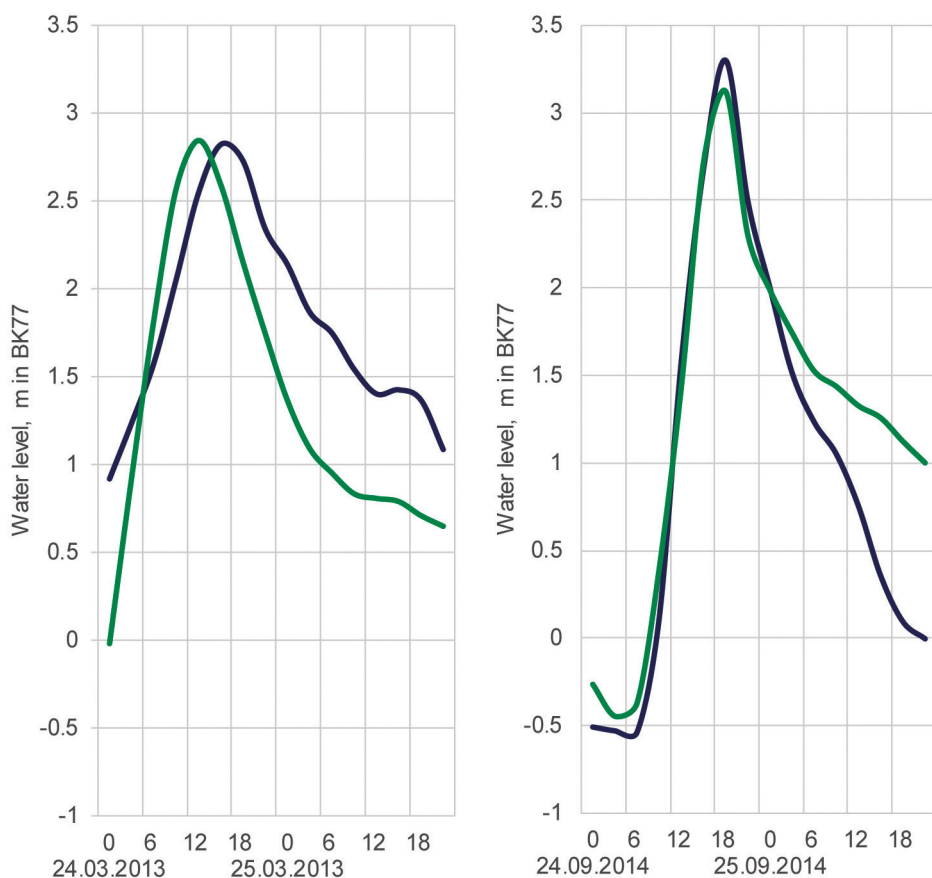
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Fig. 3. Reconstruction of extreme surges in March 2013 and September 2014 (green line - forecast, blue line - actual values)

the bridge openings did not have a major influence on the flood development.

In (Alekseevsky et al. 2014) presented results of similar experiments. Maximum flood depths in Krymsk were calculated a) without bridges in the Adagim river and b) in conditions of consider bridges as dam. In (Alekseevsky et al. 2014) was shown, that bridge backwater influence only 2-km zone upstream and downstream of bridges. These results are consistent with the flood zones on Fig. 4.

"Flash flood" component was used to compare impact of different river channel transformation on development of floods. After the 2012 flood, the channel of the Adagum River was transformed: straightening and concreting of the channel was made to decrease channel bed roughness and length of flow path,

and increase flow velocity. It was shown that effective reduction of the flooding area in the case of strong floods (like in July 2012) requires not only straightening and concreting channel bed, but regular cleaning of the transformed channel and existing bridge openings or significant reconstruction of bridge structures.

The using of the "Flash flood" component for different areas is also possible in case of existence of detailed digital terrain model and a surface roughness map (vegetation cover, built-up areas, etc.).

Modeling of the ice condition in the Sea of Azov

"Ice events" component makes automated forecast of the Sea of Azov ice condition only in cold season from November until April. Monitoring and forecasts data from
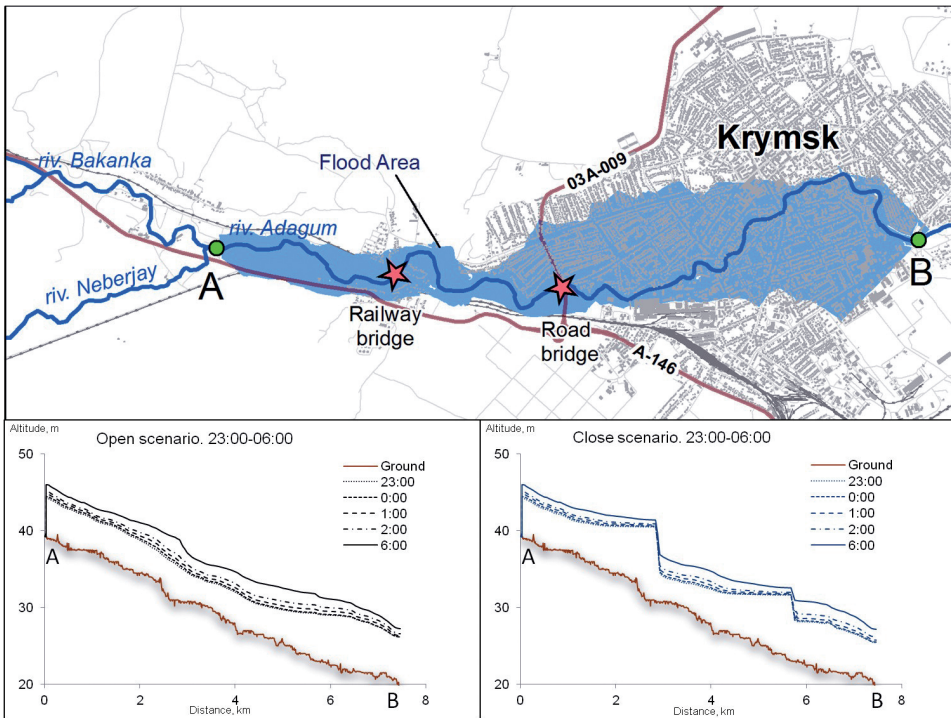
Fig. 4. Flood area and water surface profiles of "Open" and "Close" scenarios (6-7 July 2012)

the coastal weather stations are using as model inputs. The simulation results are compared with values of ice cover and water temperature from MODIS (Terra/Aqua) satellite data and with observations of the ice thickness in the ports and in the "Kagalnik" station. It was shown (Dashkevich et al. 2016) that the model can be used for creating a historical reanalysis of the Sea of Azov ice cover, as well as for operational forecasting.

Fig. 5 shows long-term dynamics (1920 to present) of the Sea of Azov ice cover and thickness annual values. Easing of ice conditions in the modern period can be noted. Average ice extent of the Sea of Azov in the beginning of the XXI century is 16%, which is almost 2 times less than in the middle of the XX century. However, despite a significant decrease of ice cover square and duration of ice period, in the last decade the average ice thickness according to the simulation results has been decreased slightly.

Modeled ice cover averaged over the winter season for the period of 1920-2016 (Fig. 5) are in good agreement with observational data in 1950-1977 (Hydrometeorological… 1986) and assessment of the ice cover based on the MODIS images in 2005-2017 (Dashkevich et al. 2016): mean absolute error is 5.2%, correlation coefficient is 0.92. During the winters 2015/16 and 2016/17 model was work in the short-term (3 days) forecasting mode (Dashkevich et al. 2016). The predicted ice cover was compared with the satellite monitoring data for individual compartments (only compartments where there was no cloud were used in comparison). The MAE was 20% with a standard deviation of 32%. The model reproduces period of the ice cover development better than the ice decreasing period. This is probably due to not taken into account the ice drifting, which has a significant role in the spread of ice in the Sea of Azov. The relatively low quality of short-term forecasts, compared to the long-term retrospective, can be explained by the low spatial resolution of the model.

Risk assessment and multi-hazards

EX-MARE has been designed to simulate the physical, chemical and biological causative factors, but it does not provide a hazard risk assessment in terms of economic objectives or performance criteria of activities.

Risk is defined as the probability of harmful consequences, or expected losses (deaths, property, or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions (EC 2011). Risk can be schematic represented as the multiplication of three components: hazard, vulnerability and quantification of the exposed elements-at-risk.

Hazard is a potentially damaging physical event, phenomenon or human activity that may cause the loss of life, property and infrastructure damage, environmental degradation (UNISDR 2009). This event has a probability of occurrence within a specified period and within a given area, and has a given intensity.

Exposure (i.e. elements potentially at risk) represents the presence of people, livelihoods, environmental services and resources, infrastructure, or economic, social or cultural assets in places that could be adversely affected (UNISDR 2009). The way

to characterize the amount of elements-at-risk (e.g. as number of buildings, number of people, economic value) also defines the way in which the risk is presented (Van Westen and Greiving 2017).

Vulnerability represents the propensity or predisposition of a community, system, or asset to be adversely affected by a certain hazard (UNISDR 2009). It can be subdivided into physical, social, economical, and environmental vulnerability.

The multiplication of risk components given above is not only a conceptual equation, but can also be actually calculated to quantify risk from different hazards. EX-MARE can be used to generate hazard data. For each hazard type (e.g. flooding, storm, oil spill) so-called hazard scenarios should be defined, which are hazard events with a certain intensity and frequency. Modeling components are used then for the hazard scenario analysis. To perform complete risk assessment it is necessary to extend EX-MARE system with exposure and vulnerability data.

One of the difficult issues in natural hazards risk assessment is how to analyse the risk for more than one hazard in the same area, and the way they interact (Van Westen and Greiving 2017). Nowadays EX-MARE is utilized standard single hazard approach,
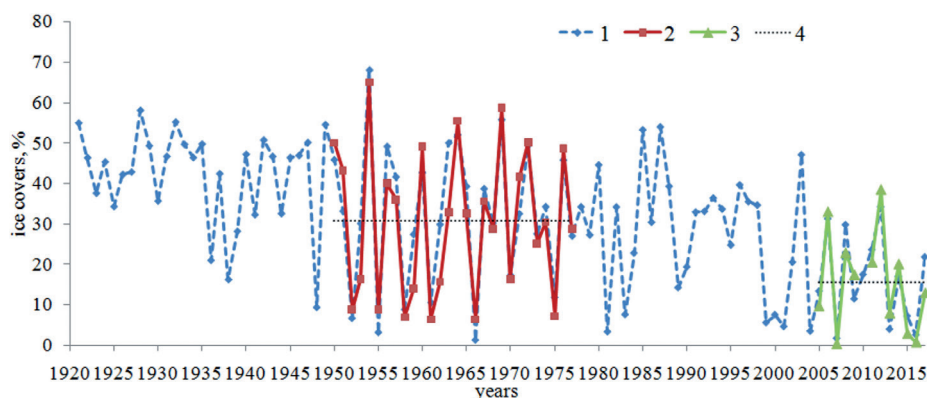

Fig. 5. Long-term ice cover of the Sea of Azov. 1 – simulation data; 2 – data according to (Hydrometeorological…, 1986); 3 – assesment based on the MODIS data (Dashkevich et al. 2016); 4 - average value

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in which hazards are treated as isolated, independent phenomena. Compared to single processes, methodological frameworks for multi-hazard risk assessment are less common in the literature, which is related to the complex nature of the interaction between the hazards, and the difficulty to quantify these (Kappes et al. 2012). Total risk within EX-MARE can be assessing as weighted sum of all considered hazard risks. The methodology (Kulygin 2017) allows estimating the weights of hazards taking into account their interaction.

The successful implementation of a comprehensive multi-risk assessment into management strategies should require the identification of the final users (e.g. local administrations, national institutions). Therefore, only after identification of stakeholders and their needs, and involvement them in the process it is possible to obtain adequate results.

CONCLUSIONS

The proposed EX-MARE system is a complex modeling platform, containing tools for the preparation and execution of calculations. It provides short-term forecasts for such hazards in the Sea of Azov region as flash floods, sea surges, strong storms, extreme ice conditions, algal bloom and oxygen depletion, oil spillage.

The structure of the EX-MARE allows expanding the system both by adding new methods of hazards risk assessment and by adding new hazard types. Presented approaches to development and organization of this system can be used while the forecasting systems for other regions are designing.

The practical application of the system would increase reliability of the decision making process results concerning the public informing about the expected hazards, thereby reducing the possible socio-economic damage.

At present, the accumulation of prepared forecasts continues, and later a detailed assessment of the quality of all EX-MARE models will be made.

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ENVIRONMENTAL FACTORS AND CONSTRAINTS IN THE DEVELOPMENT OF THE NEW TERRITORY OF MOSCOW (SO-CALLED «NEW MOSCOW»)

ABSTRACT. The article considers the main trends in the environmental situation in the New Moscow in connection with the acquisition of capital status and rapid population growth. The New Moscow is the territory annexed to Moscow as part of a large-scale project to expand the territory of Moscow at the expense of the Moscow oblast in July 2012. Under the influence of both hereditary and transformational factors, the situation in Moscow new adjoint area is rapidly deteriorating, and for Moscow in the old borders inherited factors are mostly negative for the formation of the environmental situation, and the transformation is in the direction of slow and gradual improvement.

In Moscow new adjoint area the structure of pollution sources is linked to the post-industrial type of cities (heating systems and other non-industrial sources, vehicles), as the most non-industrial part of the Moscow region was chosen to join the capital. The level of pollution is low, but the environmental efficiency is also low and the level of pollution is growing rapidly. The decline in production and structural changes in industry, as well as the growth of the car fleet, the change in traffic conditions along the roads, led to a change in the territorial proportions in atmospheric pollution in Moscow, both in the old and new boundaries, and the scale of housing construction in Moscow new adjoint area led to a pressure on water sources and changing natural landscapes.

KEY WORDS: Air pollution, solid wastes, integrated analysis, environmental conditions, environmental quality, new territory of Moscow, New Moscow, environment of Moscow

INTRODUCTION

The great urban agglomerations are bound to regions where the anthropogenic influences of recent years combine with one another. Above all this applies to the Moscow capital region, where the impact of the large-scale economy, which attracts investment and labor, intensifies the pressure on the infrastructure from automotive transport, the problems with waste-processing, deforestation, the shrinking of the environmental structure, and the exhaustion of water resources.

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Even the growth of the service sector leads only to additional traffic jams, wastes, and noise pollution in the old transport structure.

The regions where the anthropogenic impact shifts in recent years include the largest urban agglomerations, and above all the Moscow metropolitan region, where economies of scale effect, attracting investments and labor, creates an increased load on the infrastructure from motor vehicles, problems of waste disposal, cutting down forests, reduction of the environmental framework, depletion of water resources. Even the increase in service functions on the old transport basis only leads to an increase in traffic congestion, emissions and noise pressure.

Current studies of the topic

The New Moscow is the territory annexed to Moscow as part of a large-scale project to expand the territory of Moscow at the expense of the Moscow oblast in July 2012. It is an area where the environmental situation is rapidly changing under the influence of a number of factors, including as a result of the acquisition of the capital status. Capital cities in countries with economies in transition have become the main beneficiaries of changes in the economic system, post-industrial growth (Brade and Rudolph 2004; Golubchikov and Makhrova 2013). In the post-Soviet period, the capitals and their suburbs became the main centers for the attraction of migration throughout the post-Soviet space (Nefedova et al. 2016)

Capital cities, as a rule, are the poles of the transformation of the environmental situation: they create the majority of innovations provoking new environmental conflicts and create technologies aimed at reducing the anthropogenic impact on the environment of cities, they concentrate an increasing proportion of the population, but do not show growth reduction, which is caused by the restructuring of sources of anthropogenic impact, the introduction of environmental technologies and development programs (Koldobskaya 2014).

Capitals have a number of features compared to other cities, due to the ongoing large-scale process of urban transformation (new construction, reconstruction), spatial expansion and the presence of agglomeration. The concentration of administrative, political, cultural functions causes the decline of the role of industry as an economic basis and source of anthropogenic impact, and higher requirements for environmental quality - the availability of environmental policy and a master plan for the formation of green wedges and green frame, the creation of environmental infrastructure of the city.

The peculiarities of the environmental situation, typical for the capital cities are:
- an increased level of motorization and the predominant role of mobile sources in pollution is several times higher than from stationary ones (Bityukova and Argenbright 2002; Bityukova and Sokolova 2008);
- the predominant role of the electric power industry in the structure of pollution from stationary sources, which is typical for the postindustrial period and as a result the simplification of the pollution structure ones (Bityukova and Saulskaya 2017, Lokoschenko and Trifanova 2017);
- high level of gross and per capita volume of solid waste with prevalence of household waste;
- the formation of a vast belt of multifunctional country cottages and cottage settlements, both urban and rural housing, used all the year round (Brade 2014);
- clear functional zoning, including delimited residential and industrial areas. For capitals is characterized by the complexity of the functional and territorial structures, infrastructure systems (in the first place - transport).

Moscow was the first city in Russia in which environmental problems were explored from the position of their territorial differentiation due to the scale and contrast of the city(Popov et al. 2016). Since it was in the capital that the real estate market began to develop first, then

there were works identifying the role of the environmental factor in the price of residential real estate (Bitykova et al. 2006).

When assessing geoecological features, the city's capital status was not taken into account at all (Ivashkina 2010; Kasimov et al. 2017), exceptions were only works on the formation of the green framework of the capital (Krasnoschekova 2010).

After the accession to the capital of new territories, the peculiarities of their development are considered in numerous articles without taking into account the environmental factor on the one hand, as a result of the established opinion that the environmental situation in New Moscow is a priori better than in the old Moscow (Makhrova and Tkachenko 2013; Kangas 2013; Büdenbender 2017), and on the other hand, because this territory is not considered a full-fledged metropolitan area, where the requirements for the quality of life put forward by the population are higher (Kuricheva 2014; Tishkov 2014). The environmental aspects of the development of the annexed territories are considered as a description of individual problems (Bogdanov 2015), or a complex of measurements (Lurie 2015). But until the issue of assessing the factors and directions of the transformation of the environmental situation of the given territory was considered, is the current state a continuation or a change in the development vector as a result of the acquisition of the capital status.

Therefore, in this paper, New Moscow was considered against the backdrop of the whole metropolitan region, in comparison with the city territory in the old borders and the neighboring districts and cities of the Moscow oblast.

DISCUSSION

The state of the environment in New Moscow directly depends on the amounts of pollution of the air, water, and soil, as well as the level of noise, which have been changing in recent years due to large-scale housing construction. Moscow and Moscow region form a powerful region, the level of environmental tension in which increases throughout the post-Soviet period. Compared to 1990, Moscow decreased its waste emissions, water use, and sewage discharge twice as rapidly as the countrywide average, while the pace of Moscow Oblast' matched the Russian average. Moscow Oblast' is one of five Russian regions (along with the Khanty-Mansiysk Autonomous Okrug — the leading oil producing region—and the small republics of the northern Caucasus) characterized by growth in sewage emissions. In recent years measurable, if not highly significant, decreases in Moscow's output of pollution have occurred, while the share contributed by the capital region has increased, as is shown in Table 1.

The accession of new territories to Moscow was largely explained by the desire to provide a new quality of solving environmental problems. In 2011 the capital's authorities explained the choice of the land which became Troitskii and Novomoskovskii Administrative Okrugs as having the optimal location for the fulfillment of Moscow's capital functions on the basis of city-building, transportation, and environmental factors, as well as the low level of urbanization (at the time of annexation the population consisted of 250000 residents and the amount of developed space amounted to 12 million square meters). In the early stages the environmental factor was a motivation for development of the territory, but the situation is changing rapidly. Although New Moscow is called the "green lungs" of the capital, there are a number of unhealthy spots where either existing sanitary-hygienic norms are being violated at present or a negative scenario is unfolding. However, it turned out that there are negative trends for these regions, primarily due to the increased impact of road transport and the scale of housing construction.

The goal of the present research is to analyze the transformation and territorial differentiation of environmental stress within New Moscow as compared with Old Moscow and the neighboring territories of Moscow Oblast'.

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Table 1. Shares of the basic indicators of environmental pollution in Russia contributed by Moscow and Moscow Oblast' (%) (Report on the state... 2017; Environmental protection... 2016; Data base of indicators... 2000-2017)

Indicator	Region	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Volume of emissions into the atmosphere	1	2,8	2,7	2,5	3,0	3,1	2,9	2,9	2,8	2,9	3,1	3,2	3,2
	2	6,0	1,3	1,2	1,3	1,3	1,4	1,3	1,3	1,4	1,5	1,6	1,8
Fresh water use	1	4,4	4,5	4,5	4,3	4,5	6,5	6,3	6,0	5,6	6,0	6,1	4,9
	2	4,3	4,1	3,8	1,9	1,8	0,9	0,9	2,5	2,4	2,4	2,3	1,0
Volume of waste water	1	14,6	14,1	13,5	13,3	13,6	13,4	13,3	13,7	14,1	13,4	13,1	12,9
	2	11,1	10,6	10,1	9,84	10,1	5,5	5,7	5,9	6,2	5,8	5,7	5,6
Wastes from production and onsumption	1	3,6	3,5	3,5	3,4	3,6	7,9	7,6	7,8	7,8	7,6	7,5	7,2
	2	0,30	0,19	0,13	0,13	0,10	0,18	0,10	0,10	0,12	0,19	0,11	0,09
Share of GDP in prices 2005г.	1	3,9	4,2	4,6	4,9	4,7	4,9	4,8	4,7	4,7	4,6	4,9	
	2	19,1	19,5	20,1	23,5	19,6	19,0	18,9	19,2	19,3	19,9	19,5	

The rapid and multidirectional development of the territory of New Moscow after 2013 led to the formation of areas with different trends in the transformation of the environmental situation. The changing environmental situation in New Moscow is the result both of transformational factors, which are connected with the change in the territory's status and massive residential construction, and path-dependencies, which determine the level of infrastructure development and the development of the territory.

Pollution of the atmosphere from stationary sources

In the post-Soviet period industrial production in Moscow contracted significantly more rapidly than in Russian Federation as a whole. Simultaneously, the industrial sector's impact on the environmental situation in the city also decreased. The volume of wastes in Moscow decreased to one-fourth the level of 1990, while it was merely halved in the country as a whole. The share of pollutants emitted to the atmosphere from stationary

sources decreased to 6%, which was facilitated not only by explosive pace of automobilization, but also by the decline of industrial production (Report on the state… 2016). However, the rate of decline in emissions from stationary sources is gradually slowing, and this is occurring against a background of continuing contraction of industrial production (considered without taking into account the extractive sector in order to avoid statistical distortion due to the location of juridical addresses of major companies in the capital); therefore, emissions from certain stationary sources are increasing.

The change in the sectoral structure of Moscow's air pollution in the post-Soviet period is explained by a growing degree of localization: 14 of the city's enterprises produced 78% of the city's total pollution from stationary sources in the 1990s, and their share rose to 80-85% in the 2005-2016 period (calculations based on data (Report on the state… 2016).

In recent years the thirteen working power stations and their boiler houses have accounted for 50-65% the volume

of polluted emissions and the refinery has accounted for 20-30%. Moscow has done the most in all of Russia to decrease the volume of emissions from the energy sector, specifically by changing the fuel structure to use natural gas – now 96.7% of the total fuel used—and by reconstructing the stations. The level of power consumption by Moscow's industries is among the lowest among Russian regions; however, since 2005 it has had a strong tendency to grow (Basic Indicators… 2017).

Also above the Russian average has been the rate of decrease in emissions from the oil refinery, which is located in the southeastern region of Old Moscow. The refinery lowered its gross pollution by a factor of 2.2 in the 1992-2000 period after reconstruction and changes in the technological process. The share of machine-building in polluting Moscow's air is down to 2-3 percent. There is no pollution today from the metallurgical complex because of the closing of the metallurgical plant in Moscow's eastern region that had been in operation since 1883.On the other hand, pollution has risen by a factor of six coming from stationary sources of the transportation complex and

other forms of economic activity, such as the start-up of garbage-incineration plants and non-industrial pollution sources which previously were not monitored (Fig. 1). The two percent share of the remaining sectors is accounted for by the production of food products and construction materials (calculations based on Data base Regions of Russia… 2016).

There is no power station complex in New Moscow, but there are boiler houses which use 4.4% of the natural gas consumed by the city and account for 4.5% of the emissions into the atmosphere. Moscow new adjoint area's share of polluted emissions is gradually increasing (Report on the state… 2017).

A transition in the composition of emissions into the atmosphere from stationary sources has been caused by changes in the industrial sectors. Nearly half the emissions consist of NOx while CO accounts for 15%, thanks to the dominance of natural gas in the power sector; the refinery largely accounts for the 16% share of SO2 and 11% share of volatile organic compounds. The structure of emissions in the administrative districts varies little from the average values for the city except
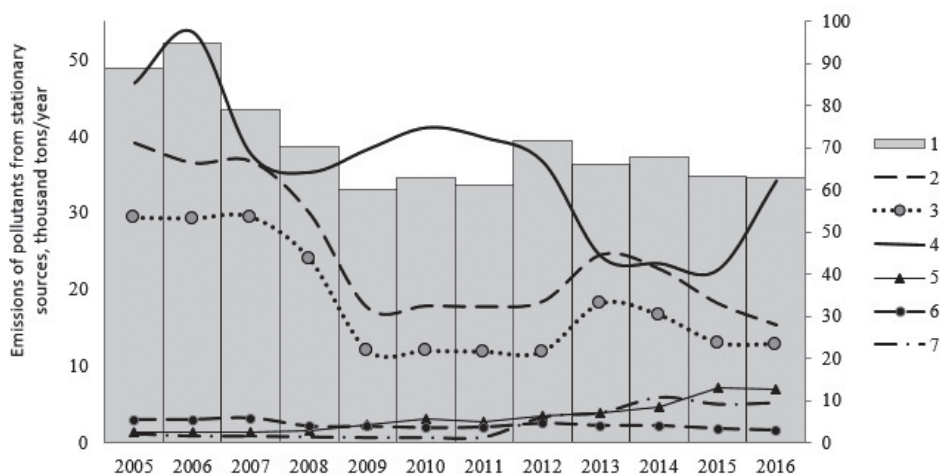
Fig. 1. Total emissions of the most prevalent polluted substances in Moscow's air from stationary sources that contribute more than 1% of the total volume, classed by type of economic activity: 1—Total (right-hand scale); 2—manufacturing; 3—petroleum products; 4—production and distribution of electricity, natural gas, and water; 5—other types of economic activity; 6—production of means of transportation and equipment; 7—transportation and communications

in the southeast, where the share of SO2 rises to 60% in Kapotnya district and to 52% for the whole of the Yugo-Vostochnyi Administrative Okrug, due to impact of the petroleum refinery (Fig. 2) (Report on the state… 2017).

In the 1990-1995 period the decrease in the volume pollutants affected all the ingredients, but after the transition to natural gas beginning in 1995 mainly NOx has accounted for the decrease in emissions. In the 2005-2015 period the emission of solid substances has been curtailed to a great extent (by 59%); sulphur dioxide emission has been halved; volatile organic compounds have decreased by sixty-seven percent. The volume of hydrocarbon emissions is increasing as a consequence of a decrease, from 56% to 40% in the portion of air pollutants that have been retained or rendered harmless by the gas-emission purification installations (calculations based on data (Data base of indicators… 2016).To achieve further reduction in the volume of emissions will be technologically complicated and expensive. In New Moscow the portion of the retained or cleansed emissions is significantly lower and in the majority of the municipalities it does not exceed 1%, with the exception of the urban district of Sherbinka (calculations based on database "Regions of Russia", 2016)

New Moscow is characterized by a low level of pollution; the volume of emissions in the territory constitutes 10-13% of Moscow's total (calculations based on data database "Regions of Russia", 2000-2016). Moscow new adjoint area's percentage share has risen somewhat because in most of Old Moscow's okrugs emissions have declined more rapidly than in the new territories, where they sometimes are growing. The main increase comes from settlements that located along Kaluzhkoe highway, New Moscow's central axis, connected with the presence of gas-pipeline infrastructure (gas-compressor station, which burns natural gas for its operation) leading to Old Moscow. The second important source of pollution is a legacy from the previous period; most of

the boilers are antiquated and use fuel oil, and consequently sulphur dioxide makes up a large portion of their emissions This is a low, but «non-capital» type of pollution, because in the post-industrial period, in the territory of old Moscow, the main sources of pollution are gas-fired power plants.

New Moscow's portion of air pollution, fuel consumption, and emissions from heating systems is 2-2.5 times higher than its share of population. This is the consequence both of the technical obsolescence of suburban boilers and the lower population density, with its spread-out infrastructure, and lower environmental efficiency. However, at the same time the low-density distribution of pollution sources allows for the ventilation of the territory. As a result, according to the monitors, the average concentrations of pollutants registered in Moscow new adjoint area's territories are 10-40% lower than the average concentrations over an analogous period in functionally similar zones in Old Moscow (Report on the state… 2017).

Air pollution from automotive transportation

The main determinant of the state of Moscow's environment is automotive transportation (93.4% of the emissions into the atmosphere).The volume of emissions from automotive transportation in the 200-2016 period rose just by 15% (979 200 tonnes in 2016). Today 10% of Russia's automotive fleet is concentrated in Moscow. The maximum annual growth in the number of automobiles (19.1%) was observed at the beginning of the nineties; thereafter the situation stabilized somewhat until a turning point was reached in 1996, when the growth rate began to decline. In recent years, the annual average growth rate of the city's automobile fleet has declined to a 5%, which indicates market saturation (Database "Regions of Russia" 2016).

Simultaneous with the increase in automobilization, there has been an intensive renewal of the auto fleet with
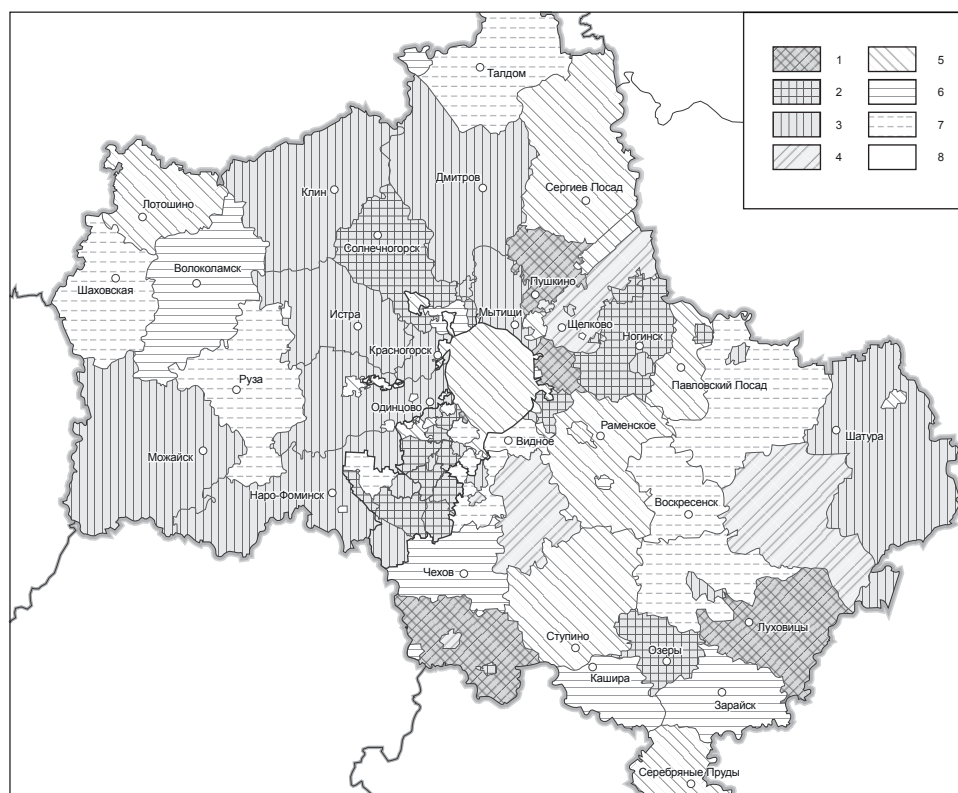
Fig. 2. Index of physical volume of air emissions of pollutants from stationary sources, 2008-2016, % (2008 = 100%) Index: 1. More than 500; 2. From 200 to 500; 3. From 105 to 200; 4. From 95 about 105; 5. From 75 to 95, and 6. From 50 to 75; 7. Less than 50; 8. No data

automobiles of higher ecological classes (approximately 2-3% per year) and a decrease in the proportion of freight-hauling trucks (by about 50% between 1991 and 2006), which have helped improve the environmental parameters of automobile transport. This has been connected simultaneously with the growth in the population's purchasing power and the strengthening of environmental regulations concerning fuel and automobiles.

If you look at the dynamics of emissions from vehicles by type of cities, the rise of the early 2000s was characteristic of all types, to the greatest extent for millionaires, the smallest for small cities. The cities of New Moscow (Troitsk, Moscow and Shcherbinka) stand out even against the background of similar cities in terms of population. The increase in emissions from vehicles differs not only from Moscow in

the old borders, but also from the cities of the near Moscow region (Fig. 3). It is here that in recent years and there has been the most significant increase in emissions into the atmosphere and, as a result of the increase in the number of cars and as a result of the fact that the transport network can not cope with the flow.

The changes in the structure of the automotive fleet and the improved quality of fuel were induced by the growing environmental consciousness of consumers. The strengthening of the regulations on automobiles and the formation of vertically-integrated companies capable of bring high-quality gasoline to the market led to investments in oil refining for the production of higher quality gasoline. Now that motor fuels have reached the planned level of quality, there are practically no options for further reduction of emissions. The improvement
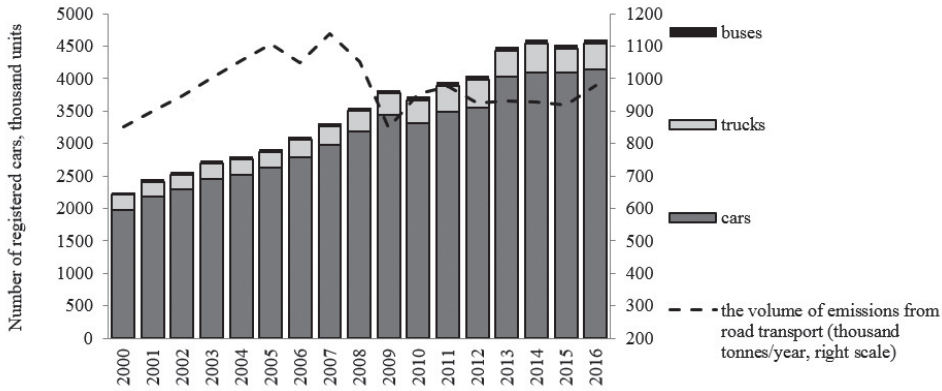
Fig. 3. Dynamics of emissions into the atmosphere from stationary source and automotive transport, 2000-2016
(Report on the state... 2017; Data base of indicators... 2017)

in the quality of gasoline and the change in the composition of the automotive fleet led to reductions in both the gross and relative amount of pollution (the amount of emission per kilometer has been reduced by 75%) from automotive transportation. Consequently, in 2007 the intense growth of the automotive fleet in Moscow ceased to correlate with growth in the volume of pollutants emitted(calculations of the authors of emission volumes along the streets). Calculation of emissions was based on primary information on traffic intensity and flow structure on each street in Moscow in 1990, 1998, 2002 and 2006 and 2016. The measurements were carried out with the help of traffic police cameras (traffic police of Moscow) and provided by the research firm ESPAR-Analytic, supplemented by data from field monitoring studies conducted by the authors and their students. The results of previous studies are published in the article written by Bityukova and Sokolova (2008).

In contrast to industrial emissions, in which case the data are to a significant decree derived from measurements, the volume of emissions from automotive transport is entirely a calculated quantity, based on the results of different studies of the emissions of various types of automobiles having various engine-operation conditions. The complexity of deriving a correct assessment of the volume of emissions from automobile transportation is due to a multitude of factors, effects of which are extremely complicated

to take into account. In the current study, based on data about the intensity of mobility, the structure of the traffic flow according to automobile type (load-carrying capacity), engine horsepower, environmental characteristics (taking into account age), and the fuel type, we calculated the annual mileage of automobiles on every arterial road taking into account adjustments for speed of traffic flow, the frequency of "stop-and-go" traffic, and the number of traffic jams. To determine the territorial differentiation of air pollution independently from mileage we calculated the volume and then the density of emissions (tonnes per square kilometer) relative to the size of the source areas of the emissions, which were obtained by the OND-86 method from every source. The OND-86 a long time remained the only document developed and approved by the Main geophysical Observatory named after A.I. Voyeykov of the USSR Goskomgidromet in the prescribed manner, and that this method is the calculation of dispersion of emissions of pollutants from emission sources in the project documentation (Tishchenko 1991).

In Old Moscow the main trend of the last 15 years has been the evening out of environmental pollution due to automobiles, as it shifts from the regions where jobs are concentrated to residential areas. As the projects to expand and reconstruct the road network have been completed, the number of areas with maximum levels of pollution has decreased.

The emissions from automotive transportation is New Moscow constitute 6% of the city's total. This amount is increasing rapidly. Areas in which the volume of emissions exceeds 1500 tonnes per year and the average density exceeds 350-550 tonnes per square kilometer (which is the base level found between the city's center and its outskirts in 2012) are found along MKAD and the main road arteries. The areas which experience rather high densities of automotive emissions in the former cities of Troitsk, Shcherbinka, and Moskovskii are not large (the maximum density of emissions in Kommunarka amounts to 530 tonnes per square kilometer).In contrast to Old Moscow, the source-areas and intensity of automotive pollution can only grow, especially in the zone adjacent to Old Moscow in the near future, thanks to population growth and the insufficient growth of the transport network (calculations based on data (Data base of indicators… 2016).

Automotive transport is also a source of noise pollution. Moreover, the noise level along major highways in recent years is not reduced in contrast to the volume of emissions into the atmosphere. This problem is significantly acute in the Moscow new adjoint area, where sources of noise are numerous construction sites. Expansion of roads involves cutting of trees, which had previously protected the surrounding areas from the noise and dust of the roads. The major source of acoustic

and vibration pollution is the airport «Vnukovo», which is on the rise.

Pollution of water resources

On the whole in Moscow the pressure on water resources is diminishing: from 2007 to 2015 a steady downward trend in the volume of sewage (27%) has been observed. However, in New Moscow both water use and sewage are growing, which is largely connected with the construction of individual homes, residential complexes, and settlements (calculations based on data Report on the state… 2017).

Construction near waterways is causing pollution from surface run-off, which despoils natural landscapes. Construction of cottages near waterways is the most pervasive, residential complexes are rarer. In 2016 work began in the water-protection zones of the Pakhra and Desna rivers on the widening of Kaluzhkoe highway and construction of an overpass over it, as well as overpasses over Moscow Oblast's segment of the Central Ring Road. Construction often disturbs the water-protection zones of rivers – even when purification facilities are built the excavated soil is piled up adjacent to the rivers.

Most of the projects and, as a consequence, new potential centers of settlement are located in a ten-kilometer zone from the Moscow Ring Road (Revzin 2015). However,
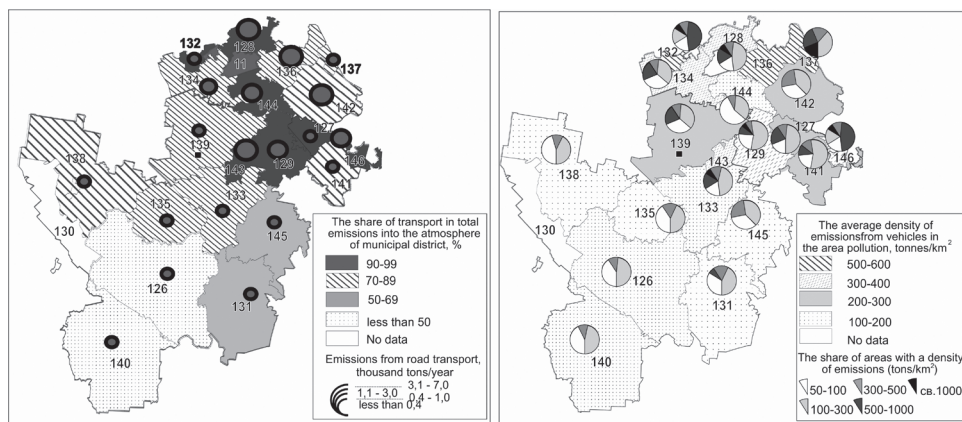

Fig. 4. Automotive emissions into the atmosphere by municipal district in New Moscow, 2016

if a few years ago the intensity of housing construction, like most of the indicators, reflected well the belt structure of the Moscow agglomeration (Brade et al. 2013), was determined by the distance from the Moscow Ring Road, without allocating the sector of New Moscow (Brade et al. 2014), the latest data show a sharp increase in construction in New Moscow.

Our calculations by the method (Popov and Kuricheva 2015) show that in 2017 the share of new buildings from the number of existing houses in Novaya Moscow in comparison with the Moscow region in the 5-kilometer zone from Moscow ring road is 4.8 times higher, in the zone of 6-10 km - 3.4 times, 11-15 km - 1.3 times, 16-40 km - 2.6 times. In the near future of New Moscow, the number of new buildings exceeds the number of existing houses by 1.5 times.

Increases in run-off from urbanized areas and in the volume of sewage are confirmed by data from monitoring, which registered growth since 2015 in the average annual concentrations of a majority of the analytic indicators in Moscow new adjoint area's waterways. The main source of biogenic pollution of the rivers is untreated and inadequately treated household wastewater and sewage while the suspended solids and metals come from rainwater and snow-melt run-off from asphalt. Therefore, in relatively wet years the concentration of suspended materials and metals increases, while the concentration of biogenic elements (nitrogen and phosphorus groups) diminishes because of dilution. The results of regular observations of water quality in the Pakhra and Desna rivers indicate that they are significantly more polluted than the Moskva river and that the main source of the pollution is found in the upper reaches of the watershed, which includes Moscow Oblast' territory (Environmental program… 2017).

According to the "Mosvodokanal" corporation, a large part of the purification facilities in New Moscow don`t meet current technical and technological standards for water purification and drainage. They require complex reconstruction aimed at boosting productivity. Moreover, the massive scale of current and planned residential construction necessitates the construction of new purification facilities. In this regard, after the rivers leave New Moscow, the concentration of pollutants declines by 10-30%.This indicates that the river-basin landscapes have not yet lost their capacity for self-restoration. Thanks to naturally occurring processes, they can restore the quality of their natural components (Report on the state… 2017).

The processing of solid household wastes

One of the peculiarities found in the interaction of the city with its hinterland is how the system of collection, hauling, and processing of waste operates. Moscow generates household, construction, industrial, and medical waste products; this article considers only the household solid wastes. Already in the early 2000s the quantity of wastes from Moscow located in the landfills and dumps of Moscow Oblast' exceeded the amount of wastes produced in the oblast'.

In 2010 one of Moscow Oblast's environmental problems was the presence of more than 50 landfills, the capacity of which was 80% exhausted, and some 1500 unsanctioned dumps. In Russia officially a landfill (poligon) is a legislatively-determined area for the collection of garbage which is equipped with devices for the collection of soil filtrates and gases from wastes. A garbage dump (svalka) also might be legal, but it is not supplied with special equipment. In reality, what is called a landfill may actually be a dump. Within Old Moscow itself there were four garbage-incineration plants, which burned one-third of Moscow's garbage. About 5% of the household solid wastes are recycled and the rest are buried in Moscow Oblast' (Generation… 2016). Today the situation regarding wastes in Moscow and Moscow Oblast' is changing, but not for the better. Old Moscow alone annually produces about 25 million tonnes of wastes from

production and consumption (household, industrial, construction, etc.), while the new territories account for about an additional 90 000 tonnes. Every year this figure increases by three percent (Gunko et al. 2016).

Troitskii and Novomoskovskii administrative okrugs currently are relatively minor producers of household solid waste, but in ten years they will catch up with Old Moscow's districts. It is especially important to consider the rapid pace of residential construction in New Moscow new adjoint area. Moreover, now there is the question of where to take the construction waste that will be generated by the destruction of buildings in Moscow in accordance with the "renovatsiya" program, which will demolish low-quality five-story buildings. It is possible that this waste will end up in New Moscow.

In July 2011 authorities in Moscow and Moscow Oblast' signed an agreement concerning production and consumption wastes which considered setting up inter-regional complexes to recycle wastes. Since 1 January 2017 it has been illegal to bury wastes containing useful materials (plastic, glass, ferrous-metal scrap, recyclable paper). Such wastes constitute up to 60% of household solid wastes (Bukreev and Korneyev 1999). The territorial schema for Moscow Oblast' for 2019 suggests creating the facilities to remove useful materials from garbage. At present for practical purposes they do not exist (Comprehensive strategy… 2013).

After annexation Moscow found that four landfills came with the new territories: Salar'evo (60 ha), Sosenki (40 ha), Malinki (8.6 ha), and Rakitiki (4 ha) (Fig.5). Currently they are closed and undergoing reclamation. In addition, about sixty unsanctioned dumps turned up in Moscow new adjoint area. Along with the removal of large areas, the main negative effects of landfills are the leaching of filtrates into the soil and groundwater, emission of greenhouse gases such as carbon dioxide and methane, spontaneous combustion, unpleasant odor, and a massive infestation of rodents. (Fig. 5)

Currently there is no plan to open new landfills or other facilities for recycling in New Moscow, and so it is difficult to say how the problem of dealing with wastes will be resolved. However, despite the afore-mentioned law banning the burial of wastes that can be recycled, at present 34 landfills are in operation in Moscow Oblast' which continue to receive garbage from the capital, among other sources. Moreover, new landfills are planned for five spots in Moscow's hinterland. According to expert opinion, these tracts are located primarily in the eastern and southeastern parts of Moscow Oblast', which are densely populated and have insufficient infrastructure. All the new landfills moreover will have trash-reprocessing plants. Therefore, the question of opening new landfills in the future for household waste, or industrial and construction waste, remains open, despite the official ban. Along with the landfills, four plants for the terminal detoxification of wastes, each with a capacity of 700 000 tonnes, are planned for Moscow Oblast' (Fig. 5). Half of the plants' capacity will be reserved for the terminal detoxification of household solid wastes coming from Moscow (Comprehensive strategy… 2013).

In reality, the environmental consequences will depend on two factors: 1) whether or not the waste collected will be sorted and 2) the temperature of the terminal detoxification. Widely accepted as best practice to maintain safety is to employ high temperature incineration (over 2000° C) and pyrolysis (high-temperature anaerobic disintegration) at a temperature near 3000° C (Drobnaya and Gubonina 2008). But if the incineration will consist of burning the unsorted flow of trash at a low temperature, the fears of the nature-protection groups will be justified. The main negative consequence would be emissions into the atmosphere both of fine ash and metallic dust and the known-carcinogenic dioxin. The radius of toxic contamination from a trash-incineration plant can reach 25 km. (taking into account the wind pattern) (Gorbacheva 2009); accordingly both Moscow Oblast' and New Moscow fall within the potential zone of contamination.
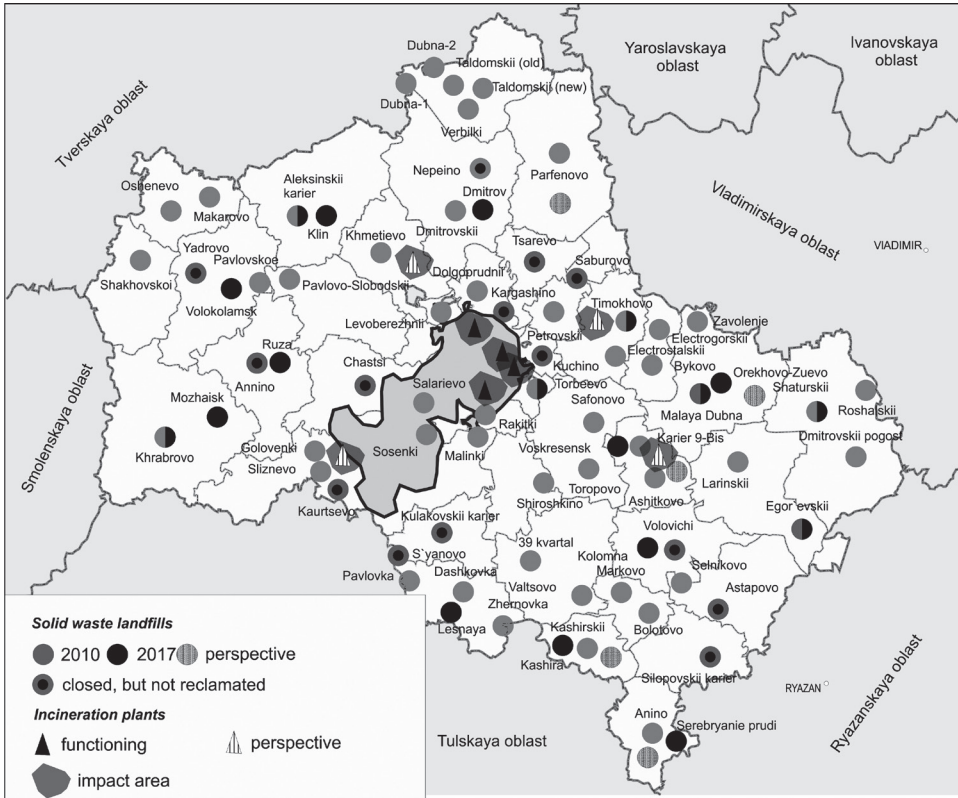
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**Fig. 5. Transformation of the garbage-processing infrastructure in Moscow Oblast'
and Moscow, 2010-2017 (Comprehensive strategy... 2013)**

CONCLUSION

Despite the fact that Moscow's annexation of new territories was to a large extent presented as the solution to environmental problems, there are negative tendencies in New Moscow. The number of pollution sources as well as the size of the built landscape is increasing steadily; this is causing the balance between transformational and inherited factors to change rapidly in the dynamic environmental situation.

1. The developmental legacy, or "path dependency," plays an exceedingly large role in the new territories. One of the factors affecting the level of impact is the structure of the automotive fleet, the planning structure, bridges, the width of the roads, the structure of the road network, the network's weak connectivity, the enhanced role of transit functions, and so on. Currently the density of the road network and its connectivity are growing significantly more slowly than the quantity of multi-story residential buildings in New Moscow.

Also among the inherited factors is the increase in the number of boilers, heating mains, and purification facilities to protect water sources, which leads to greater strain on the territory's natural environment.

2. Transformational factors, which both intensify (e.g., the number of automobiles) and reduce (e.g. improved fuels and engines) the anthropogenic impact, depend to a great extent on the socio-economic situation and it is these factors that have caused the changes seen in recent years. As a result of the changes discussed above, the correlation between volume of harmful emissions and size of the automotive fleet has come to an end. The significance of these factors is extremely great.

The proportion between transformational and inherited factors changes rapidly in the formation of the environmental situation. Thus, if for Moscow in the old boundaries the inherited factors are mainly negative for the formation of the environmental situation, and the transformation takes place in the direction of a slow and gradual improvement, and for the territory of New Moscow, both groups of factors are still acting in the direction of the negative scenario.

3. Trends in the environmental situation on the territory of Moscow in new borders:

- closer to the territory of Moscow in the old borders on the pollution sources structure and specific emissions into the atmosphere based on the volume of production, since the most non-industrial part of the Moscow region was chosen for accession to Moscow

- close to the corresponding belt of the Moscow region in terms of environmental efficiency (the degree of capture of emissions and waste);

- own trends due to the effects of rapid population growth – the growth of air emissions from housing and transport. Despite the fact that the level of pollution in the New Moscow is low, but the environmental efficiency is also low. As a result, pollution levels are growing rapidly.

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UNESCO WORLD KARST NATURAL HERITAGE SITES: GEOGRAPHICAL AND GEOLOGICAL REVIEW

ABSTRACT. The paper is devoted to the review of the World Karst Natural Heritage and the perspectives of such new properties in the Russia. Presently there are 37 World Karst Natural Heritage sites on the globe; 34 of them have the natural heritage and 3 sites have the mixed, natural-cultural significance. The World Karst Heritage distribution by the countries and by parts of the world was analyzed. A brief description of outstanding universal value of the "Lena Pillars Nature Park", being currently the only Russian karst area nominated at the List of World Natural Heritage by a specific type of the karst – ground frozen karst, was given. The necessity of the new World Karst Heritage properties characterizing by the karst development in sulfate and salt rock sites are considered. The karst areas, located in extreme (cold or arid) climate conditions, are in the focus of separate attention.

KEY WORDS: karst, world heritage properties, geological conditions, climatic peculiarities, perspective nominations.

INTRODUCTION AND BACKGROUND

The identification, protection and preservation of natural and cultural heritage having the outstanding universal significance for the humanity are the one of the United Nations Educational, Scientific and Cultural Organization (UNESCO) objectives. This idea was the basis for the international «Convention for the protection of the world cultural and natural heritage» signed in 1972. Cultural heritage includes «monuments, groups of buildings and sites with historical, aesthetic, archaeological, scientific, ethnological and anthropological value» (World Heritage… 2005); and "outstanding physical, biological and geological formations, habitats of threatened species of animals and areas with scientific, conservation or aesthetic value" (World Heritage… 2005) are referred to the natural heritage.

Currently the Convention has been joined by more than 190 countries, and the World Heritage Fund, operating under the auspices of the Convention, assists to States parties in the World Heritage Sites identification, protection and development.

The aim of this paper is to present the review of the World Karst Natural Heritage and the conditions in which the unique outstanding karst is developed as well as to indicate the perspectives and necessity of the new Russian karst nominations preparation.

THE WORLD KARST HERITAGE DISTRIBUTION ON THE GLOBE

Among the natural sites, inscribed on the World Heritage List and having the high natural or natural-cultural (mixed) status (in total 241 sites as of January 1, 2018), a special group is formed by the 37 karst properties (Fig. 1, Table 1) (Gunn 2004; Williams 2008; Trofimova and Hada 2016; etc.). Such large number of karst properties described by the universal significance is defined by a wide spread of karstic rocks (limestone, dolomite, etc.): nearly 30 % of continental surface is characterized by the conditions of karst development.

Thirty-four World Karst Heritage sites are distinguished by their natural properties. The picturesque canyons, profound karstholes (Fig. 2), blue-eyed karst springs as well as the enormous underground systems are preserved here. Three karst properties are determined by a mixed (natural and cultural) status: the temples, monuments, etc. referring to the different stages of contemporary civilization development and coupled with the caves where the priceless archaeological and paleontological material was found.

Nahanni National Park (Canada) (18, here and in the rest of the text the number (X) in
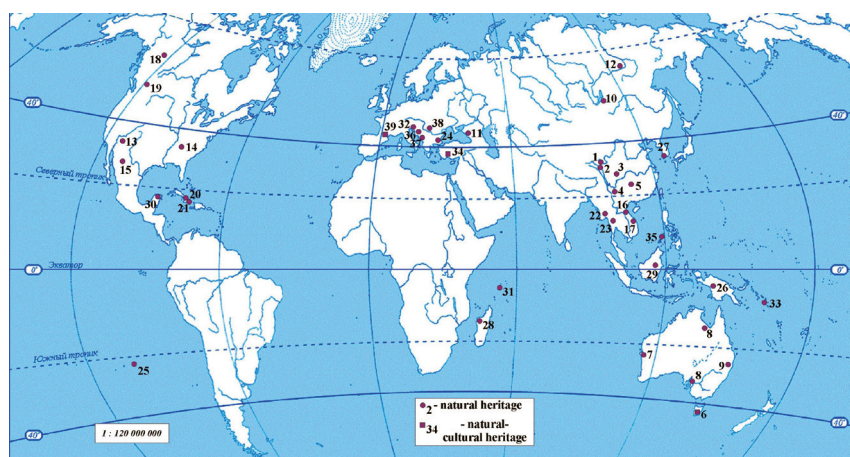

Fig. 1. World Karst Heritage

Fig. 2. Karsthole of Leye, Guangxi, South China Karst (5) (photo Y. Zhang)

Table 1. World Karst Heritage

№	Country	Heritage properties	Lithological conditions	Climatic type	Type of heritage		Date of inscription	Protected area, ha
					Natural	Natural-Cultural		
1	China	Jiuzhaigou Valley Scenic and Historic Interest Area	L, D	Cw	+		1992	72 000
2		Huanglong Valley Scenic and Historic Interest Area	L, D	Cw	+		1992	60 000
3		Wulingyuan Valley Scenic and Historic Interest Area	L	Cf	+		1992	26 400
4		Three Parallel Rivers of Yunnan Protected Areas	L, D	Cw	+		2003	1 700 000
5		South China Karst	L	Cf	+		2007	49 537
6	Australia	Tasmanian Wilderness	L, D	Cf		+	1982	1 584 233
7		Shark Bay, Western Australia	L	Bs	+		1991	2 200 902
8		Australian Fossil Mammal Sites (Riversleigh, Naracoorte)	L, D	Bs	+		1994	10 300
9		Greater Blue Mountains Area	L	Cf	+		2000	86 200
10	USA	Grand Canyon National Park	L, D	Bw	+		1979	493 270
11		Mammoth Cave National Park	L	Cf	+		1981	21 191
12		Carlsbad Caverns National Park	L	Bs	+		1995	18 926
13	Canada	Nahanni National Park	L, D	Df	+		1978	476 560
14		Canadian Rocky Mountain Parks	L, D	Df	+		1984	2 299 104
15	Cuba	Desembarco del Granma National Park	L	Aw	+		1999	41 863
16		Alejandro de Humboldt National Park	L	Aw	+		2001	71 140

17	Thailand	Thungyai-Huai Kha Khaeng Wildlife Sanctuaries	L	Am	+		1991	622 200
18		Dong Phayayen-Khao Yai Forest Complex	L	Am	+		2005	615 500
19	Vietnam	Ha Long Bay	L	Am	+		1994, 2000	150 000
20		Phong Nha-Ke Bang National Park	L	Am	+		2003, 2015	85 754
21	Bulgaria	Pirin National Park	M	Cf	+		1983	38 350
22	Croatia	Plitvice Lakes National Park	L	Cf	+		1979, 2000	29 482
23	Indonesia	Lorentz National Park	L	Af	+		1999	2 350 000
24	Madagascar	Tsingy de Bemaraha Strict Nature Reserve	L	Aw	+		1990	152 000
25	Malaysia	Gunung Mulu National Park	L	Af	+		2000	52 864
26	Mexico	Sian Ka'an	L	Aw	+		1987	528 000
27	Montenegro	Durmitor National Park	L	Cf	+		1980, 2005	32 100
28	Philippines	Puerto-Princesa Subterranean River National Park	L	Aw	+		1999	22 202
29	Republic of Korea	Jeju Volcanic Islands and Lava Tubes	L, D	Cf	+		2007	9 475
30	Russia	Lena Pillars Nature Park	L, D	Df	+		2012, 2015	1 387 000
31	Seyshelles	Aldabra Atoll	L	Af	+		1982	35 000
32	Slovenia	Škocjan Caves	L	Cf	+		1986	413
33	Solomon Islands	East Rennell	L	Af	+		1998	37 000
34	Turkey	Hierapolis-Pamukkale	L	Cs		+	1988	1 077
35	United Kigdom	Henderson Island	L	Cf	+		1988	3 700
36	Hungary-Slovakia	Caves of Aggtelek Karst and Slovak Karst	L	Cf	+		1995, 2000	56 651
37	France-Spain	Pyrénées –Mount Perdu	L	Cf		+	1997, 1999	30 639

parentheses correspond to that represented in Table 1 and shown on Fig. 1) is the first karst natural object inscribed on the UNESCO List in 1978.

As can be seen from Table 1 and Fig. 1, the largest number of the World Heritage Sites is situated in the China - five natural areas nominated: (1-5). All of them belong to the areas of karst development in the central and southern parts of the region researched. According to M.M. Sweeting (Sweeting 1995), the karst occupies more than 15% of the China territory, that is the reason that the numerous works of the Institute of Karst Geology (Guilin, Guangxi) are devoted to the karst processes study. In December 2008 this Institute was renamed to the International Research Center on Karst under the Auspices of UNESCO where the substantial attention is focused on the exploration of karst manifestations universal significance.

Four unique karst objects are located in the Australia: (6-9), therewith the World Heritage Site "Australian Fossil Mammal Sites (Riversleigh, Naracoorte)" (8) consists in two parts, the northern and southern, united in the one nomination. Since the end of last century the Australian colleagues have paid

much attention to the protection of karst areas, in particular to the ones having the property of the World Heritage (Middleton 2016; Watson et al. 1997).

Three outstanding karst properties are found in the United States: (10-12), two ones are distinguished in the Canada: (13-14), Cuba: (15-16), Thailand: (17-18) as well as in the Vietnam: (19-20). In fourteen countries - Bulgaria, Great Britain, Indonesia, Korea, Madagascar, Malaysia, Mexico, Seychelles, Slovenia (Fig. 3), Solomon Islands, Turkey, the Philippines, Croatia and Montenegro there is the one karst site with a high international status of UNESCO, two of which are the cross-border, belonging to two countries simultaneously: the Hungary and the Slovakia: (36) as well as the France and the Spain: (37).

As it was indicated in the Table 1, the following regularity is observed in distribution of UNESCO karst properties by the parts of the world: in Asia - 16 sites with a total area protected of 7241 km^2 (7 241 009 ha), in North America – respectively 8 and 3950 km^2 (3 950 054 ha), in Europe – 7 and 191 (191 335), in Australia - 4 and 3882 (3 881 635) and in Africa – 2 and 1870 km^2 (1 870 000).

Fig. 3. Škocjan Cave (Slovenia): to the left – entrance to the cavern, to the right – underground waterfalls (photos A. Trofimov)

By lithology, all World Karst Heritage properties are characterized by karst development in carbonate rocks (Table1): the overwhelming majority of the sites (26 ones) are belonging to the regions of limestone outcrops (L in Table 1), 10 nominations hold for dolomites (D in Table 1) and limestones and 1 property is located in the frame work of limestones, dolomites and marbles (M in Table 1). The regions of evaporate karst (in halites, gyps, anhydrites, etc.) are not represented at the World Karst Heritage List on the whole, although according to the explorations realized, for example, by V.N. Dublyansky, G.N. Dublyanskaya (2007), the total area of karst rocks is estimated at 51 millions km^2, of which the limestones occupies the area to 40 millions km2, gyps and anhydrites - 7 millions km2and salt – not more than 4 millions km2. Hence, the area of evaporate karst development constitutes more than 20 % of the total karst manifestation areas on the globe.

Predominance of warm climatic conditions for karst development is the second important feature of UNESCO's karst properties (Table 1): 34 cases. Only 3 nominations refer to a cold climate. Four World Heritage Sites (23), (25), (31), (33) are described by the climate of tropical forests /Af - here and further by Latin letters is the type of climate according to V.P. Köppen (Drozdov et al. 1989)/; also four properties: (17-20) are characterized by the transitional climate: from the climate of the tropical forests to the climate of the savanna /Am/, but the climate of savanna /Aw/ is observed for five areas: (15-16), (24), (26) and (28). The climate of deserts /Bw/ is noted only for the one site: (10), but the climate of the steppes /Bs/ is mentioned for the three properties: (7-8) and (12). One site nominated has been marked by a warm temperate (with a dry summer) climate /Cs/: (34), and three properties: (1, 2, 4) are described by the same warm temperate climate, but with a dry winter /Cw/. The warm temperate climate with uniform humidification /Cf/ has the most spread for the World Heritage karst areas: 13 sites. Cold temperate climate with uniform humidification /Df/ is appropriate for three properties: (13), (14) and (30).

The advisability of the new nominations to reflect the karst development «in cold regions, arid /semi-arid regions and tropical oceans regions, and to identify evaporite karst sites of outstanding universal value", was underlined by P. Williams (Williams 2008).

RUSSIAN WORLD KARST HERITAGE

As it was shown above, currently only one Russian natural karst object was inscribed on the List of World Heritage: the Lena Pillars Nature Park (30) within which the different forms of karst relief have been occurred. The Nature Park Lena Pillars gained its high status precisely as an example of the region where the universal outstanding type of the karst –frozen ground karst, is widely spread (Butorin et al. 2012): on the 2nd of July 2012 - for the Buotamsky (Botomsky) site with an area of 1 272 150 hectares and on the 6th July 2015 – for the Sinsky site with an area of 114 850 ha.

The karst of the Lena Pillars Nature Park (NPLP) is developed in a cold dry continental climate: the mean annual air temperature in the area reach -9.8 °C with a mean annual precipitation of 249 mm. The karst is developed in the Lower Cambrian limestones and dolomites of 400-500 m thick, covered by cryogenic-eolian deposits in the valley band of the Prilenskoe Plateau and on the watersheds of the Lena, Buotama and Sinyaya Rivers. The area of exploration is characterized by a high degree of rocks fracturing, mainly sublatitudinal and submeridional directions (Butorin et al. 2012; Korzhuev 1961).

The uniqueness of the NPLP karst is predetermined by its development in the conditions of continuous permafrost up to 500 m thick, where the moisture condensation processes are the main factor of karstogenesis. On one hand, during spring and summer periods the soil layer actively condenses the water moisture from the air because of the considerable amplitudes of daily air temperature fluctuations, reaching 12.8°C. On the other hand, the condensation of moisture occurs on the lower part of the active layer as a consequence of big

gradients (to 7.8°C per 1 m) between earth temperatures and lower situated perennially frozen rocks. As observed in a condenser created at the Melnikov Permafrost Institute (Siberian Branch of the Russian Academy of Sciences), 80 mm of water is condensed at the average in the Central Yakutia during the warm season (Shepelev 1980), constituting more than 30% of annual precipitation. Moreover, the permafrost blocks the quick filtration of precipitation into karst massifs. Thus, the accumulation of water, which in turn, causes the karst processes, occurs on the surface. This moisture, cooled almost to zero temperatures, is distinguished by a considerable aggressiveness in relation to karst rocks: since dissolved carbon dioxide (being also a leading factor of a karstogenesis) is characterized by the greatest solubility in cold water: the CO2 absorption coefficient is 0.665 at the solution temperature of 30°C, at the temperature of 15°C – 1.019 and at 0°C is already 1.713 (Jakucs 1973).

Numerous publications (Butorin et al. 2012; Korzhuev 1961; Rozentsvit 1948; Trofimova 2017; etc.) have been dedicated to the description of the NPLP classic karst phenomena: karren, sinkholes, dry valleys, niches, caves (Fig. 4), etc.

DISCUSSION

As it was mentioned before, 37 karst properties are currently described by a high status of an outstanding universal value on the globe. Obviously, for Russia (where 8 karst areas, 22 karst provinces, and 57 karst districts are distinguished only on the Russian Plain (Chikishev 1978)) there is a considerable potential for natural karst sites of such high status, therewith, for example, both for conditions of sulphate (karst of the Belomoro- Kuloy Plateau in the Arkhangelsk Region) and salt karst (the Kempendyay salt springs in the Yakutia), that is more the areas considered are referred to the conditions of moderately cold climate with uniform humidification (Df).

A remarkable example of a naked sulphate karst is developed in SE part of the Belomorsko-Kuloy Plateau located on the NW of the Russian Plain at 70-180 m above sea level. Lower Permian gypsums and anhydrites with a typical thickness 40-70 m are exposed here. The rocks have practically a monomineral composition: 95-98% consisting of CaSO4 x 2H2O (The Karst... 2011).

Fig. 4. Caves of the Sinyaya River Valley: to the left – in the locality Peschanka, to the right – near a mouth of the River Silbakh (photos A. Trofimov)

The sulphate rocks of the Belomorsko-Kuloy Plateau are considerably karstified especially in wide-spread karst fields, so-called "shelopnyaky" by a local dialect where a density of the superficial karst forms (sinkholes, karst basins, small flat-bottom valleys) reaches extremely unique values: more than 3000 (The karst... 2011) per 1 km2. As it is described by A.G. Chikishev (1965): "Sometimes the crests separating the sinkholes are such narrow that it is impossible to across theirs without risk of falling down. The diameter of sinkholes is varied from 5 to 50 m and the depth is changed between 1.5-15.0 m".

Underground forms of sulphate karst are developed in the frame work of the Belomorsko-Kuloy Plateau very intensively too. So, 16 caverns by a total length of 22,856 km (The Karst... 2011) are described in the Kulogorsky area among which the famous Kulogorskaya-Troya Cave having 17 km of a length at amplitude to 18 m. For the first time this underground cavity was visited by Academician A.G. Schrenk in 1837 enthusiastically described the delightful ice formations of the cavern (Schrenk 1848).

At the beginning of the 21st century another ice cave in gypsum – Kungurskaya Cave (by total length of 5,6 km at 27 m of the depth) was proposed by the Russian karstologists for the inclusion on the World Heritage List, moreover the nomination for this cavern was written in 2006. But this property wasn't supported by the experts of the IUCN. The main reason is the artificial tunnel created in underground cavity last century which changed considerably the natural conditions of underground system.

In terms of salt karst, extremely unique natural phenomenon occurs each winter in the Kempendyay River Valley (right tributary of the Viluy River, East-Siberian Platform) where the numerous Kempendyay salt karstic springs characterizing by a high salinity - nearly 317 g/l (a real pickle) - are situated. In the winter the salt aufeises in the form of ice hillocks by a height of 5-7 m and up to tens of meters in diameter are formed near the outputs of the springs.

Karstic salt aufeises are composed of hexagonal plate and prismatic needle crystals of hydrohalite ($NaCl \times 2H_2O$) precipitated (upfrozen) from the pickles at the negative temperatures (starting from -1,0°C). The ice hillocks exist only in the cold half of the year since the melting point of a hydrohalite is positive namely +0.1°C. At the transition of air temperatures to positive values the ice hillocks disintegrate: a part of crystallized water evaporates, a part of that runs and only upfrozen waterless pure table "ice" salt (consist of NaCl to the extent of 98,668 %) remain in situ being widely used by a local Yakut population beginning in 1640 (Uzemblo 1966).

First the description of the «ice» salt of the Kempendyay salt karstic springs was realized in 1828 by geologist I. Tchaikovsky (the father of the Great Russian composer P. I. Tchaikovsky). He noted that in summer period «winter crystals are destroyed and turn into a fine salt dust of the purest whiteness... which is can be taken and put in bags without any difficulty» (Dzens-Litovsky 1966).

The necessity of the researches, related with the preparation of new nominations for the Russian karst sites is determined by the anthropogenic pressure which is growing every year to karst landscapes being very fragile and vulnerable. For example, 2 July 2012 the above-described Buotamsky site of the Nature Park Lena Pillars was inscribed on the World Heritage List during the 36th session of the UNESCO but it is in the summer of 2012 in the Valley of Sinyaya (the Sinsky site of NPLP) a gabbro-diorite quarry was found in a few kilometers from the mouth of its right tributary: River Billyakh. However, already in 2013 the preparation of Sinsky site nomination was started under the influence of local population and at the support of the direction of the natural park. In fact the prompt work of Natural Heritage Protection Fund of Russia saved the nature of the Valley of Sinyaya from the destruction: after 39th session of UNESCO (25 June-10 July 2015) for which the Sinsky site nomination was supported almost unanimously, the further exploitation of the quarry was completely stopped.

CONCLUSIONS

1. So far, 37 karst properties were inscribed on the List of UNESCO World Natural Heritage starting from 1978.

2. The World Karst Natural Heritage has been distributed by the parts of the World in the following order: in the Asia – 16 sites, in the North America – 8, in the Europe – 7, in the Australia - 4 and in the Africa - 2.

3. It seems advisable for Russia (as well as on the whole for the globe) to prepare the new nominations for the unique outstanding karst of the sites located in the evaporite karst, more than that in conditions of cold climate. Two new nominations are proposed for the first step: sulphate karst of the Belomoro- Kuloy Plateau in the Arkhangelsk Region and salt karst of the Kempendyay salt springs in the Yakutia: both properties are disposed in cold climatic conditions. ■

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ONLINE INTEGRATED MODELING ON REGIONAL SCALE IN NORTH-WEST RUSSIA: EVALUATION OF AEROSOLS INFLUENCE ON METEOROLOGICAL PARAMETERS

ABSTRACT. In this study the aerosols influence on selected meteorological parameters during two summer 2010 periods is evaluated with focus on the North-West Russia and urban area of St. Petersburg. For that, the seamless fully online-integrated Enviro-HIRLAM model is used. The simulations are realised in short- and long-term modes for selected periods. For evaluation of aerosol influence, in addition to the control/ reference run, the runs with direct, indirect and both combined aerosol effects are performed.

It was found that for the North-West Russia region, the direct aerosol effect had increased air temperature (by 1-3°) and decreased total cloud cover (by 10-20%). The indirect effect decreased temperature (by 0.4-1°) and increased cloud cover (by 10-20%). The combined effect was the largest territorially; and such effect both decreased temperature and cloud cover (by 1-3° and by 6-20%, respectively) as well as increased these (by 0.4-0.6° and 10-20%).

KEY WORDS: aerosols influence, Enviro-HIRLAM, online integrated modelling, North-West Russia

INTRODUCTION

In the 21st century, the industrial development has reached higher levels. In particular, almost all large cities of Russia have own industrial enterprises. These produce large amounts of anthropogenic emissions. For megacities, there are several sources of these emissions such as transport, energy and heating production from combustion, etc. Among pollutants, many can have influence on living standard of humans as well as can influence the environment.

In this study, the evaluation of pollutants influence, in particular, on spatio-temporal distribution of aerosols on meteorological parameters (on example of the North-West Russia (NW RU) as well as the St. Petersburg metropolitan area) was carried out. It has been realized through the online integrated modeling and analysis of aerosols influence on regional and megacity scales (Nerobelov 2017).

Aerosols are little solid or liquid particles with sizes in interval from 10^{-3} to 100 μm. These particles can be of natural as well as anthropogenic origin. Usually aerosols influence is divided into direct aerosol effects (DAE) and indirect (IDAE). The direct influence is reflected in aerosol dispersion and absorption of solar and heat radiation that can lead to changing in the Earth's radiation balance. The indirect influence is represented in changing of radiative properties and life cycle of clouds (due to aerosols) and after all in influence on radiation balance. These aerosol types of effects were studied and discussed by Beresnev and Gryazin (2008); Ginzburg et al. (2009); Ivleev and Dovgaluk (1999).

MATERIALS AND METHODS

Research domains in focus

Saint-Petersburg is the biggest industrial center of Russia. There are a few continuously working engineering enterprises on territory of the city, but the main sources of pollution are transport related with traffic emissions (about 86% of all). In 2013 this city was claimed as one of the most polluted among Russian cities. It was decided to choose NW RU and the St. Petersburg metropolitan area for estimating of aerosols influence on main meteorological parameters (such as air temperature at 2 m and total cloud cover) on regional scale and with zoom to the metropolitan area.

Selected meteorological periods

In our study, the focus was on a season with a weak wind speed and anticyclonic weather conditions. In particular, the abnormally hot weather over the studied region was observed in summer 2010, and it was caused by a blocking anticyclone (Ovanesianc et al. 2010a-c). Such meteorological conditions led to large-scale forest fires on the territory of the European Russia. Therefore, this summer was chosen to perform online-integrated simulations (in particular, for short-term study - 10-12 July and for long-term - 1-30 August 2010). Dominated anticyclonic weather conditions in summer 2010 could underline on how aerosols influenced on selected meteorological parameters such as the air temperature at 2 m (direct effect). In addition, there was a possibility for observing aerosols influence on cloudiness (indirect effect). Also, the large-scale forest fires, which occurred during summer 2010, were significant sources of natural aerosols. This could intensify aerosols influence on considered meteorological parameters.

Seamless/ online-integrated Enviro-HIRLAM modelling

The Environment-High Resolution Limited Area Model (Enviro-HIRLAM) is developed as a fully online-integrated numerical weather prediction (NWP) and atmospheric chemical transport (ACT) modelling system for research and joint forecasting of meteorological, chemical and biological weather. For more information about Enviro-HIRLAM modeling system and modules (with corresponding references) see in Baklanov et al. (2017). This model is capable to provide forecast of multiple meteorological fields such as air temperature, relative and specific humidity, atmospheric pressure, wind speed and direction, cloud cover, turbulent kinetic energy, etc. based on

forward in time integration of the primitive equations and physical processes such as radiation, vertical diffusion, convection, condensation and others. This integrated modeling system was originally developed by the Danish Meteorological Institute (DMI) in a cooperation with several European universities (and since May 2017 it continued to be developed at the University of Helsinki, UHEL, Finland), and it is used in various applications. General block-scheme of the Enviro-HIRLAM system is shown in Fig. 1.

The Enviro-HIRLAM model was employed to perform simulations for both short- and long-term periods. In particular, the simulations were done for period 1-30 Aug 2010 as well as for selected episode with the unfavorable meteorological conditions. This episode is: 10-12 Jul 2010. The model setup includes: horizontal resolution of 15 km, 40 vertical levels, time-step of 360 sec.,

meteorological data assimilation – every 6 hours, output – every 3 hours (GRIB and netCDF formats). For the NW Russia region in focus, 4 runs of the model were performed: CTRL (or control/reference run, e.g. without any aerosol effects included), DAE (direct aerosol effects), IDAE (indirect aerosol effects) and COMB (combined, where direct and indirect aerosol effects included). The analysis focused on evaluation of aerosol influence on selected key meteorological parameters such as the air temperature at 2 m (T2M) and total cloud cover (TCC).

RESULTS AND DISCUSSIONS

The aerosols influence on the meteorological parameters was estimated on the regional scale (with focus on the NW Russia territories) as well as by zooming down to the Saint-Petersburg metropolitan area.
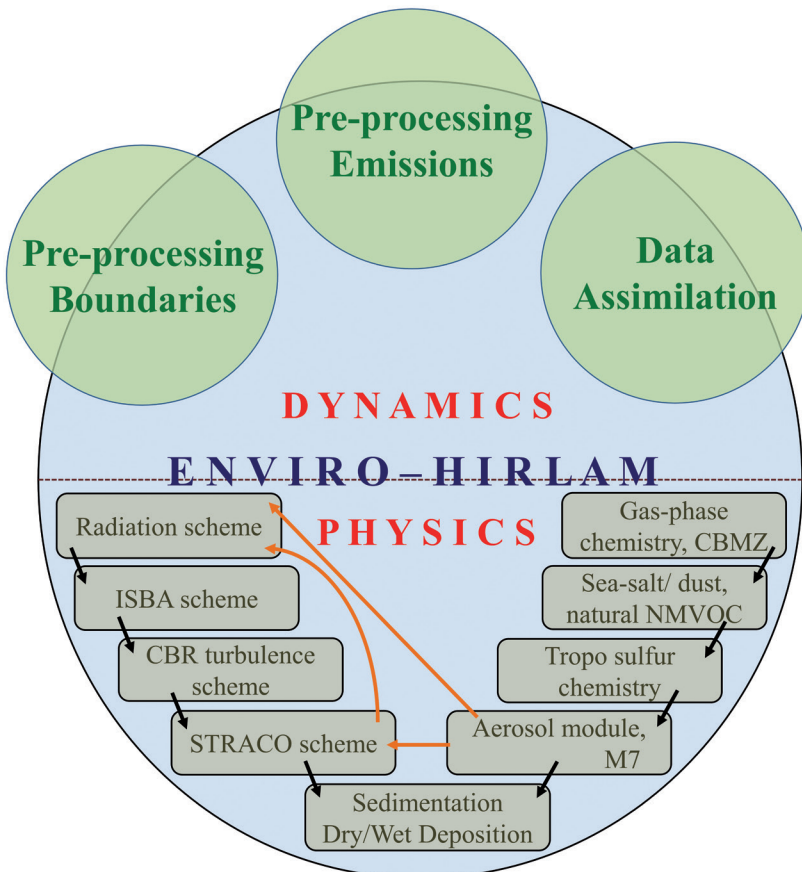

Fig. 1. Flow chart of the Enviro-HIRLAM modelling system

Aerosols influence on meteorology on regional scale: case study 10-12 July 2010

For the air temperature at 2 m (almost all domain - AlAD seen on Figs. 2-3, top-center) the direct aerosol effect influence was significant in the south-east, north-west and west areas of the domain in focus. Such influence led to the temperature decrease (on 2-3˚C) on the west. In addition, there were large areas with the temperature decrease (1˚C) on the north - between the Gulf of Bothnia and the White Sea. A few small areas can be distinguished and one large, where the temperature increased (1-2˚C) on the east and south-east. In case with the indirect effect, the influence on the temperature was negligible, and therefore, it was not included in this figure. The most significant changes of the temperature values can be observed in the northern part of the domain. Large areas (with decrease on 1-2˚C) were observed there (see Fig. 3-top-left). The combined effect (Figs. 2-3, top-right) showed a merging of the temperature changes from both the direct and indirect effects (decrease on 1-3˚C: west and north; and increase on 1˚C: east and south-east). Nevertheless, there were some little differences from both of these effects (for example, influence zones on the north and west were wider, than in case of the direct and indirect effects).

As seen (Fig. 2, bottom-center) with the direct effect the most significant changes (decrease on 10-30%) in the total cloud cover were in the northern, eastern and south-eastern parts of the research domain. The indirect effect also was significantly weaker than the direct and combined, and therefore, it was not included in the Fig. 2 (bottom). In this case, the TCC increased in the northern part (10-30%) and decreased in the north-eastern (40%). The combined effect (Fig. 2-3, bottom-right) included several zones with the direct and indirect effect influences. However, all these zones became wider in the size, and the values became larger in the case of the combined effect (decrease on 10-40%: south-east and east; and increase on 10-50%: northern part and west).

Aerosols influence on meteorology with zoom to St. Petersburg: case study 10-12 July 2010

The indirect effect influence on the air temperature at 2m and the total cloud cover with a zoom to St. Petersburg was insignificant; so it was not included in Fig.
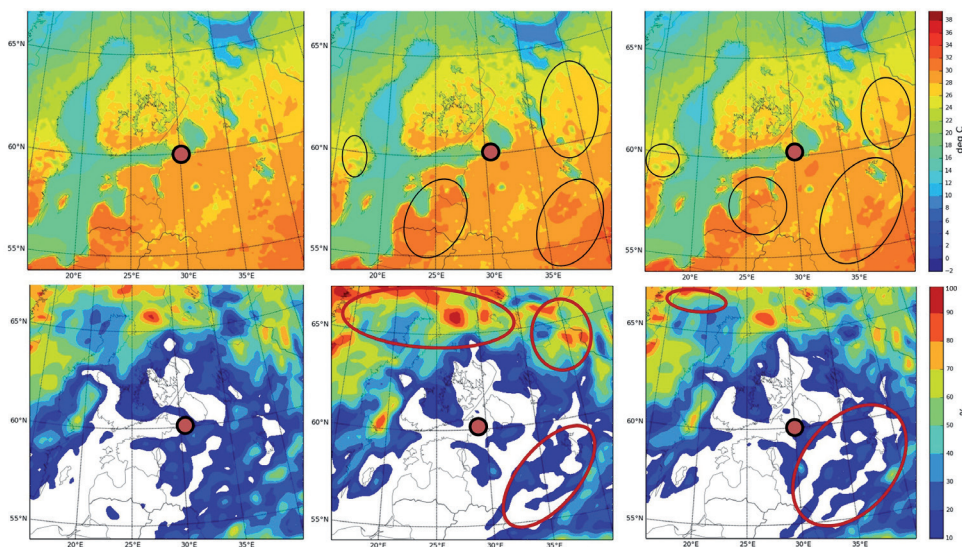

Fig. 2. 3-day (10-12 Jul 2010) averaged (top) air temperature at 2 m (T2M) and (bottom) total cloud cover (TCC) fields at 12 UTC for the Enviro-HIRLAM model runs: reference/control (CTRL), with direct aerosol effect (DAE) and combined aerosol effect (COMB) included (from left to right)

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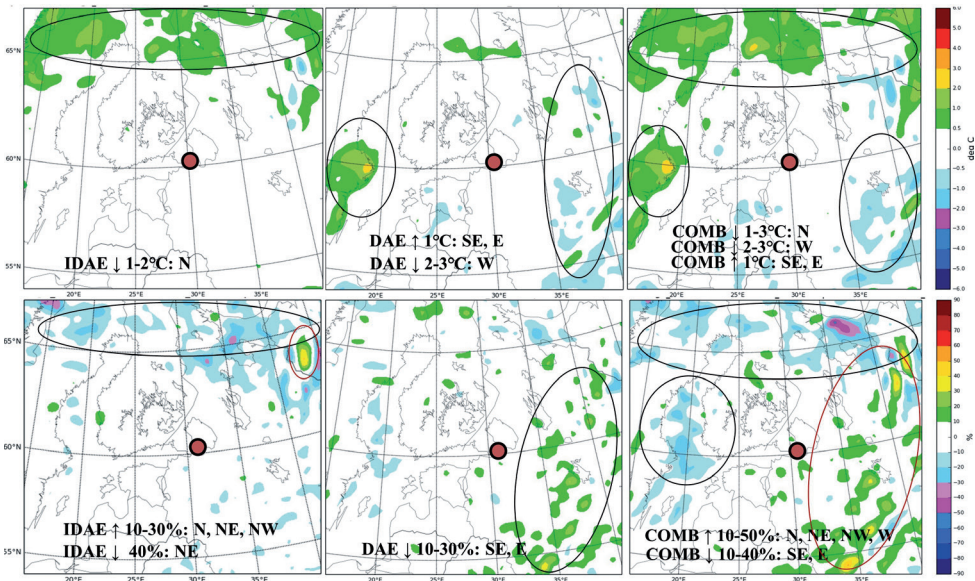
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Fig. 3. 3-day (10-12 Jul 2010) averaged (top) air temperature at 2 m (T2M) and (bottom) total cloud cover (TCC) fields of differences at 12 UTC for the Enviro-HIRLAM model runs: reference/ control-indirect aerosol effect (CTRL-IDAE), control-direct aerosol effect (CTRL-DAE) and control-combined aerosol effect (CTRL-COMB) (from left to right)

4. As it can be seen on Fig. 5 (top-left), the indirect effect was mostly reflected as the temperature decrease, but also the increase was observed. For example, it was decreased on the south and south-east (on 0.4°C), and increased - on the east (0.4°C). The direct effect influence (Fig. 4-5, top-center) was stronger than the indirect. Mostly it was observed in the eastern part of the research area. This effect increased T2M on the south-east, east and north (0.8°C) and decreased on the west (0.4°C) of the domain. The combined effect influence (Figs. 4-5, top-right) was almost similar to the direct effect. The main differences between these were in the widening of sizes of the influence zones and the values inside were higher in the case of the combined effect. This effect decreased the temperature on the west and north-east (0.4°C) and increased in the eastern and northern parts (on 0.4-1.0°C).

In the case of the TCC, the indirect effect (Fig. 5, bottom-left) increased it (3-15%) on the south, south-west, north-east, east; and decreased (3-6%) on the south-east. The direct effect (Figs. 4-5, bottom-center) led to decrease in most of the cases. It decreased the cloud cover by 3-18% on the north-

east, north, south-east and south-west of the domain. The combined effect (Figs. 4-5, bottom-right) was similar to the direct effect, and it led to the TCC decrease (6-21%) on the north-east, north, south-east and south-west. But the zones of influence for the combined effect were wider and the values inside these were higher. This effect was stronger than the direct and indirect effects.

Aerosols influence on meteorology on regional scale: long-term period of August 2010

Evaluating the monthly averaged results, it was found, that the indirect effect (Fig. 6-top-center) looked like in the reference run for the air temperature at 2 m. The most significant indirect influence can be seen in the center and in the eastern and northern parts of the domain, where the temperature decreased. For the total cloud cover (Fig. 6, bottom-center), the indirect effect increased values almost within all research area. The direct effect also decreased T2M (Fig. 6, top-right) in the center and eastern part. For TCC (Fig. 6, bottom-right) it was weaker than the indirect influence, and it can be seen in the southern part, where the cloud cover decreased.
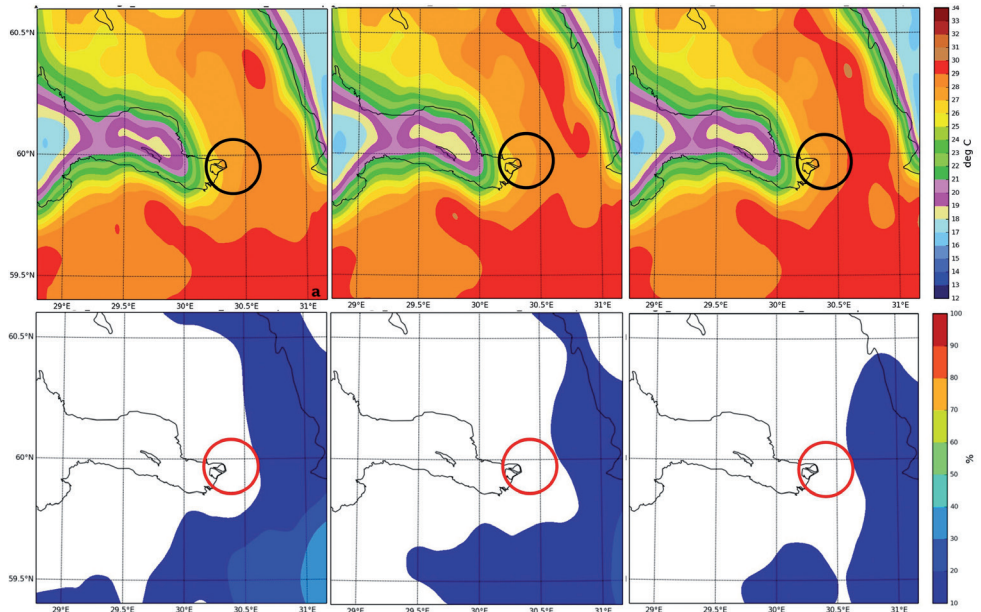
Fig. 4. 3-day (10-12 Jul 2010) averaged (top) air temperature at 2 m (T2M) and (bottom) total cloud cover (TCC) fields at 12 UTC for the Enviro-HIRLAM model runs: reference/control (CTRL), with direct aerosol effect (DAE) and combined aerosol effect (COMB) included (from left to right)
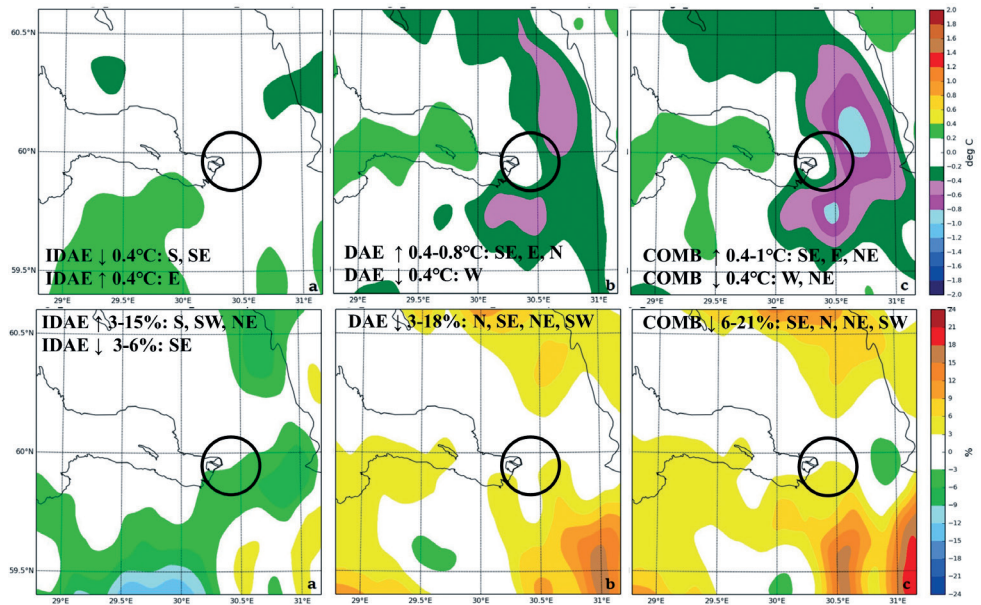

Fig. 5. 3-day (10-12 Jul 2010) averaged (top) air temperature at 2 m (T2M) and (bottom) total cloud cover (TCC) fields of differences at 12 UTC for the Enviro-HIRLAM model runs: reference/control-indirect aerosol effect (CTRL-IDAE), control-direct aerosol effect (CTRL-DAE) and control-combined aerosol effect (CTRL-COMB) (from left to right)

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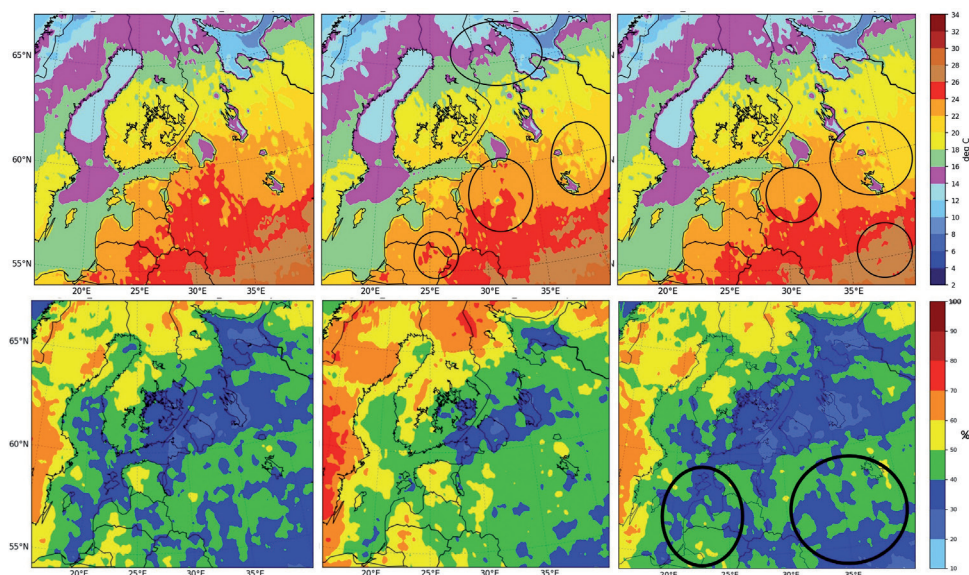
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Fig. 6. Monthly (Aug 2010) averaged (top) air temperature at 2 m (T2M) and (bottom) total cloud cover (TCC) fields at 12 UTC for the Enviro-HIRLAM model runs: reference/ control (CTRL), with indirect aerosol effect (IDAE) and direct aerosol effect (DAE) included (from left to right)

A more detailed information is presented in Fig. 7 showing differences between the model runs, and here, more peculiarities can be identified. For example, for the indirect effect the air temperature in general decreased (on 0.4-0.8°C) in the northern and western parts (Fig. 7, top-left). At the same time the cloud cover increased (3-20%) within all research area, mainly on the north and west (Fig. 7-bottom-left). For the direct effect it can be noticed, that T2M (Fig. 7-top-right) decreased (0.4-2.4°C) in the northern part with the temperature growth (1.2°C) on the south-east. The cloud cover (Fig. 7-bottom-right) decreased (3-12%) by the direct effect mostly on the north, south-east and south, but also it increased (3-12%) on the south-east.

For further analysis, let's write hours (h) thereafter as the equivalent of UTC (universal coordinated time). As it can be seen from the Table 1, the direct effect (DAE) mainly influenced on the south-east area of the domain in focus, where it decreased the air temperature on 1.6-3.2°C and increased on 0.8-2.8°C, relatively to the reference case. The temperature decreased during night-time hours (00-06) and during time period after 12 h (12-15 h). This effect also increased

temperature during the second part of the day (12-21 h). The maximum increase (on 2.8°C) was noticed at 21 h on the south-east. The maximum decrease (3.2°C) was observed at 06 and 15 h on the east and south-east. Let`s consider the boundaries of the zones of increase (ZoI) and the zones of decrease (ZoD) as a widening and narrowing in the size, respectively. For the air temperature, the ZoI became larger from 12 to 21 h and smaller from 00 to 06 h; and the ZoD became larger in size from 00 to 09 h and smaller - from 12 to 18 h.

For the indirect effect, the observed changes were mostly insignificant (NoSC), except during hours 00, 12 and 18-21 h. Basically the indirect effect influenced in the northern and southern parts of the research area. The temperature growth on 0.8-1.2°C was observed in the south-east, and north, and the temperature drop on 0.4-0.8°C was observed in the northern part and central zone. In addition, it can be noticed, that ZoI appeared and became wider after 18 h and then smaller – after 21 h. The zones of ZoD became significantly wider at 12 h and almost disappeared after 18 h.
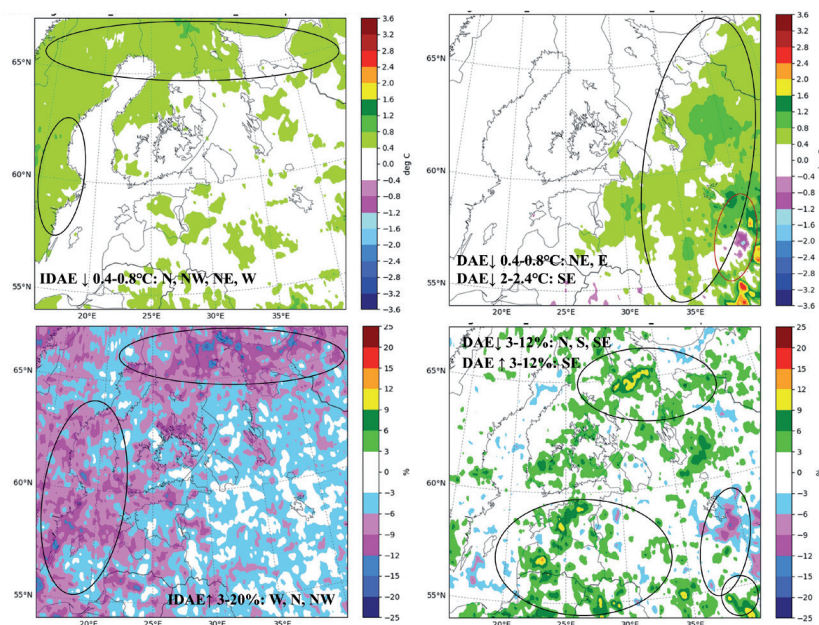
Fig. 7. Monthly (Aug 2010) averaged (top) air temperature at 2 m (T2M) and (bottom) total cloud cover (TCC) fields of differences at 12 UTC for the Enviro-HIRLAM model runs: reference/ control-indirect aerosol effect (CTRL-IDAE), control-direct aerosol effect (CTRL-DAE) (from left to right)

Table 1. Diurnal cycle variability (averaged over 1-30 Aug 2010) of the air temperature at 2 m (T2M) changes due to direct (DAE) and indirect (IDAE) aerosols effects / comments: no significant changes – NoSC; zone of increase – ZoI; zone of decrease -ZoD; central zone – CZ; almost all domain - AlAD/

Term (UTC)	DAE-Direct Aerosols Effect			IDAE-Indirect Aerosols Effect		
	Zones of the most significant influence	Type (↑↓) and value (±°C) of influence	Tendency	Zones of the most significant influence	Type (↑↓) and value (±°C) of influence	Tendency
00	SE	↓1.6 ↑2.4	NoSC	N	↓0.8	NoSC
03	SE	↓1.6 ↑0.8	ZoI – smaller ZoD – wider	NoSC	NoSC	NoSC
06	E, SE	↓3.2	ZoD – wider ZoI– disappeared	NoSC	NoSC	NoSC
09	SE	↓3.0	ZoD– wider	NoSC	NoSC	NoSC
12	E, SE, SE	↓2.8 ↑1.2	ZoD – smaller ZoI – appeared	NW, NE, CZ	↓0.4	ZoD – wider
15	SE	↓3.2 ↑1.2	ZoD – smaller ZoI – NoSC	NoSC	NoSC	NoSC
18	SE	↓3.0 ↑2.0	ZoD – almost disappeared ZoI– wider	S, SE	↑1.2	ZoI – wider ZoD – almost disappeared
21	SE	↓2.0 ↑2.8	ZoI – wider	SE, N	↑0.8	ZoI – smaller

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As it can be seen in the Table 2, although mostly of cases on a diurnal cycle the direct effect increased the total cloud cover (ranging from 3 to 12%) in the domain, and during 06-18 h in some areas from 9% (06 h) and up to 12% (12-18 h). The largest changes (12%) in TCC due to this effect were observed during 12-18 h and practically in all areas of the domain. Note, that the increase was predominantly observed during evening and nighttime hours in the western part. The tendency of the aerosol effect was not significant at midnight, although it has well pronounced variability on a diurnal cycle. In particular, both zones (ZoI and ZoD) became wider at 12 h, and smaller in size - at 15 h; moreover, the zone of decrease almost disappeared at the late evening hours.

The indirect effect increased TCC almost within all research domain. The areas with the most significant influence were located in the northern and western parts of the domain. The cloud cover increased from 00 to 18 h (on 15-20%) and then decreased at 21 h (down to 15%). As in case with the direct influence for TCC, the indirect influence was stronger at afternoon hours (12-18 h) and weaker in other hours on a diurnal cycle. For TCC, the indirect effect was stronger, than the direct. The tendency of the aerosol effect was insignificant at midnight time. In general, the ZoI zones were smaller during 21-03 h and were wider during 12-18 h. As the TCC field can not be represented by a continuous function due to irregularities in the cloud cover distribution, the tendency of the aerosol influence and its magnitude can depend on how rapidly and in which direction the cloud systems can move. Therefore, tendency of the aerosol influence on TCC can vary in time and space stronger than on temperature field.

CONCLUSION

In this study, the main aims were to evaluate the aerosol influence on the meteorological parameters on example of the North-West Russia with zoom to the St. Petersburg metropolitan area. The modelling of the aerosols influence on the meteorological parameters (such the air temperature at 2 m and total cloud cover over selected areas in

Table 2. Diurnal cycle variability (averaged over 1-30 Aug 2010) of the total cloud cover (TCC) changes due to direct (DAE) and indirect (IDAE) aerosols effects / comments: no significant changes – NoSC; zone of increase – ZoI; zone of decrease -ZoD; central zone – CZ; almost all domain - AIAD/

Term (UTC)	DAE-Direct Aerosols Effect			IDAE-Indirect Aerosols Effect		
	Zones of the most significant influence	Type (↑↓) and value (±%) of influence	Tendency	Zones of the most significant influence	Type (↑↓) and value (±%) of influence	Tendency
00	W	↑9	NoSC	NW, N, SW	↑15	NoSC
03	W	↑6	ZoI – smaller	NW, N, SW	↑15	ZoI – smaller
06	SE, N, CZ, W	↓9 ↑3	ZoI – smaller ZoD – wider	NW	↑15	ZoI – wider
09	N, S, CZ	↓9	ZoD – wider	NW, N, W	↑15	ZoI – smaller
12	AIAD	↓12 ↑12	ZoD – wider ZoI – wider	NW, N, W	↑20	ZoI – wider
15	AIAD	↓12 ↑12	ZoD – smaller ZoI – smaller	N, NW, NE	↑20	NoSC
18	S, N, CZ, E, SW	↓12 ↑12	ZoD – smaller ZoI – wider	N, NW, NE, SE	↑20	ZoI – wider
21	W, SW	↑6	ZoI – smaller ZoD – almost disappeared	W, NW, NE, SW	↑15	ZoI – smaller

focus) was performed using Enviro-HIRLAM modeling system in both the short- and long-term modes. These simulations were realized for the short-term (i.e. case studies with the most unfavorable meteorological and air pollution conditions) and long-term periods chosen for modeling over the North-West Russia (i.e. 10-12 Jul 2010 and August 2010). The summer periods of 2010 were chosen because of specific weather conditions (high atmospheric pressure, low wind speed) and large aerosols sources such as large-scale forest fires. These factors provided better representation of possible aerosols' influences on selected meteorological parameters. The four simulations were made: control/ reference (CTRL); with the direct aerosol effect (DAE), with the indirect aerosol effect (IDAE), and with both effects included (COMB). The most important findings are the following. The direct effect in most of cases increased the air temperature ($1-3^0C$) and decreased the total cloud cover (10-20%). In contrast, the indirect effect decreased the air temperature ($0.4-1^0C$) and increased the total cloud cover (10-20%). The combined effect influenced on the meteorological parameters in both ways: decreased the air temperature (by $1-3^0C$) and the total cloud cover (by 6- 20%) as well as increased the both ($0.4-0.6^0C$, 10-20%) in some areas of the modelling domain.

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CHANGES IN TRENDS OF ATMOSPHERIC COMPOSITION OVER URBAN AND BACKGROUND REGIONS OF EURASIA: ESTIMATES BASED ON SPECTROSCOPIC OBSERVATIONS

ABSTRACT. The analysis of the CO and CH4 total column (TC) as well as aerosol optical depth (AOD) data in urban and background regions of Eurasia for different seasons and periods from 1998 to 2016 years is presented. Trends estimates based on long-term spectroscopic datasets of OIAP RAS (Obukhov Institute of Atmospheric Physics, Russian Academy of Sciences) for stations Moscow, Zvenigorod (ZSS, Moscow province), Zotino (ZOTTO, Central Siberia), Beijing (joint site of OIAP RAS and IAP CAS (Institute of Atmospheric Physics, Chinese Academy of Sciences)), SPbSU stations Peterhof and NDACC stations located in Eurasia were compared between themselves and with similar assessments obtained from satellite data. Significant decrease of anthropogenic CO in megacities Moscow (3.5±2.2%/yr) and Beijing (1.4±1.4%/yr) in autumn months of 1998–2016 were found according ground-based spectroscopic observations. In spite of total anthropogenic CO emissions decrease (for Europe and China) and absence of growth of wild-fires emissions in 2007–2016 we found that CO TC in background regions of Northern Eurasia has stabilized or increased in summer and autumn months of 2007–2016. Decrease of AOD over Central and Southern Europe and over China (1–5%/yr) was observed after 2007. Since 2007 an increase in CH_4 TC trends over Northern Europe as well as for tropical belt of Eurasia has been obtained. Analysis of satellite observations AIRS v6 of CO and CH_4 TC and MODIS AOD data confirmed the ground-based estimates of trends.

KEY WORDS: remote sensing, atmospheric spectroscopy, atmospheric composition, global changes, urban and background regions, Eurasia, trends

INTRODUCTION

We present an analysis of recent changes in total content trends of important atmospheric compounds such as carbon monoxide (CO), methane (CH_4) and aerosols.

Carbon monoxide is one of major atmospheric pollutants. CO concentration largely determines the air quality in large and small cities (WMO/IGAC 2012; Elansky 2014; Elansky et al. 2018). Its emissions and concentrations are largely interrelated with anthropogenic and/or wildfires emissions and concentrations of other pollutants, as example aerosols (Rakitin et al. 2011; Golitsyn et al. 2015; Elansky et al. 2018). CO lifetime is relatively long, from 10 days in summer to 3 months in winter (Khalil et al. 1999; Novelli et al. 1998; Jacob 1999) and therefore it's a good tracer to investigate the long transport of pollutants from area with intensive sources to background regions. CO largely determines the OH and O3 concentrations and oxidation capacity of atmosphere (Jacob 1999).

Methane is the second greenhouse gas (GHG) after CO_2 by the integral significance of the greenhouse effect and the first one by the greenhouse effect per molecule (Myhre et al. 2013; Sonneman and Grygalashvyly 2014). Numerous works and researchers report about growth CH_4 concentrations after short period of stagnation since 2007 in almost all Earth regions; this growth is usually connected with climate changes and global warming processes. Some authors consider possible strong future methane emission growth especially in Polar regions from hydrates of Arctic shelf deposits (Shakhova et al. 2014). Also CH_4 is one of major sources of atmospheric CO (Jacob 1999).

Aerosols concentration is one of the most important characteristics of air quality. Their presence in atmosphere also influence on climatic characteristics through radiative forcing. Emissions of some kinds of aerosols: soot or black carbon, and smoke aerosols (Golitsyn et al. 2015) from fuel combustion and wild

fires correlate with CO ones. Therefore, when studying the global changes in atmospheric composition we could expect an agreement in sign of CO and aerosol trends in urban and industry regions and regions of repetitive wildfires. The task of joint studying the trends of two tracers (CO and aerosols) in bulk atmosphere seems to be interesting. Both TC CO and AOD values characterize the condition of whole troposphere and their trends should poorly depend on the local sources emissions.

Numerous papers and reports devote to the about global and/or regional decrease of surface concentrations and total column (TC) of some atmospheric pollutants such as CO (Yurganov et al. 2010; WMO/IGAC 2012; Worden et al. 2013; Warner et al. 2013; Golitsyn et al. 2015), NO2 and aerosols (Hilboll et al. 2013; Coen et al. 2013; Chubarova et al. 2016), and simultaneous growth of concentration of GHGs CO_2, CH_4 etc. Climate changes take part simultaneously with changes of the atmospheric composition, both in background and urban areas (WMO/IGAC 2012; IPCC 2013).

Analysis of the CO total column (CO TC) trends in different regions of Eurasia for time-period of 1998 - 2014 was presented in our previous papers (Rakitin et al. 2011; Wang et al. 2014; Golitsyn et al. 2015; Wang et al. 2018). In preliminary results, we have paid an attention to CO TC positive trends for autumn months of 2007-2014 over rural outskirts of Moscow (ZSS, 53 km West from Moscow center) and Saint-Petersburg (Peterhof, 35 km to south-west from the St. Petersburg). In (Rakitin et al. 2016; Rakitin et al. 2017) the positive trends of CO TC were found for summer and autumn months of 2007–2015 over Russian and European spectroscopic observation stations (increase 0.5–3.6%/ yr in dependence on site). This results were unclear for us, because CO global decrease from the beginning of 21-st century usually associates with reduction of anthropogenic emissions (WMO/IGAC 2012; IPCC 2013). Aim of the present study was update of our previous CO and CH_4 TC trends estimates for ground-based stations of OIAP RAS,

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SPbSU and NDACC and comparison of the CO trends distribution with the same for CH_4 and AOD based on satellite observations, for different Eurasian regions, seasons and time periods. In addition, we wanted to investigate a possible reason of background CO increase, perhaps connected with emissions from wildfires in Eurasia.

MATERIALS AND METHODS

OIAP RAS, IAP CAS and SPbSU measurements of TC CO and CH_4

The ground-based observation of CO and CH_4 TC were carried out at 4 sites of A.M. Obukhov Institute of Atmospheric Physics (OIAP RAS) (Moscow, ZSS, ZOTTO and Beijing – joint IAP CAS and OIAP RAS observations station) by absorption spectroscopy method with using by identical grating spectrometers of medium resolution (0.2 cm-1), (Dianov-Klokov et al. 1989; Rakitin et al. 2011; Golitsyn et al. 2015). At Peterhof site the ground-based FTIR observations have been carried out by Saint-Petersburg State University (SPBSU), see details in (Poberovskii et al. 2011; Makarova et al. 2011). Specifics of observations and sites location please see at Table 1.

NDACC ground-based datasets of TC CO and CH_4

In this study, we also analyzed TC CO dataset from Thule, Kiruna, Harestua, Ny-Alesund, Bremen, Zugspitze and Jungfraujoch NDACC stations. Locations and specifics of stations are presented in Table 1. The details about the European NDACC stations could be found in (Senten et al. 2008; http://www.ndsc.ncep.noaa. gov/sites/).

Satellite AIRS datasets

Satellite data (product AIRS v6, Level 3 (L3), i.e. diurnal averaged for 1°x1° CO and CH_4 TCs, ascending data only for 2003-2016) were used to investigate spatial and temporal distributions of this species and

their long-term variations (Aumann et al. 2003; Worden et al. 2013). MOPITT and AIRS CO datasets are the longest among the presently functioning orbital missions; AIRS advantage is possibility to measure both CO and CH_4 columns with frequency of 300-350 days per year for every cell 1°x1° against 50-60 measurements per year for CO only (MOPITT).

Ground-based AERONET datasets of AOD

Estimates of AOD trends were provided by using of ground-based observations of Eurasian AERONET-network sites, diurnal AOD data for 500 Nm wavelength, Level 1.5, (Holben et al. 1998, 2001; http:// aeronet.gsfc.nasa.gov/) and orbital MODIS Terra/Aqua 1°x1° diurnal AOD data for 550 Nm of Level 3 collection 5.1 (http://modis. gsfc.nasa.gov/). AERONET L 1.5 was chosen in accordance with a largest number of daily data in comparison with L2.0.

Satellite MODIS datasets of AOD

MODIS/Terra and Aqua data are available from 2001 and 2003 years respectively.

MODIS AOD data aren't available for winter months for middle- and high-latitude regions; therefore AOD MODIS so called "annual" trends for all Eurasian regions excluding sub-tropical and tropical ones relate to season from April to October (approximately).

Before obtaining of satellite trends distribution the comparison between satellite data (diurnal means in spatial resolution 1^0x1^0 for AIRS CO and CH_4 total column and MODIS AOD products) and ground-based ones was produced (Rakitin et al. 2015; Rakitin et al. 2016; Wang et al. 2018). Best correlation of orbital diurnal CO TC data with ground-based ones was obtained for AIRSv6 (R2~0.7-0.8 and slope~1 for CO TC for linear type of the regression dependences) especially under background conditions and for MODIS/ Terra for AOD (R2~0.6-0.8, slope~0.51-0.96) that is in a good agreement with another works (Worden et al. 2013; Anderson et al. 2013; Kim et al. 2016).

Trend evaluation method

Trends were calculated separately for seasonally/yearly averaged means for both ground-based and satellite data; estimates for every case are presented for linear type of approximation together with values of their 95% confidence intervals.

Results and discussion

Typical levels of anthropogenic CO and aerosols atmospheric pollution in Beijing are 2–5 times higher in comparison with Moscow ones, that is in good agreement with our previous results (Rakitin et al. 2011; Wang et al. 2014; Golitsyn et al. 2015). According to ground-based data the negative trends in CO TC were found

for both megacities for different time-periods (decrease 1.7÷3.5%/yr for Moscow and 1.4÷2.3%/yr for Beijing in dependence on time-period and season), in spite of significant increase of motor vehicles in both megacities, see Fig. 1 and Table 2. Our estimates for megacities are confirmed by the conclusions of other reports (WMO/IGAC 2012; IPCC 2013; Warner et al. 2013; Worden et al. 2013, Elansky et al. 2018) about total reduction of CO anthropogenic emissions in most of world megacities.

In other hand the CO TC trends in summer and autumn seasons after 2007 year over background regions (OIAP sites ZSS, ZOTTO, SPbSU site Peterhof and Northern European NDACC stations) were positive

Table 1. Locations of ground-based spectrometers

| Site (number) Analyzed time intervals (years)	Typical season, amount of observation days per year for CO/CH$_4$	Coordinates, °N/°E/height above sea level	Affiliation, country, region
ZSS (1) 2003–2016	Round the year, 70–90/70–90	55.7°/36.8°/200 m	OIAP RAS, Russia, Moscow province
Moscow (2) 2003–2016	Round the year, 70–90/ 0	55.7°/37.6°/200 m	OIAP RAS, Russia, center of Moscow
ZOTTO (3) 2008–2016	June–August, 10–15/0	60.8°/89.4°/120 m	OIAP RAS, Russia, Central Siberia
Peterhof (4) 2003–2016	Round the year, 60–80/ 50–70	59.88°/ 29.82°/20 m	SPbSU, Russia, Leningrad province
Beijing (5) 2003–2016	October–November, 15–20/0	39.97°/116.38°/80 m	IAP RAS, Russia, CAS, China, Beijing
Thule (6) 2003–2015	April–September, 20–70/10–50	76.53°/68.74°/30 m	NDACC, Greenland
Kiruna (7) 2003–2015	Round the year, 50–100/ 50–100	67.8°/20.4°/420 m	NDACC, Sweden
Harestua (8) 2003–2014	Round the year, 30–60/30–60	60.2°/10.8°/600 m	NDACC, Norway
Ny-Alesund (9) 2003–2014	March–October,20–40/20–40	78.9°/11.9°/15 m	NDACC, Norway, Spitsbergen
Bremen (10) 2003–2014	Round the year, 10–30/10–30	53.1°/8.8°/30 m	NDACC, Germany, industrial region
Zugspitze (11) 2003–2014	Round the year, 30–50/30–50	47.42°/10.98°/2964 m	NDACC, Germany, Alps
Jungfraujoch (12) 2003–2015	Round the year, 20–50/30–50	46.55°/7.98°/ 3850 m	NDACC, Switzerland, Alps

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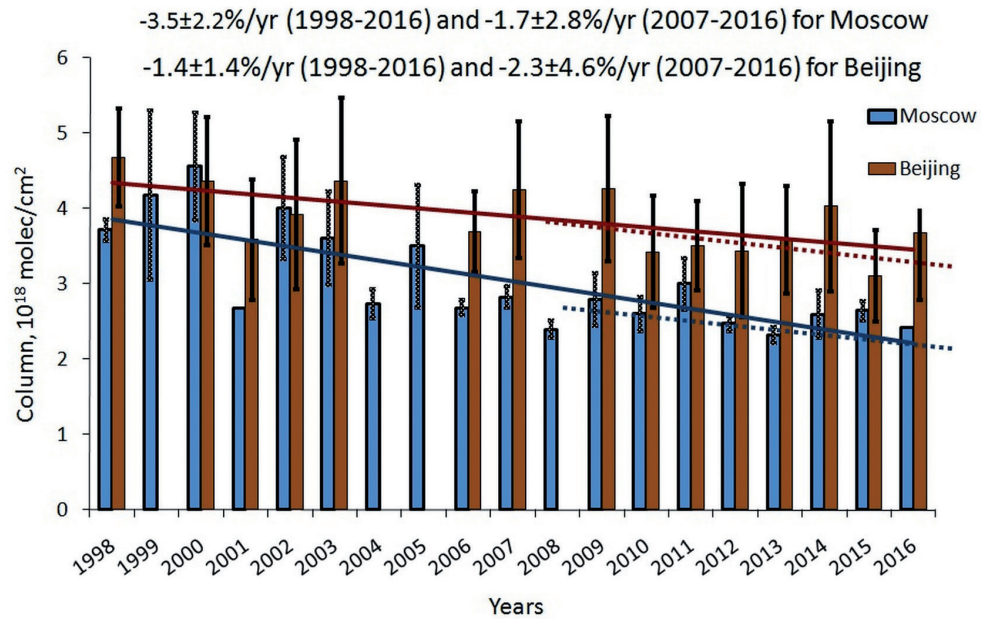
Fig. 1. CO TC means and trends for Moscow and Beijing (1998–2016, averaging for October-November)

(increase 0.4-2.4%/yr, see Fig. 2 and Table 2) according to both ground-based and satellite observation. Distributions of trends obtained from AIRS v6 satellite data is in fairly good agreement with the ground-based estimates (Table 2, Fig. 2).

According to AIRS v6 data an acceleration of CH_4 TC increase after 2007 was found for Northern Europe and tropical belt of Eurasia (Fig. 3). Significant seasonal differences in trends were not found for almost all of Eurasian regions, that confirms our previous results (Rakitin et al. 2017).

Table 2. CO total column trends for different time-periods according to annually and seasonally averaged data of ground-based and satellite measurements. Numbering of sites corresponds to Table 1. The positive seasonal average TC CO trends are marked by bold font

Ground-based observations: sites, years	Ground-based			AIRS		
	Season	Trend, %/year		Time periods	Trend, %/year	
		Season	Year		Season	Year
ZSS (1) 1998–2016 2003–2016 2007–2016	Sep-Nov	-1.25±1.51 **0.15±1.10** **0.94±1.26**	-1.33±0.76 -1.60±1.31 -0.58±1.87	2003–2016 2007–2016	-0.48±0.84 -0.21±1.54	-0.70±0.33 -0.46±0.52
Moscow (2) 1998–2016 2003–2016 2007–2016	Sep-Nov	-3.54±2.21 -2.53 ±2.39 -1.65±2.82	-2.32±0.98 -2.83±1.67 -2.11±2.47			
ZOTTO (3) 2008–2016	Jun-Aug	~1.10		2003–2016 2007–2016	0.50±2.06 **1.66±4.09**	-0.37±0.57 **0.02±0.96**

Peterhof (4) 1998−2016 2003−2016 2007−2016	Sep-Nov	-0.71±1.48 **0.20±0.87** **0.83±1.44**	-0.16±0.59 -0.37±0.81 -0.33±1.81	2003−2016 2007−2016	-0.39±0.72 0.26±1.04	-0.62±0.33 -0.26±0.43
Beijing (5) 1998−2016 2003−2016 2007−2016	Oct-Nov	-1.40±1.36 -1.96±2.67 -2.29±4.57		2003−2016 2007−2016	-0.81±0.84 -0.27±1.29	-1.03±0.44 -1.00±0.78
Zhule (6) 2003−2015 2007−2015	Jul-Sep	-1.13±2.88 **0.13±3.55**	-1.81±1.54 -1.34±2.93	2003−2016 2007−2016	-0.14±0.58 **0.26±1.04**	-0.34±0.27 -0.21±0.42
Kiruna (7) 2003−2015 2007−2015	Jul-Oct	-1.14±1.38 **0.47±1.33**	-1.16±0.74 -0.26±0.98	2003−2016 2007−2016	-0.48±0.75 **0.24±1.09**	-0.61±0.32 -0.27±0.38
Harestua (8) 2003−2014 2007−2014	Jul-Oct	-0.59±2.18 **1.56±3.07**	-0.79±1.29 **0.35±2.43**	2003−2016 2007−2016	-0.52±0.82 **0.10±1.27**	-0.72±0.35 -0.39±0.46
Ny Ales. (9) 2003−2014 2007−2014	Jul-Sep.	**0.17±2.15** **2.36±3.36**	-0.67±1.80 **1.07±1.72**	2003−2016 2007−2016	-0.06±0.63 **0.63±0.80**	-0.52±0.32 -0.30±0.49
Bremen (10) 2003−2015 2007−2015	Jul-Oct	-0.25±2.55 **2.08±4.68**	-0.05±1.18 -0.52±2.81	2003−2016 2007−2016	-0.57±0.68 -0.07±1.01	-0.79±0.34 -0.49±0.47
Zugspitze (11) 2003−2014 2007−2014	Jul-Oct	-0.07±1.11 **1.33±1.43**	-0.56±0.97 **0.17±1.85**	2003−2016 2007−2016	-0.63±0.71 -0.08±1.10	-0.85±0.40 -0.53±0.54
Jungfr. (12) 2003−2015 2007−2015	Jul-Oct	-0.30±0.84 **0.89±1.07**	-0.93±0.55 -0.32±0.96	2003−2016 2007−2016	-0.65±0.72 -0.04±1.08	-0.89±0.36 -0.58±0.47

According to AERONET and MODIS observations, AOD trends over Central and Southern Europe were negative (see Table 3 and Fig. 4), for all seasons (except winter) and time-periods. For Northern Eurasia AOD temporal changes were positive only in Central Siberia, that due to intensive Siberian wild fires of 2012, 2014 and 2015 years; also a decrease of AOD was obtained for China, Table 3 and Fig. 4. Our estimates for different regions are in good agreement with results of other reports and papers (IPCC 2013; Coen et. al. 2013) including regions of Moscow and Beijing (Chubarova et al. 2016; Wang et al. 2017).

Apparently from Table 2, the TC CO trends for all stations in the European part have changed a sign after 2007. Thus trends show values, which are more than 1% per year in the summer-autumn period (marked by bold font in Table 2) at the Harestua, Ny-Alesund, Bremen, Zugspitze stations. The trends also have changed at the ZSS, Peterhof, Jungfraujoch, Kiruna and Zhule stations, but the trend value is less expressed.
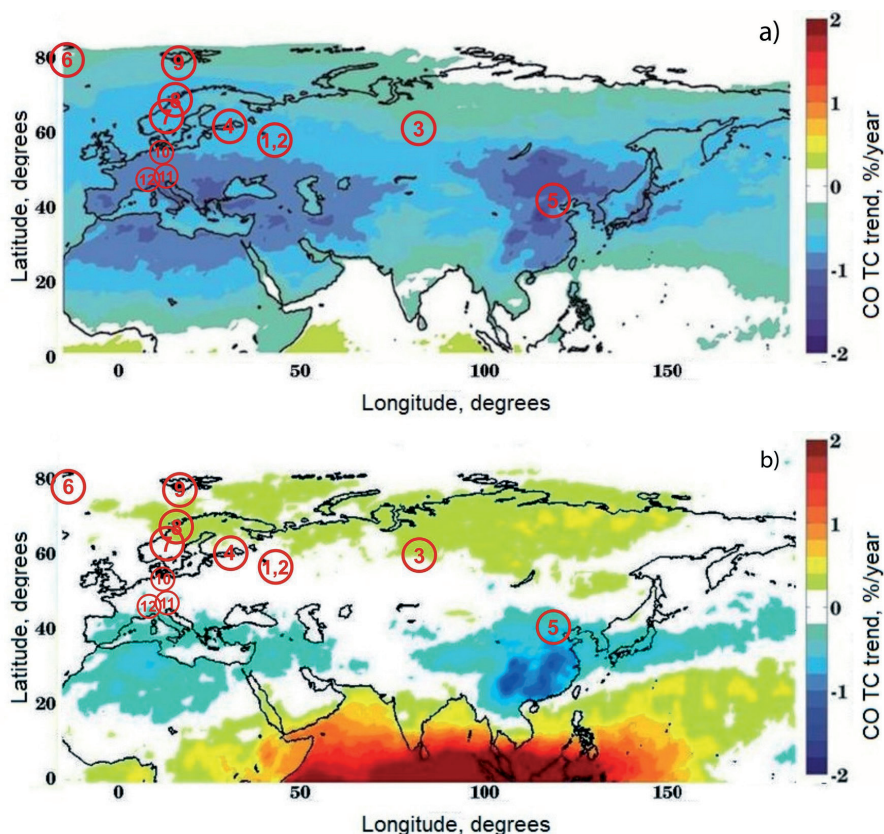
Fig. 2. Distribution of CO total column trends, according AIRS v6 data: a) - annual averaged values for 2003-2016; b) - autumnal averaged values for 2007-2016. Numbering of sites corresponds to Tables 1 and 2

CO TC and AOD positive trends after 2007 in summer months could be explained for some sites and regions by impact of Siberian wild-fires of 2012, 2014 and 2015 years. However in autumn months fires usually finish. CO life-time in troposphere varies from 1-2 weeks in summer to 3 months in winter (Novelli et al. 1998; Khalil et al. 1999; Jacob 1999). So, a significant impact of intensive summer Siberian wild-fires of 2012, 2014 and 2015 years or winter Malaysian ones (occurred in 2015) on atmosphere over Moscow and Saint-Petersburg outskirts in October-November as well as their influence on Northern European background regions seems improbable.

Therefore, such changes in summer and autumn CO trends cannot be explained by growth of wildfires impact at least in Europe where wild-fires emissions decreased

for both time-periods 2007−2016 and 2003−2016 (Randerson et al. 2017; GFED v4.1; Rakitin et al. 2017). Possible reason, needing additional evidence is the changes in atmospheric photochemical system for example, can be an additional formation of carbon monoxide from methane that concentrations increased after 2007.

CONCLUSIONS

A significant decrease of CO total column and AOD in two large megacities Moscow and Beijing was found for time-period of 2007−2016. CO TC trends in summer and autumn months after 2007 changed their sign from negative to positive in almost all of background regions of Northern Eurasia. After 2007 an acceleration of increase of CH_4 TC was found for tropical and subtropical belt of Eurasia as well as for Northern Europe. Changes in AOD

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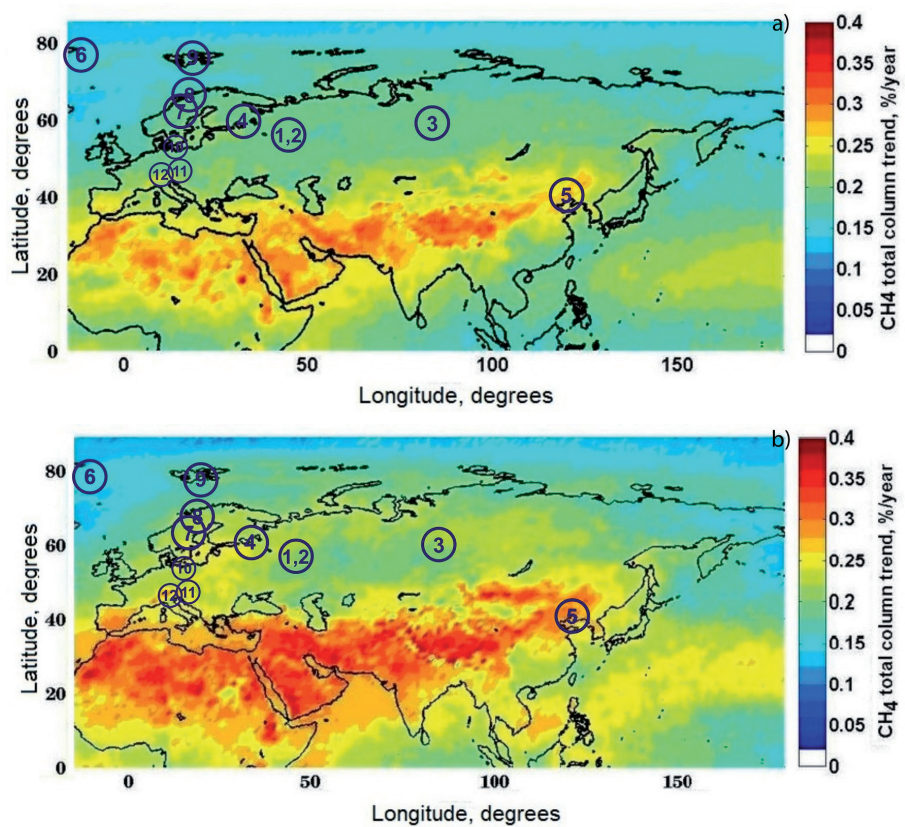
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Fig. 3. Distribution of CH4 total column trends according to annually averaged AIRS v6 data: a) - for 2003–2016; b) for 2007–2016. Numbering of sites corresponds to Table 1 and 2

Table 3. Aerosol optical depth (AOD) trends according AERONET and MODIS observations (summer months and annual average, 2003−2015 and 2007−2015 time-periods)

| Sites, years | AERONET | | MODIS | | | | |
| | Trend, %/year | | Years | Trend,%/yr, Terra | | Trend,% /yr, Aqua | |
	Jun-Aug	Annual		Jun-Aug	Annual	Jun-Aug	Annual
Zvenigorod (1) 2003−2015 2007−2015	-0.5	-2.7	2003-2015 2007-2015	-0.3 -4.0	-1.7 -3.2	0.1 -4.7	-1.1 -5.6
Moscow (2) 2003−2015 2007−2015	-0.2 -3.4	-1.9 -4.1	2003-2015 2007-2015	-0.9 -5.1	-2.4 -4.4	-0.5 -4.5	-4.9 -1.2
Tomsk (3) 2003−2015 2007−2015		-2.3 -1.6	2003-2015 2007-2015	1.1 0.9	0.0 -1.2	1.0 2.3	-0.8 0.7

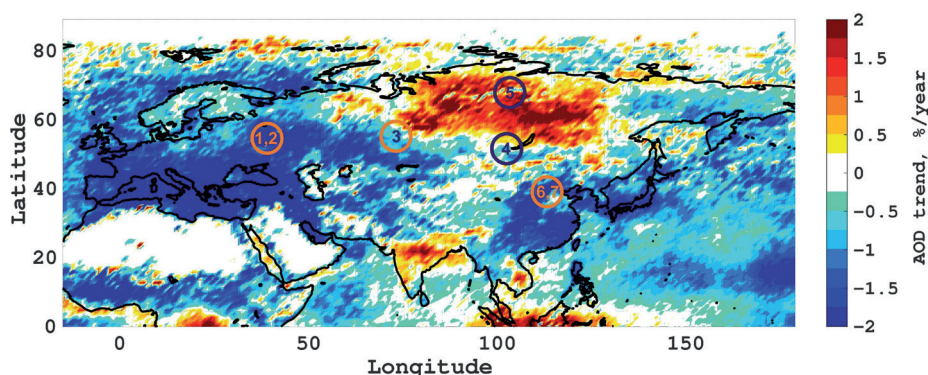| Irkutsk (4) 2004−2015 2007−2015	0.9	3.1 1.4	2004-2015 2007-2015	1.1 0.9	1.9 -2.8	0.5 -1.2	-0.4 -3.4
Yakutsk (5) 2003−2015 2007−2015	6.1 7.7	3.5 0.5	2003-2015 2007-2015	2.5 3.9	1.9 1.7	2.6 4.6	2.3 -0.03
Beijing_(6) 2003−2015 2007−2015			2003-2015 2007-2015	-0.5 -4.4	-0.1 -1.3	-0.6 -1.8	0.3 -1.3
XiangHe (7) 2004−2015 2007−2015	-2.0	0.2 -1.6	2003-2015 2007-2015	-0.4 -4.2	-0.1 -1.2	-0.6 -1.8	0.3 -1.3

Fig. 4. Distributions of aerosol optical depth (AOD) trends (annual average) according MODIS/Terra for 2007−2016 years

trends for time-periods of 2000−2007 and 2007−2016 were insignificant. A significant decrease of AOD was obtained for almost all of Eurasian regions except of East Siberia, India and South-East Asia for both time-periods. Such pattern of changes in atmospheric composition especially in CO trends cannot be explained by growth of anthropogenic and/or wild-fires emissions. Possible reason of beginning of CO growth may be the change in the ratio of the natural sources and sinks with a significant role of atmospheric photochemical mechanisms.

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REVITALIZING DEPRESSED AREAS OF THE RUSSIAN NORTH (THE CASE OF VELIKY USTYUG)

ABSTRACT. The study discusses the experience of «Veliky Ustyug – Ded Moroz Homeland» - one of the most successful Russian projects of regional tourism development in scarcely populated and depressed areas of the Russian North.

Founded in 1147, Veliky Ustyug is among the oldest towns of the Russian North with a 'historic city' and 'open-air museum' status. However, in the 1980-1990s it was a typical small town with depressive socio-economic structure based on forestry, small enterprises, folk crafts and distinctive social challenges such as migration, high unemployment, et al. The project «Veliky Ustyug – Ded Moroz Homeland» comparable to Santa Claus Village in Rovaniemi, Finland has increased greatly the tourist flow to the town and improved considerably its socio-economic situation.

The research is based on extensive field studies, theoretical observations and includes statistics analysis as well as the results of in-depth interviews with experts and regional stakeholders taken in 2011-2016, review of official legislation. Study reveals that the main idea of the project is to revitalize the depressed community with a wide range of social, educational, economic, infrastructural, cultural, leisure and tourism activities to promote its future sustainable development. The project life cycle is discussed within the birth, growth and maturity periods; each of them is provided with quantitative characterization. Key problems of the project and their possible solutions are identified. The main constraints to the project connected with poor transport accessibility of the destination and high seasonality of tourism demand are considered.

KEY WORDS: tourism, sustainable regional development, depressed territories of the Russian North, tourist cluster, Veliky Ustyug, Rovaniemi

INTRODUCTION

Veliky Ustyug is one of the oldest towns in the north of European Russia. Located in the Vologda region 450 km northeast from the regional centre and more than 900 km from Moscow, Veliky Ustyug was founded in 1147 at the confluence of the Sukhona and the Yug rivers and is coeval to Moscow and Vologda. Almost all the territory around the town is covered by taiga forests with some meadows in floodplains. Though sparsely populated the area has always been known for timber production, dairy farming, flax cultivation and local craftworks as well as active trading. In course of reforms in the 1990s most of the local enterprises were closed or privatised and the economic situation in the area became depressed. It caused distinctive social challenges such as high unemployment and migration flows to Central Russia. Disastrous flooding in 1998 aggravated the situation. The number of residents in the town has declined and now the population of Veliky Ustyug is estimated at 31.6 thousand. The population of the municipal district around Veliky Ustyug (comprising 2 urban and 17 rural settlements) is about 23.3 thousand and the population density is 2.3/km² (Municipal data sheet 2016).

Unlike Karelia and Komi regions or the Kola Peninsula where indigenous non-Russian people prevailed till the XX century, this area was settled by Russians who came from Veliky Novgorod in the XI-XII centuries and later from the Upper Volga region. Therefore, Russian cultural traditions gained a strong foothold here. Nowadays Veliky Ustyug retains its rich cultural heritage with a 'historic city' and 'open-air museum' status. It has one of the best-preserved architectural ensembles in Russia with 153 sites classified as cultural and historical heritage of national significance and 25 sites classified as cultural and historical heritage of local significance. Most of the architectural and historical attractions refer to the XVI-XVII centuries when the town was the junction of key trade routes of national importance. The way north to Arkhangelsk, the main sea-port in the medieval and early modern Russia until Saint Petersburg's foundation in 1703,

crossed the ways fur traders used collecting furs from the huge area in the east. The commercial importance of Ustyug was so big that the town was named 'Veliky' ('Great') for its role in trade and communications. The Veliky Ustyug region is also the birthplace of Semyon Dezhnev, Yerofey Khabarov, Vladimir Atlasov and other Russian explorers of the Siberia and the Far East regions whose names can be now found on the world map. Despite all of the above advantages, the town did not attract many tourists. This was largely due to its complicated transport position. There was only one paved road from Vologda going northeast to Kotlas and a sideline of Vologda-Vorkuta railroad that was mostly out of use. The local airport had occasional passenger service to Vologda. In addition, there were no tourist products attractive for travellers.

The Veliky Ustyug area can serve as a distinctive example of a marginal territory located in distant periphery and lagging behind the rest of the region in terms of economic and social development. In general, marginal areas are usually characterized by a sparse network of settlements, large areas of pristine landscapes and very limited number of economic activities. Marginal territories have the potential for development but due to their geographical position are not able to find sufficient motivation, forces and means to grow (Pokrovsky and Nefedova 2014). The idea of sustainable tourism involving the recognition of potential negative impacts of tourism activities and the need to manage them in order to achieve the sustainable development goals should also be taken in consideration (Saarinen 2006).

Industrial production in the Veliky Ustyug region remains the main sector of local economy and is represented by woodworking, food production, electric power, machinery and construction materials manufacturing. Timber production plays the key role as the forested area covers about 80% of the region. But industrial enterprises are not the main taxpayers; their share in tax revenues is small as they are often registered in other places. The main part of regional tax revenues is formed by trade, education, health care, tourism and

other services. As before, the demographic situation in the region is characterized with the population decrease; the death rate exceeds the birth rate. Migration outflow in recent years is small, but in general the region is depopulating.

MATERIALS AND METHODS

The study is based on observations and records made in course of field trips held by the authors in 2011-2015. The first trip was held in 2011 when the express destination analysis in high season was made. It included observations and data collection on the main attractions, tourist activities and transport accessibility of «Veliky Ustyug – Ded Moroz Homeland» project.

The study was continued in 2012 off-peak season when the Department of Recreational Geography and Tourism, Faculty of Geography, Lomonosov Moscow State University expedition group of 11 students and 2 researches made a comparative analysis on regional tourist products branding and promotion for Vologda, Tot'ma and Veliky Ustyug. There was also sociological survey on tourism development prospects held in Veliky Ustyug which covered 3 groups of respondents: tourists, local residents and experts (local tourism industry representatives) and was aimed at revealing their evaluation of current and future tourism development prospects in the region. The survey was added by detailed study of the «Veliky Ustyug – Ded Moroz Homeland» destination ancillary services and amenities.

In September 2015 a number of in-depth semi-structured interviews on «Veliky Ustyug – Ded Moroz Homeland» tourist cluster project with experts and regional stakeholders including the representatives of regional and municipal tourist administrations and managers of tour companies who offer tours to Veliky Ustyug were held in the region. The main research topics included the goals of the project, its objectives, cluster structure, infrastructure facilities, project efficiency and sustainability. Expert interviews were preceded by marketing research on prospects for youth

tourism development in Vologda region conducted in course of the «Gates of the North» tourist exhibition in Vologda.

After 2017 peak season special research supported by Russian Travel Industry Union gave the opportunity to get expert assessments on current situation and future development prospects from the CEOs of six leading national tour operators and sum up the results and problems of «Veliky Ustyug – Ded Moroz Homeland» project (RATANews 2017).

The field researches, marketing research and surveys formed the basis of the study. They were added by economic and statistical analysis, comparative geographical analysis, foreign experience assessment and content analysis of tourist information presented in guidebooks and websites.

Theoretical and methodological source of the study is formed by fundamental works of Russian and foreign scientists on regional development problems in marginal and sparsely populated areas of the North. It also includes regional statistics analysis and previously published literature review. The study is supported by regulatory and normative documentation assessment aimed at providing better understanding of different types of tourism development initiatives in the remote and sparsely populated areas of Russia.

Particular attention was paid to Santa Claus Village (Rovaniemi, Finland) experience (Pretes 1995, 2006; Grenier 2007; Hall 2008). The study of the foreign experience which in many ways served as an example for «Veliky Ustyug – Ded Moroz Homeland» project is of particular importance for understanding the key performance trends and means for the arrangement, promotion and modification of its tourist product as well as the impact on regional economic development and sustainability.

The project «Veliky Ustyug – Ded Moroz Homeland» was launched in 1998 on the initiative of the Moscow City Government and the Vologda Region Administration. The idea of the project came from the

Moscow City Mayor Yu. Luzhkov and was supported by the regional and municipal tourism authorities (Vinogradov et al. 2008). It is necessary to point out that the idea to place the fairy-tale hero residence in Veliky Ustyug came 'from above'; it was not a public initiative. The people who started the project in Veliky Ustyug admit that they have learned about Santa Claus Village (Rovaniemi, Finland) successful experience but the idea of their project and the conditions for its implementation were quite different.

From the very beginning, serious limitations for the project were obvious. They included poorly developed accommodation facilities (only 2 units with total capacity of 119 bed places), lack of direct transport communication with Moscow and unsatisfactory condition of local cultural attractions. However, it was counterbalanced by strong state support and enthusiastic leadership of local tourism authorities.

It is evident that the project has a universal value and contains different instruments for comprehensive and sustainable regional development. The Vologda Region Government, Veliky Ustyug Municipal Administration and the Moscow City Government, who has contributed 2 million roubles to run the project, became the founders of the venture.

In 1998 an open joint-stock company (JSC) «Ded Moroz» was registered in Veliky Ustyug. Today «Ded Moroz» JSC is a big travel company with a wide range of group and individual tours designed for the «Veliky Ustyug – Ded Moroz Homeland» project. In addition, it is the owner of the «Ded Moroz – Veliky Ustyug» registered trademark which is widely used in food and beverage industry.
In the same year the Moscow Mayor and the Governor of the Vologda region signed an agreement on the implementation of the «Veliky Ustyug – Ded Moroz Homeland» project. It has provided a number of measures to promote the project including corporate project identity, brand name, gift books for children and souvenir production, TV and other media commercials, organisation of the annual ceremony of Ded

Moroz arrival from Veliky Ustyug to Moscow, corresponding New Year and Christmas outdoor decoration, etc. It is very important to mention that this document provided the foundation for the prearranged exchange of children and school tourist groups between Moscow and Veliky Ustyug that formed the main tourist flow for the destination at the first stage of the project.

In 1999, the key attraction – the Homeland (Votchina in Russian) of Ded Moroz located 12 km from Veliky Ustyug in a beautiful pine forest on the riverbank was opened. The house of Ded Moroz as well as cottages for tourists, special facilities for winter activities, the zoo, and botanical garden with greenhouse, shops and other amenities were built. At the same time, the town residence of Ded Moroz opened in the centre of Veliky Ustyug. It included a great hall, souvenir shops with local craftworks (Vologda lace, birch bark carving, local silver jewellery, etc.), another museum and Ded Moroz post office.

In 2007 the official website of the project (www.dom-dm.ru) was launched. It tells about «Veliky Ustyug – Ded Moroz Homeland» project in detail and provides tourists with the necessary information about local tourist attractions, events and amenities. There is also a special website (www.votchina-dm.ru) with additional information on the destination. Both websites give the option to send e-mails to Ded Moroz.

Over time, the project gained additional support from new stakeholders. For example, the Russian Railways company has revived railway connection with Veliky Ustyug and launched special charter trains for children's tourist groups. These trains are used not only as a means of transport but also serve as a means of accommodation that helps to a certain extent to cope with the shortage of accommodation facilities in Veliky Ustyug. The first train of this kind started from Moscow to Veliky Ustyug in 1998 and brought 320 guests. Nowadays, Russian Railways provide up to 20 special tourist trains for children from the main cities of Russia annually from mid-November until

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mid-January period (Vinogradov et al. 2008). The educational part of the project has been developed gradually. In 1999, the first special training courses for managing tourist groups attracted by the project were held. Later, training courses for tour guides, for children's groups in particular, were organized. In 2003 the regional methodical centre for advanced training in tourism and hospitality was formed. Training courses for the new specialties that are of great demand for the project such as tourism and event manager, bartender, waiter, hotel cleaner, folk craftsman, etc. started in Veliky Ustyug secondary educational institutions. Technical support for the project was provided through cooperation with scientific and research centres, investment forums and conferences on tourism development.

In the 2000s a new stage in sponsoring the project started. It was supported by the national leading oil, gas and chemical companies such as Lukoil, Azot JSC, Gazprom, Severstal and other key entrepreneurs of the Vologda region. There was continuous Moscow city budget financial support. In total, from 1999 to 2014 the project was invested with 2.5 billion roubles and 40% of investments were private (Information on the project realisation 2015). The situation in Rovaniemi was quite similar: the project was launched by state Finnish Tourist Board, and then different forms of public-private partnership started to develop. Finnish post office and Finnair as a national carrier also supported the project (Pretes 1995).

The Veliky Ustyug project growth was also supported by a series of events.

They included Ded Moroz, New Year and Christmas thematic events as well as various festivals, competitions, creative programs for children and youth from different regions of Russia, educational programmes and games, sport tournaments, exhibitions, etc. The motto of Ded Moroz «Do the Good!» became the main idea of all creative activities and events carried out within the framework of the project.

Special attention was paid to the social orientation of the project, which is mainly implemented through children's communication with Ded Moroz. Ded Moroz post office has already received nearly 3 million letters from children all over Russia and abroad at www.pochta-dm.ru. The letters' content indicates high level of interest and confidence in the project. In 2005, a new therapeutic and recreational housing for children with disabilities, orphans, and children from deprived families opened in Ded Moroz Homeland. Non-governmental organisations, business groups, small companies and individuals take part in charitable events and activities there.

RESULTS AND DISCUSSION

«Veliky Ustyug – Ded Moroz Homeland» project resulted in a massive increase of tourist flow to the destination. Despite the decline in tourist arrivals in some years mainly due to unfavourable weather conditions and inconsiderate price policy the tourist flow has grown up to 278.5 thousand in 2016 (Fig.1).
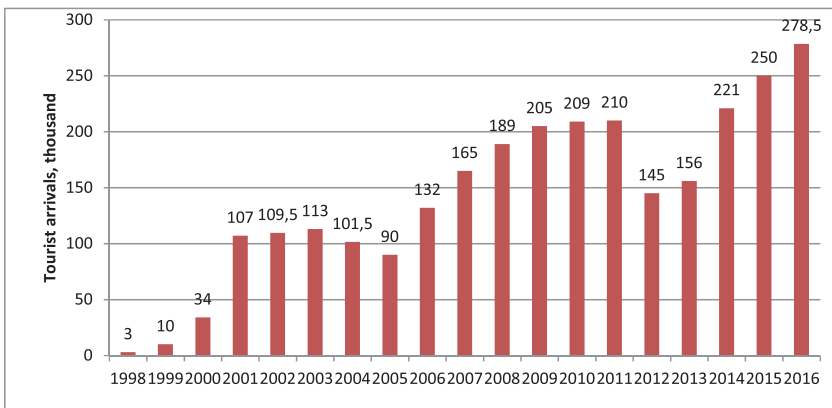

**Fig. 1. Tourist arrivals to Veliky Ustyug, 1998-2016 (thousand)
Source: Department of Culture and Tourism of the Vologda region**

The analysis of territorial distribution of tourist arrivals to Veliky Ustyug showed that the main target markets are located in two metropolitan areas – Moscow and Moscow region, Saint Petersburg and Leningrad region (Fig. 2).

Fig. 3 shows the distribution of arrivals by purpose of visit, indicating the dominance of cultural and leisure motivations. Other types of tourism also have good prospects for future tourism development and can help in elaborating new tourism products and reducing seasonal fluctuations.

In comparison to Santa Claus Village visited by international tourists mainly (Grenier 2007), Ded Moroz Homeland is aimed at domestic tourism only.

Rovaniemi has positioned itself as a leading North European centre for winter tourism by developing outdoor activities and special events, with Santa Claus village acting as an addition to the existing polar attractions and activities (Pretes 2006; Grenier 2007). Santa Claus tourism has become an important Christmas season tourism activity in the region located right on the Arctic Circle. Moreover, strong brands like Santa Claus are clearly important contributors to the construction of regional advantage (Hall 2008).

In contrast to Rovaniemi, Veliky Ustyug had only cultural attractions and no additional advantages. The project here is based on the idea of common unification regarding national roots and traditions through associating with the image of Ded Moroz (sometimes translated as Father Frost) that symbolises kindness, happiness, hope and faith in future for both children and adults. The main objectives of the project are as follows:
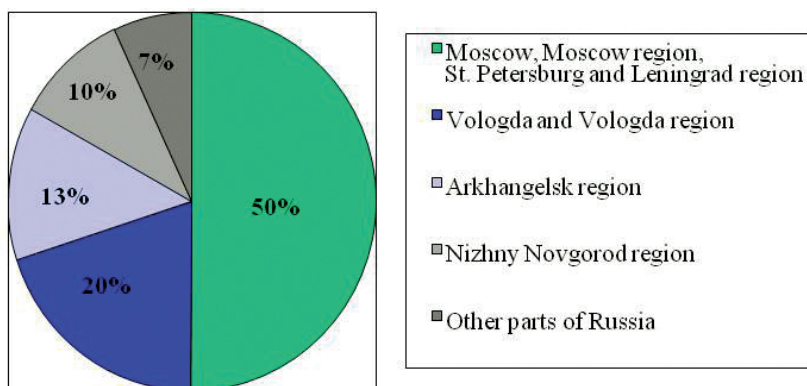

Fig. 2. Territorial structure of tourist arrivals to Veliky Ustyug, 2014 (share)
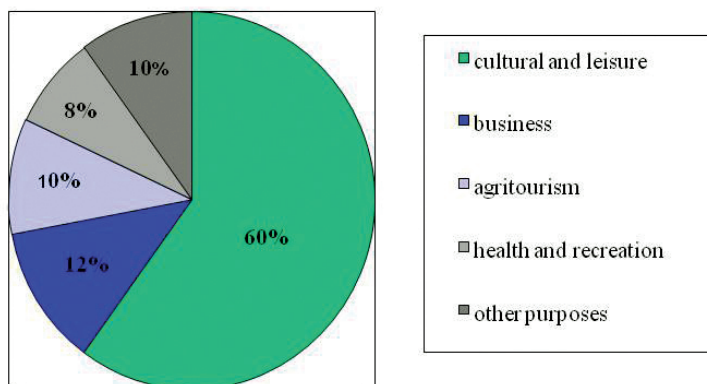**Source: Department of Culture and Tourism of the Vologda region**

Fig. 3. Tourist arrivals to Veliky Ustyug by purpose of visit, 2014 (share)
Source: Department of Culture and Tourism of the Vologda region

1) educational – teaching young people traditional national and universal values, moral and aesthetic principles as well as kindness and mercy;

2) social – creating positive example of a small town revival in Russia;

3) economic – modern tourism industry and tourism infrastructure development and generation of unique tourism products for the national and international tourist markets;

4) ecological – conservation of cultural and natural heritage of the Russian North;

5) cultural – revival, improvement and reconstruction of local traditions and crafts as the essential part of national culture.

The project has had a positive impact on the local economy and social life. As Saarinen (2003) points out, in northern regions tourism provides more employment opportunities than any other field of economy. It is gradually used as a medium for many social and economic goals at regional and local level. Moreover, the community-based tradition of sustainable tourism growth stresses the wider involvement and empowerment of various actors, especially host communities, in development by emphasizing the elements of social capital in a local context (Saarinen 2006).

During the project implementation, transport and tourism infrastructure of Veliky Ustyug has been rapidly developed, the historical town centre was renovated, and new shopping centres and supermarkets as well as mobile communication and taxi services appeared in the town. The number of accommodation facilities in the town and its vicinity has increased significantly. There are now 14 hotels, 14 cottages, 1 sanatorium, 3 lodges, 18 guesthouses and other accommodation facilities in the area and the total number of bed places has exceeded 2.8 thousand. The average room occupancy rate was 70% in 2014 (the average room occupancy rate in Russia is just over 30%). During the same period the number of public catering enterprises increased by

six times. Eleven travel agencies are now engaged in providing tourist services in Ded Moroz Homeland while in 1998 there was only one agency of this kind (Information on the project realisation 2015).

The social efficiency of the project is proved by generating new jobs and emerging local employment (Bessolova 2013). In 1998 only 50 people were employed in local tourism industry; in 2015 there are almost 4 thousand employees in this sphere. That accounts for 13% of the total employed population of the district. Tax revenues from the project account for approximately 10% of Veliky Ustyug budget income (Veliky Ustyug municipal district data 2015).

«Veliky Ustyug – Ded Moroz Homeland» project has been repeatedly recognised as the most successful regional tourist project and regional brand in Russia. In recent years, it started to act as a model for other towns and regions of the country where other Russian fairy-tale heroes (like Snow Maiden or Baba Yaga) are used for tourism development. Ded Moroz is not a global symbol as he and other fairy-tale heroes belong to Russian culture only. However, these products are successful as they can be easily commodified. This idea supported by the regional tourist authorities and tourism industry has initiated the development of about 15 similar projects in different parts of the country. Taken together they form an interregional cultural and tourist project «Fairy-Tale Map of Russia». Not all the projects are that successful but they try to follow Ded Moroz model. It is very important to match up the potential of the suggested brand with the size and economic profile of the place and to provide its active promotion and infrastructure investments.

In 2000, a trilateral agreement on cooperation between Moscow, Vologda Region and the Lapland Province in Finland was signed to start the international project «Santa Claus – Ded Moroz». There are good relationships with foreign partners in Sweden, Germany, Belarus, Latvia, etc.

Along with the poor transport accessibility, seasonal character of tourism activities is

the key problem for Veliky Ustyug project development. Seasonality has always been a very serious problem for Rovaniemi (Pretes 2006; Grenier 2007; Hall 2008). One of the first attempts to make the season longer was connected with the celebration of Ded Moroz birthday organized annually on November, 18. Then a wide range of all-season programmes for children staying in Veliky Ustyug was arranged. They included «Festival Express» – summer recreational programmes for children, «Ded Moroz Decorations» – guided tours to introduce craftworks and traditions of Veliky Ustyug municipal district for children, «The Youth Embassy» programme – training the young ambassadors of «Ded Moroz Homeland» project to provide support for various social activities in their schools and settlements, Army Cadet School, International School of Russian Studies, etc.

The variety of events has expanded greatly. A year-round cycle of festivals in the Homeland of Ded Moroz was launched. Due to these measures, there is a positive tendency to smooth out seasonal fluctuations. The number of visitors in summer, spring and autumn periods has increased. Nevertheless, the problem of seasonality remains urgent. In 2012 a decision to turn the «Veliky Ustyug – Ded Moroz Homeland» project into a year-round tourist destination was taken. New tourist sites and infrastructure objects are constructed as parts of investment project «Ded Moroz» which has received the tourist cluster status. As Hall (2008) states, clustering and innovation are the best regional policy ideas for peripheral areas. In 2015, the project was included in the Federal Target Programme «On the Inbound and Domestic Tourism Development in the Russian Federation (2011-2018)».

The cluster plan consists of a set of inner projects and tourism infrastructure items such as:

- interactive cultural and leisure centres (new facilities for recreation and entertainment);

- sports centres and health tourism facilities, including the year-round children's campsite;

- trade and exhibition centres;

- places for agritourism, hunting and fisheries (eco-village);

- centres for national traditions revitalisation (Russian izba - traditional countryside log house).

The cluster infrastructure objects are dispersed around all the territory of Veliky Ustyug municipal district including Ded Moroz Homeland area. Therefore, it will help to develop rural territories around the town. The cluster project started in 2014 and is about to be completed in 2018. According to 2016 data the plans for the tourist arrivals and the number of bed places in collective accommodation facilities have been already fulfilled. Tourist flows are expected further increase and at least 250 additional job places will be created. The strategic goal of the project is to reach 650 thousand visitors to Veliky Ustyug municipal district in 2030 (Alexandrova and Vladimirov 2016).

Another important result of the project is connected with public initiatives for tourism development appeared 'from below' with tourist activities proposed by local community. When the positive impact of tourism on local economy and social development became obvious the residents of the Veliky Ustyug area started to suggest their own ideas on tourist activities based on local traditions, culture and history. For example, several guesthouses restoring the traditions of northern peasant dwelling with traditional Russian stoves, original utensils, traditional clothing and food were organised. They present cultural and educational programmes, events and food in traditional Russian style and other activities based on traditional folk culture, which is typical to the Russian North. Such projects are of great social importance for the area. Therefore, they are supported and promoted by the municipal authorities and have preferential tax treatment.

Some projects combine more multifaceted ideas and traditions. Starting from 2013 the project «Mit'kina Doroga» (Mit'ka's Pathway) is been developing in Veliky Ustyug area.

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Local inhabitants started to restore the road built in the XIX century by a local farmer for a vow given during his wife's illness. The road goes to the old church that is now abandoned and needs restoration. This project symbolises life journey of a peasant family, their family values, religious traditions, local history and ethics. The project also has unique nature tourism potential as the road passes through Strelensky geological reserve close to the Upper Strelna and Opoki landscape protected areas. «Ded Moroz» JSC supports the project as it helps to attract tourists in summer period and to maintain year-round staff employment.

CONCLUSION

The success of Veliky Ustyug project is largely determined by particular attractiveness of the fairy-tale hero theme which brings tourists to the world of childhood, dreams and magic. This idea is widely supported by active advertising campaigns as the New Year is one of the most favourite holidays among Russians. The popularity of the project is also connected with its diverse and well-preserved environment – both natural and cultural. That is why tourists from big cities come here.

Many experts emphasise that lack of snow in winter is an increasing limitation for Santa Claus Village development. Though the location of Ded Moroz Homeland was chosen rather emotionally, thanks to the beauty of local landscapes and climate, there is no problem with snow in the Veliky Ustyug area.

At the same time, main problems are caused by inconvenient road configuration and poor technical quality of transport network and infrastructure in Veliky Ustyug which is typical for the northern peripheral regions of Russia.

The results of the study reveal one more problem that is extremely relevant but is not properly understood yet. The example of «Veliky Ustyug – Ded Moroz Homeland» shows that tourist destination which has a very strong brand, on the one hand, and the peripheral position, on the other, hinders the development of the entire regional tourism system. Spatial framework of regional tourism system is formed by tourist centres connected by transport and tourist routes. If the central link falls out of the supporting frame, the entire system collapses and tourism spatial organisation fails.

In many respects Veliky Ustyug has appeared to become a tourist centre artificially, therefore it cannot form the regional tourism system core. According to objective reasons, Vologda should be the core of the regional tourism system (in terms of tourism potential, transport accessibility, administrative status, etc.). The amorphous regional tourism system confronts the competition between existing and new emerging tourist centres like Cherepovets or Vytegra. Instead of cooperation, which is highly important for tourism development, this confrontation leads to uneasy relations between tourist centres.

Tourist flows do not circulate around the destination because of Veliky Ustyug poor transport accessibility even despite the fact that Votchina is operating at the limit of its capacity. During high season in 2016, the organizers had to limit visits by unorganised tourists because of the huge number of guests. Only prearranged tourist groups were allowed to visit Ded Moroz Homeland. Many experts admit that the festival in Veliky Ustyug has turned into a conveyor belt with huge line of Ded Moroz visitors and no fairy tale atmosphere that emphasises its commodification.

Tourist destination, claiming to be the core of the regional tourist system, in this case cannot perform its function due to objective circumstances. Organisation of new tourist infrastructure facilities in Veliky Ustyug will only aggravate the contradictions. The peripheral position is still the main limitation to tourism development in Veliky Ustyug.

Tourism is a tool for developing the territory, which can be very effective under certain conditions. Thanks to tourism, the territory can reveal the potential for self-development and sustainability. The sustainable use of resources and the environment and the well-

being of communities are goals to which sustainable tourism should contribute. That is why the case of Veliky Ustyug gives the example of public and private initiatives combination contributing to diverse tourism development preserving local culture and traditions as well as economic activity of the remote northern territories preventing their depopulation and depression. ■

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RECENT TRENDS IN THE DEBATE ON INDIA'S NATIONAL FOOD SECURITY ACT (NFSA) – 2013: TRAGEDY OR TRIUMPH?

ABSTRACT. Present article follow up the recent debates that is being discussed in the country with respect to the National Food Security Act – 2013. Present article is based on the secondary sources of information collected through various books, magazines, journals, newspapers, government and non-governmental reports. The purpose of the article is to trace the discussion among various economist, planners, researchers and policy makers in order to analyse whether National food Security Act is a triumph for those who are in desperate need of it (poor and destitute), or a tragedy for those officials speaking against the Act. The main emphasis of the article is to discuss the cost of implementation of NFSA because it was believed that after its implementation it will put heavy burden on the government exchequer due to subsidies provided under it. Article also examines the challenges related to Food Corporation of India with respect to procurement, storage and distribution of foodgrains. Moreover, article also discusses the NFSA with respect to the Integrated Child Development Scheme, its affect on small and marginal farmers of the country, challenges related to public distribution system.

INTRODUCTION

After India's independence in 1947 the major emphasis of the Governments both at the Central and the State level was to increase the foodgrain production for fulfilling the growing needs of its rapidly increasing population (Hashmi and Shakeel 2014). In the early 1960s the Government of India came up with seed-fertilizer technology known as Green Revolution. MS Swaminathan also known as father of Green Revolution in

India has been credited for paving the way to success through introducing and further developing the biotech seeds in Indian agriculture especially of wheat. Fortunately, the Green Revolution came out as a big success leading to increase in foodgrain production of India from 82.02 million tonnes during 1960-61 to 108.42 million tonnes during 1970-71. The availability of foodgrain which was 408.22 grams per head per day in 1966 increased up to 468.77 grams per head per day in 1970 and later it

risen up to 472.6 gram per head per day in 1990. Warding off doomsday predictions of hunger and famine, India declared itself as a food self sufficient and self reliant country because of Green Revolution in the sixties, where we hardly had to resort to foodgrain imports except occasionally (Swaminathan and Bhavani 2013).

The seeds for providing food security to its people were already sown in the form of HYVs but its roots started spreading when the Government of India came up with Public Distribution System (PDS) for providing food to the needy in those areas where domestic agricultural production was low or nil. The main function of PDS after independence till 1992 was to distribute foodgrains to the urban scarcity areas and it prevented the rise in foodgrains prices and ensured access to food especially to urban consumers. Private trade was considered exploitative and the PDS was considered as countervailing power to private trade (Desai and Vannemam 2015). But in the opinion of some scholars PDS came out as a big failure because of its poor implementation, corruption and black-marketing. There are studies showing that the benefits which PDS was entitled to provide is not reaching to the poor and needy and the objectivity of food security through poverty alleviation remains unachieved (Radhakrishna and Subbarao 1997; Jha et al. 2013). Later, some big changes were too made in PDS but the situation remained more or less the same at all India level though in some states PDS proved to be good in alleviating people from food insecurity such as Chhattisgarh, Tamil Nadu and Kerala (Puri 2012; Paolo and Vandewaalle 2011; Bathla et al. 2015).

The facts related to food and nutrition security prior to the implementation of NFSA portrayed a very dismal picture. The child malnutrition and micronutrient deficiency in India was among the highest in the world, it was even worse than many much poorer countries. About 62% of pre-school children were deficient in Vitamin A leading to an estimated annual 330000 child deaths. More than 60% of the pregnant women, 63% breast feeding mothers and 70% pre-school going children were anaemic (Galvin 2012).

According to NFHS-III (2005-06) at aggregate level the proportion of adolescent girls and boys in between the age of 15-19 suffering from anaemia was 56% and 30% respectively. At disaggregate level 2% of adolescent girls were severely anaemic followed by 15% and 39% moderate and mildly anaemic respectively. During NFHS-II (1998-99) the condition was more or less similar because 2%, 18% and 41% of the adolescent girls were severely, moderately and mildly anaemic, showing that there has not been much change in the trend (Dureja 2016). The Government of India came up with National Food Security Bill which later became an Act in 2013 for providing food to its people through its various schemes such as Targeted Public Distribution System (TPDS), Mid Day Meal Scheme (MDM) and Integrated Child Development Schemes (ICDS). Moreover, Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA) too was launched by the government to provide jobs to the unemployed for increasing their purchasing power because it is believed that in India the problem of food security is not because of unavailability of food but it is because of people's inability to purchase the available food due to low income.

The government started to play on the front foot meaning thereby, with the help of its different department and ministries it is now administering a series of programmes that have direct and indirect influence on hunger and food insecurity. Remarkably, ICDS the most important wing of the Ministry of Women and Child Development have initiated the work for the improvement of the health and nutritional status of children and expecting mothers by providing bundle of benefits such as additional nutrition, health inspection, immunization, referral services etc under the aegis of NFSA through a group of cutting edge workers at the Anganwadi Centres. Moreover, the mega PDS a monumental programme of Ministry of Food and Civil Supplies also works under the aegis of NFSA for providing food at an affordable and subsidised rate to eligible households while Ministry of Rural development execute MNREGA with objective to ameliorate the household

income for better access to food. Another programme which needs to be emphasised is Mid Day Meal Scheme (MDM) being implemented under the Ministry of Human Resource Development is the world's largest school feeding programme providing food to children upto middle school (class 8th) (Mishra 2016).

Now the enquiry is, even after the implementation of NFSA and the goals for which it has been applied has been achieved or not. The desire for providing food to each and every person of the country has been met or not. The International Food Policy Research institute (IFPRI) shows that India is suffering from alarming hunger, ranking 97th in the global hunger index out of 118 developing countries under study in 2016, India with respect to human development index ranks 130th in 188 developing countries in 2015 and country's rates of malnutrition and starvation related disease and death remains staggeringly high. India ranks below several countries in sub-Saharan Africa such as Cameroon, Kenya and Niger. The countries like Chad, Ethiopia and Sierra Leone have better position than India even though the per capita income in these countries is much lower than India. Neighbouring countries such as Sri Lanka, Bangladesh, Nepal, Myanmar and China all are ranked above India. The Rapid Survey in Children shows that 38.7% children under the age of 5 are stunted, 19.8% are wasted and 42.5% are under weight. According to a survey 38.7% of the children under the age of 5 are suffering from stunting followed by 19.8% children suffering from wasting and 42.5% are under weight. The current data shows that from among the total, about 21% of the child deaths across the world are reported in India (Mishra 2016). India after the First Demographic Divide of 1921 has made a commendable progress in declining infant mortality rate but inspite of this nearly 760000 children die annually because of malnutrition, undernutrition and disease (Kumar 2016). NFSA faced severe criticism because immense importance and reliance has been given to already existing institutions such as PDS and ICDS which have established history of ineffectiveness.

OBJECTIVES OF THE STUDY

The main objective of the present article is to track the debates and discourses from the time when National Food Security Bill came in existence till the date it became an Act. Article also examines the development that took place even after the implementation of the Act. The NFSA was severely criticised by various scholars, planners and policy makers thus article tracks the debate on social, economic and political grounds. Moreover, the article discusses NFSA as a triumph and tragedy both, discussing whether it has fulfilled its objective of providing food to the people and making them food secure followed by discussion in the repercussions and failure of NFSA with respect to black marketing, corruption and inefficiencies. The article tries to analyse whether the cost incurred in the implementation of this Act is a wasteful expenditure or an investment in the country's future. Whether NFSA will prove to be an asset for the poor and destitute or it will become a liability on the nation's economy. It also discusses the queries which have been arisen out due to the implementation of NFSA like would subsidized foodgrains solve the problem of malnutrition? Is there any better choice other than food transfer in order to help the poor such as through investing in education and health or through cash transfer? Is the amount of subsidy provided to such a large number of people affordable? Should a country like India continue to invest money on the highly flawed PDS system?

MATERIALS AND METHODS

Present article is basically a review article based on the secondary sources of information collected through various books, magazines, journals, newspapers, government and non-governmental reports.

RESULTS AND DISCUSSION

Cost of Implementation and Subsidy Burden of NFSA

For the sceptics, Nation Food Security Bill before it was passed by both houses of parliament was and Nation Food Security

Act after its implementation is the most debated piece of discussion in years. The most important dimension of discussion of NFSA was and is mainly around the issue of the cost of its implementation and its impact on the nation's economy. The cost of implementation of NFSA is estimated differently by various scholars. The first estimate incorporated in the study was given by Bhalla (2013) and his estimation of the cost was 44.0 billion US$ (3000 billion INR) (1 US$ is taken as 68.17 INR as on 27th May 2018) annually or 3% of the GDP and this figure is almost three times higher than the official estimate offered by the government. Bhalla in his article mentioned that the food security bill will increase costs of foodgrain subsidy by 336%. If the cost of the food security is 3% of the GDP, then a serious debate about affordability is necessary. Bhalla begins with assuming that subsidy provided in a year is 100. According to the NSS report, 45% of the population was accessing the PDS in 2011-12. The bill says that it will cover a total of 67%. In this condition the subsidy will be [(100*67)/45] around 150 approximately, showing a 50% increase almost. Later he points out that, on the basis of NSS 2011-12 the average consumption of foodgrain from PDS was 2.1 kg per person per month but the bill says that it will provide 5.0 kg per person per month. The allocation of foodgrain has increased in the bill by more than 50%. In such condition the subsidy will be [(150*5)/2.1] around 357 approximately. While analysing the subsidy price per kg of foodgrains he says that that subsidy will increase from Rs 13.5 per kg to Rs 16.5 per kg with market price staying constant at Rs 19. Under this situation the subsidy will be [(357*16.5)/13.5] around 436 approximately. In 2011-12 total food subsidy was 10.56 billion US$ (720 billion INR) so after the implementation of NFSA the subsidy will be (720*4.36) around 46.04 billion US$ (3139 billion INR) or 3% of the GDP. Kotwal et al (2013) severely criticised the implementation cost of NFSA by Bhalla. Bhalla for his cost estimation took 2.1 kg per person per month as an average consumption through PDS which shows the consumption of entire population of the nation. But under NFSA it is mentioned that 67% of the total population will be covered. Under this condition it becomes evident that only 45% of the population was getting 2.1 kg grains per person per month this shows that each person was getting 4.67 kg per person per month (2.1/0.45). So if the beneficiaries were getting 4.67 kg per person per month during 2011-12 then in such condition subsidy will be [(150*5)/4.67] around 160 approximately and calculating the subsidy price per kg of foodgrains with market price constant at INR 19 the subsidy will be [(160*16.5)/13.5] around 195. Even 195 is too an overestimated figure because Bhalla might have got confused between per capita NSS consumption figure with that what Central government supplied to the State governments. In 2011-12 the PDS off-take was 51.3 million for 45% population which stands around 1.21 billion in such condition the per capita supply of grains by the government will stand out at 7.9 kg per month. Thus, the subsidy will be (150*5)/7.9 around 94.93 and adding subsidy price per kg of foodgrains at constant price of INR 19, the subsidy will come [(94.93*16.5)/13.5] around 116. Thus, the total cost of implementation of the bill will be (720*1.16) around 12.46 billion US$ (850 billion INR) approximately which will stand around 1% of GDP. Sinha (2013) in her article criticising the estimate by Bhalla said that it is erroneous to assume present level of leakages as assumed by NSS will remain same in future. In the opinion of Bhalla, in order to provide 5 kg of grains per head per month to the people the government will have to allocate 8.3 kg of grains per head per month meaning thereby adding extra amount which go out through leakage and the subsidy on this higher amount of grain will be the government's real expenditure. Another dimension which needs to be emphasised here is that, as Bhalla in his process of cost estimation said that the actual assigned quota of grains is 5kg but due to leakage only 3 kg grain reaches to the beneficiaries because 40% leakage has been held constant by Bhalla for estimating the cost. Thus, for assuring that beneficiary should get full 5 kg of quota, in the opinion of Bhalla, government should release 8.3 kg of grains so that 40% (3.3 kg) will be leaked in the process of distribution and 5 kg will reach to the beneficiary. This shows that, when government was

allocating 5 kg of grains per head per month to the people the actual amount received by the beneficiaries was only 3 kg meaning thereby that 2 kg (40%) was lost in leakage. To solve this problem, it was suggested that government should allocate 8.3 kg grains per head per month so that after a leakage of 40% the beneficiary should get 5 kg of grains meaning thereby now 3.3 kg is lost in leakage. In the opinion of the author in this process of solution there are more chances of leakage because earlier on the basis of 40% leakage, only 2 kg grain was leaking (5 kg minus 3 kg) but now by providing 8.3 kg of grains/head/month the government is providing the leakers a chance of leaking 5.3 kg of grains (3 kg minus 8.3 kg). So inspite of finding solution for leakage and corruption the system is incorporating these social evils as an integral part of NFSA and under such condition the leakage will increase with time and the amount reaching the poor will remain the same leading to increasing cost of implementation of the Act.

Taking the debate further, Mishra (2013) in her article estimated the cost of implementation of NFSA at 18.26 billion US$ (1245.02 billion INR) and estimated that the annual cost of the NFSA will be anywhere between 6.51 billion US$ (444.11 billion INR) to 11.21 billion US$ (764.86 billion INR) in 2013-14 and the total cost of grandfathering of existing beneficiaries would be around 3.0 billion US$ (204.74 billion INR). Moreover, in her article she mentions that the BPL population before the implementation of NFSA were getting 7 kg of grains per head but after the implementation of NFSA they will get 5 kg of grains. Meaning thereby, they will lose 2 kg of grains per head and the BPL households which were early getting 35 kg per household will not get the same quota. This shows that the existing APL (above poverty line) beneficiaries who move out of coverage would be worse off and the BPL (below poverty line) individuals whose entitlement is reduced by 2 kg would also loose. Thus, to ensure that no one should affected with respect to their current assigned quota or what they are currently getting an additional of 3.0 billion US$ (204.74 billion INR) will be required which Mishra has termed as the cost of

grandfathering the existing beneficiaries. But Sinha criticising the fact said, that while calculation of extra grandfathering cost Mishra does not taken into consideration the fact that many states even now are not providing 35 kg to BPL households. Mishra further argues that 180 million APL beneficiaries moving out of coverage needs to be compensated by providing 3 kg of grains per head. Criticising this issue, Sinha said that firstly, it is not clearly mentioned in the study that how Mishra has arrived at these figures. Secondly; entitlement under APL category are actually given only in few states and the quantity provided also varies. Moreover, principal advisor to the Supreme Court commissioners on the right to food Mr. Biraj Patnaik rubbishes the claim and said that many economists in recent days have cited exaggerated figures. In his opinion, the implication on the food subsidy because of PDS will not be more than 3.66 billion US$ (250 billion INR).

Now the matter of concern is that after the implementation of NFSA what will be the scenario related to food subsidies provided in the Act. It might be argued that the foodgrain subsidy incurred by the Government of India for the PDS and other welfare schemes has been increasing over the years. Food subsidy bill represents the basic direct cost incurred by the Central Government on procurement, stocking and supplying of various food based safety nets such as PDS. During the last ten years, food subsidy has more than quadrupled from 3.38 billion US$ (230.71 billion INR) in 2005-06 to 15.47 billion US$ (1055.09 billion INR) in 2015-16 at current prices. As a percentage of agricultural GDP it has increased from 4.5% to 13.2% during the same period. Increasing economic costs of handling foodgrains, record procurements in recent years and widening differences between the economic cost of foodgrains and the central issue price have been the major factors leading to the ballooning food subsidy (Kumar 2017). The food subsidy accounted for about a third of total subsidies by the Government of India (which includes fuel, fertilizers, education, etc.) in 2011-12 and is likely to increase to about 40% due to the NFSA. In the absence of the NFSA

the foodgrains subsidy was expected to grow by 28% during 2013-14 to 2014-15 reaching to 20.7 billion US$ and with the advent of NFSA the amount will reach upto 24.3 billion US$ or about 1.2% of the GDP. It has been predicted that the NFSA would worsen the already compromised fiscal situation of the country. The Government of India fiscal deficit for 2013 was about 4.9% of GDP (approximately US$144 billion); The International Monetary Fund predicts India's total fiscal deficit (inclusive of state governments) to be 8.5% of GDP in 2014 (Varadharajan et al., 2014). As per the budget put forwarded by Government of India defines that food subsidy has rarely surpassed 1.0% of the country's GDP during the last three decades with only year 2011-12 as an exception when the GDP slightly jumped above 1%. If India has finally decided to provide food security to all its citizens then it has to make sufficient financial provisions for food security programmes. Keeping in mind the huge population base followed by large proportion of malnourished and undernourished, spending 1 or 2% of the GDP is not a big amount to incur to end hunger and food insecurity (Swaminathan 2013).

Concerns related with Integrated Child Development Scheme (ICDS)

It is well known fact that that Food Security Bill was brought into existence by Congress-led United Progressive Alliance (UPA) and later it became an Act. During the time, the matter was highly debated in the Parliament by the Ministers of opposition BJP-led National Democratic Alliance (NDA) for the expansion of provisions, universalisation of the scheme and increase in the quantum of the entitlements. But after two years of implementation of the NFSA the same party i.e. NDA who was earlier debating about the proper implementation, universalisation and expansion of the Act is now throttling the NFSA by making it bleed with thousands cut both economically and socially. The same ministers who were earlier talking in favour of NFSA have not allowed even a single dimension of NFSA unmolested and unabated. The most serious blow came from the NDA was when they started to cut down

the budget to some of the key programmes of the Act. The ICDS has a 50% cut and Mid Day Meal Scheme's budget was reduced from 1.90 billion US$ (130 billion INR to 1.32 billion US$ (90 billion INR). Some of the other welfare schemes which were directly related to nutrition and food security of the masses have faced similar and vicious cutbacks (Patnaik 2016). The ICDS provides 'take home ration' (THR) to pregnant and lactating women and infants under three years of age and children between 3 years to 6 years of age will get hot-cooked meals. A total of 6.5 crore beneficiaries from among which 4.6 crore are infants and 1.9 crore are mother which are currently getting benefit under the ICDS scheme. Coffey and Hathi (2016) while analysing the situation of pregnant and lactating women in India said that the pregnant and lactating women are extremely undernourished and poor maternal nourishment is evidenced by a high neonatal mortality rate, low pre-pregnancy body mass, poor weight gain during pregnancy and a high rate of anaemia. The programmes prior to the implementation of NFSA were not adequately addressing the problem of poor maternal nutrition and the situation even after the implementation of NFSA is more or less the same because it has been more than two years after the Act was passed, and the government has made no plans to implement it. A report by NITI Aayog entitled 'Reforming Take Home Ration' under ICDS scheme prepared a proposal to substitute THR with cash Transfer. It is mentioned in the report that the THR scheme is affected by leakages, poor quality food supplements and vested interests. Cash transfer will benefit the women in having better food, more rest to pregnant women and will improve birth weight among Indian Children. At the same time the Union Minister Maneka Gandhi said that instead of providing food through anganwadis a much better option would be providing 'nutrient packets' (packets having dry mixture of peanuts, millets and micro-nutrients which can be consumed with milk, water and juice) which can be easily delivered to the children and mothers via Indian Postal Service (Bhuyan 2017). However, food experts opine that ready-to-use therapeutic foods (nutrients packet) cannot always be

a substitute for hot cooked meals because there is nothing better than a hot-cooked fresh meal. The Director General of Indian Council of Medical Research said that therapeutic food/nutrients packets can be used as an extra food for children suffering from acute malnutrition but these nutrients packets should not replace the normal diet. (The Indian Express 2017). Substituting THR with cash transfer is widely debated among the scholars and the cash transfer proposal faced severe criticism because according to Nation Nutrition Monitoring Bureau (NNMB) there is protein-calorie gap among children and providing supplementary nutrition with respect to THR is the best way out than cash transfer because in cash transfer their are chances that money may be spent in other things. The most important concern related to cash transfer is that it is not inflation indexed meaning thereby that cash transfer would fail to keep pace with the rising food prices (Nair 2017). Moreover, the secretary of the Women and Child Development Ministry said that thought debate is going on between THR and cash transfer but before coming to a final decision a pilot survey will be undertaken in some of the selected districts in order to test the efficacy of implementing the ICDS supplementary nutrition component through cash transfer (money will transferred in the Jan-Dhan account of the mother).

Underlying Accusations of Food Corporation of India (FCI)

It is a well known fact that the NFSA is largely dependent on FCI for procurement, storage and distribution of foodgrains to the people of the nation. The reason behind procuring foodgrains from the farmers is threefold. Firstly, the FCI procure foodgrains from the farmers to build an operational stock for supply under TPDS and other welfare schemes. Secondly, FCI procure foodgrains and build buffer stocks to meet any kind of emergency whether natural and manmade and thirdly, open market purchase and sale in order to stabilise the domestic prices and provide food security requirements through sale of subsidized grains. Government estimated that 61.2 million tonnes of foodgrains will be required annually after

implementation of the NFSA from among which 54.7 million tonnes of foodgrains will be used to feed the TPDS scheme and 6.5 million tonnes to meet the other grain needs. This estimate was later revised slightly upwards to 61.4 million tonnes after the Census 2001 figures used for the earlier calculations were replaced with Census 2011 figures (Saini and Gulati 2015). So if FCI will procure foodgrains in such a huge amount then it will lead to inflation because the supply to the open market will decrease. Another problem that comes out is that of storage because the development in the infrastructure of storage has not kept pace with the increase in procurement and this has widen the gap between the storage capacity and actual foodgrains procured from 6 million tonnes in 2008 to 33 million tonnes in 2012. The increased level of procurement and distribution of the foodgrains as a result of NFSA requires higher storage and warehousing capacities. Though an initiative has been taken by FCI to make the storage capacity of 18.1 million tonnes through private entrepreneurship guarantee scheme out of which only 3.2 million tonnes of capacity has been completed until now (Jha and Tanksale 2015). For effective implementation of NFSA (creation of new storage capacity, maintaining, managing and transportation of foodgrains), there is an additional requirement of 22-32 million tonnes of storage capacity with cost upto 83 billion INR. It will surely impose a huge financial burden on the exchequer because of rising costs of managing these foodgrain stocks. Another problem which comes out is of maintenance of the grain stock because if the grains remained undistributed they will rot due to inadequate storage facilities and faulty storage techniques. Evidences shows that, even after the implementation of NFSA when the total food stock in FCI reached to 80 million tonnes against a buffer stock norm of 31.9 million tonnes (Patel 2017), nearly 25 million tonnes of the grains were kept in open storage and an estimated of about 21 million tonnes of grains got damaged eaten by rodents, pests and birds. It is believed that as much as 194 thousand tonnes of foodgrains worth crores of rupees kept in security were wasted between 2005 and 2013 (The Hindu 2016). In addition to the operational stocks

above, the Central Government is required to hold a stock of foodgrains at all the times to ensure food security during periods when production fall short of normal demand and during the times when an increased grain supply in the open market is needed to stabilise prices (strategic stocks). At present FCI maintains five million tonnes of grains (3 million tonnes of wheat and 2 million tonnes of rice) as strategic stocks in its granaries. Moreover, total economic cost and minimum support price (MSP) of the foodgrains during the past were on the rise but the central issue price (the price at which the Central government sell foodgrains to the state governments) and the price charged to the consumers at FPS (fair price shop) have remained almost the same. During the last decade the total economic cost of wheat has been raised from 0.12 US$ (INR 8) per kg to 0.24 US$ (INR 16.5) per kg but the central issue price for the BPL beneficiaries remained unchanged and kept at 0.06 US$ (INR 4.15) per kg. Thus, as the gap between the central issue price and the MSP will get widen (Jha and Tanksale 2015) and the average sale realization of FCI's will be low as compared to the cost incurred, making it economically inefficient. Thus, the major financial implication comes from the fact that NFSA fixed the CIPs (central issue price) at INR 3/2/1 for three years since the commencement of the ACT and will result into increase in the subsidy burden on the government (Saini and Gulati 2015). Going through all these issues and challenges which FCI was facing, the BJP led National Democratic Alliance government set up a high level committee (Shanta Kumar Committee) in 2014 August in order to restructure, reorient and reform the FCI. Committee recommended that that the current PDS be replaced by cash transfer allowing FCI and the States free from procuring, storing and distributing the grains and in due course of time FCI can be completely dismantled and folded up. But the situation of food and nutrition security in India even after the implementation of NFSA presents a picture so grim that it seems unwise to dismantle the FCI all of a sudden. A more sensible way would be to increase the applicability and utility of the existing system (Basu and Das 2015).

Storage of Foodgrains

A high level committee set up by Government of India to look into the matter of restructuring FCI has suggested that the number of beneficiaries covered under NFSA should be reduced from 67% to 40%. This is because Government on one hand is increasing the MSP to support the farmers and on the other hand it is lowering the issue price for supporting the beneficiaries thus, it has been recommended by the committee that subsidy (in the form of low PDS price) and MSP should be linked and linking will support government in containing fiscal deficit. Though government will get benefit by interlinking PDS and MSP but the farmers will be the larger sufferers because the government will try to keep PDS price as low as possible for the beneficiaries which means that the increase in MSP would be minimum too which will severely affect the farmers (Sood 2012). The committee has also recommended that instead of FCI, let the private sector to procure and store the foodgrains in those states which are performing well in procurement because this will save the MSP paid by the government to the farmers and the amount of money saved can be directly transferred into the account of the farmers and the beneficiaries through adopting cash transfer system (Rajalakshmi 2017). Another point is that the FCI's per unit storage cost is 30% higher, labour cost is almost four times higher for rice and seven times higher for wheat, interests payments are four times higher for rice and two and a half times for wheat due to longer storage periods (Sinha et al. 2011). The committee has suggested that if the Government avoid the cost on procurement, storage and distribution and adopt cash transfer method then it can save an amount 4.84 billion US$ (330 billion INR) leading to the reduction in the subsidy burden on the exchequer (Jitendra 2015).

Distribution of Foodgrains

More than 70% of the grains are procured by the northern states and rest procured the southern states. Northern zone accounts for as high as 67% of the total storage capacity followed by southern zone (14%), western

zone (11%), eastern zone (7%) and north-eastern zone (1%). While 64% storage space is available in five States (Punjab, Haryana, Uttar Pradesh, Chhattisgarh and Andhra Pradesh) 13% is in two States (Rajasthan and Maharashtra) and 23% is shared by 24 States and UTs (union territories). Moreover, the most important challenge with respect to distribution under NFSA is to check the leakage and corruption and ensure rigorous monitoring of foodgrains to the last mile distribution point i.e. up to the fair price shops (FPSs) from where the consumer takes his assigned quota during its transport from northern states to southern states. This involved heavy transportation costs. Moreover, it is mentioned in the NFSA that the issue price will same for a period of three years and after its implementation the issue price will be revised in July 2016 to reduce the burden on the exchequer. Increasing the issue price will no doubt improve the Centre's finances by reducing the subsidy component. However the increase in the cost of foodgrains supplied may face political pushback. The food subsidy bill under the antyodaya anna yojana (AAY) scheme has been climbing over the years and it rose to 1349.19 billion in 2015-16. This is largely due to the widening gap between the economic cost of foodgrains and the price at which it is issued by the FCI. As far as the economic cost is concerned, it was 0.45 (INR 30.9) per kg for rice and 0.32 US$ (INR 22.0) for wheat during 2015-16 up by 5.0% and 7.3% respectively. The MSP was too on the rise, for instance the MSP for wheat increased by 5.2% for 2016-17 to 0.22 US$ (INR 15.25) per kg as against 0.22 US$ (INR14.7) per kg (up by 4.3%) for rice. But, the issue price for the wheat and rice for Antyodaya scheme, BPL and APL card holders has not been revised by the government since July 2002 leading to put undue financial burden on the exchequer (Muthukumar 2016).

Addressing Food Access Through Public Distribution System (TPDS)

In the contemporary times the core problem related with India's food insecurity is not related with food availability or domestic food production but it is related with its distribution. On an average India is producing more than 250 million tonnes of foodgrains annually and more than 60 million tonnes on an average has been kept in stock all the time in the recent past for emergencies and government procure enough food grains from the farmers in order to distribute it among the needy. But TPDS is unable to achieve the objective which it was meant for. The NFSA is also challenged as far as the TPDS is concerned because the identification of eligible household is left to the discretion of the State Government. In the absence of the eligibility criteria for the selection of the beneficiaries, no one is really entitled to anything as a matter of right this defeat the purpose of an Act (Dreze 2013). Moreover, the very basic debate that exists is between 'targeted' and 'universal' distribution system. Few believe that targeting is unfair because it divides the population into permanent social division of APL and BPL and it is true that the crux of NFSA is not to create class conflict. Targeting is also and divisive and it prevent the emergence of a cohesive public demand for a functional PDS and a vocal demand is very important for the success of the PDS (Dreze 2016). The crux of PDS whether targeted or universal is to provide food and nutritional security to the masses and this aim is not likely to come cheap. Many scholars have estimated the cost of NFSA will be more than one lakh crore rupees but a nation where close to 40% of children are stunted and 20% wasted, with an overwhelming 79% of children aged between 3 months and 3 years being anaemic, any strong step to cope up with mass undernourishment is bound to be expensive and to pay such a price to protect everyone from hunger and food insecurity is not much. Therefore, scenario after the implementation of NFSA on the basis of Economic Survey Report 2014-15, out of 55.44 billion US$ (3780 billion INR) which accounts for 4.2% of the GDP was spent on key subsidies during the financial year March 2015. Out of this amount, 18.04 billion US$ (1230 billion INR) which accounts for 1.14% of the GDP was spent on food subsidy which increased to 18.18 billion US$ (1240 billion INR) during 2015-16. According to FAO the percentage of undernourished population in India during 2010-12 and 2014-16 was 15.6% and 15.2%. Thus if we

compare the amount of money spent of food subsidy and decline in the percentage of undernourished then there is no doubt in saying that India's welfare system is suffering with leakages. Policy makers and researchers are of the opinion that in a situation when food subsidy is on the rise and the benefits of distribution is on the fall then amendment must be done in order to make an efficient use of public resources. Widespread corruption has diverted the benefits of the poor to the pockets of the intermediaries and officials. Neither the system covers the genuine beneficiaries, nor does it support the recipients with total of benefits (Lenka 2017). Thus, it becomes necessary to analyse whether Government should focus in improving the current PDS by reducing cost, plugging leakages and bringing effectiveness or replacing the PDS with food stamps and cash transfer. Moreover, as mentioned in the NFSA that Central government will take the responsibility of procuring, storing and delivering foodgrains at the doorstep of the State Warehouses thus, it is the responsibility of State Government to identify the beneficiaries and certify that the entitlements are enforced amongst the beneficiaries. In case the State fails to provide grains (legal entitlements) to the beneficiaries then it is supposed to pay the 'Food Security Allowance' in cash form. This lead to serious matter of debate and some of the scholars opined that if we provide cash to the people directly then FCI could make itself free from the operations like procurement, storage and distribution of grains because after getting cash people can buy the grains directly from the market.

Cash or In-Kind Transfer

Some of the scholars support the idea of cash transfer rather than the in-kind transfer (food transfer). In a study it was found that when the poor were provided with food transfer they consumed more food than in cash-transfer (Gentilini 2007). Fraker (1990) analysed that the consumption of food in food-transfer increased from 17.0 to 47.0% when a dollar of food stamp was increased but in case of cash transfer the increase experienced was nominal from 5 to 13% at the same amount. Similarly, Barret in 2002

in his study found that the household's nutrient availability increases by 2-10 times in food transfer than similar value of cash in cash transfer. But in the opinion of Sharma (2006) cash-transfer is much better than that of in-kind transfer because in cash transfer the beneficiary is free to use the money other than the purchase of foodgrains. It might be possible that he/she may improve the quantity, quality and diversify their consumption basket. Moreover they can also use the money in health and education. In Uruguay, while providing unrestricted cash assistance to pregnant women resulted into decline in the frequency of low birth weight followed enhanced maternal nutrition and weight gain during pregnancy (Amarante et al. 2011). It is believed that crediting subsidies into bank accounts will reduce leakages, delay etc. During 2017-18 the Centre's food subsidy bill is expected to go down by 3.66 billion US$ (250 billion INR) due to the direct benefit transfer arrangement. Baye et al. (2014) gives a mixed opinion, in their study they though came at conclusion that the households receiving cash had better dietary diversity but these households preferred to receive a mixed of food and cash rather than cash alone. Because the cash may be spent on non-staples food such as fruits, vegetables etc. Relying on the cash transfer alone means that the beneficiary's household will have to depend on the free market to meet all their food needs. The stabilising effect from inflation which is the main function of PDS would come to an end. But cash transfer is also not an easy task because for providing money at household level the financial infrastructure should be very high for installing banks, automated teller machines (ATMS) and post offices at village level which is a very tough task. Cash transfers thus are only a partial substitute to the PDS.

As debated whether cash transfer is more beneficial and productive or the food transfer but one cannot deny the fact that PDS in India contributed positively and beyond expectations in the State like Chhattisgarh, Tamil Nadu, Punjab and Kerala. The state of Chhattisgarh has experienced a transmogrified change in its PDS system because it used to have a very inefficient

and corrupt system (Vydhianathan and Radhakrishnan 2010). Using information and communication technology the State has brought all the PDS related operations on the web and one can easily check the mobility and the location of foodgrains within the chain. The fair price shops (FPSs) was 'de-privatised', earlier the FPSs was owned by a private owner but now the FPS are run by community based organizations such as gram Panchayat, self help groups (SHGs), Van Suraksha Samitis (Forest Cooperatives) and other cooperative societies (Dreze and Khera 2010; Bathlaet al. 2015). The motto behind this was when the people will be run their own ration shop the chance to cheat will be minimised to least and if cheating still prevails this means that they are cheating themselves. The government has computerised the full chain from the procurement of grains from the farmers to the distribution to target consumers. Chhattisgarh now cover more than 80% of the rural population under PDS and has it from 'targeted' to 'quasi-universal' PDS (Puri 2012; Dreze 2016). So at the time when many experts were of the opinion that PDS should be replaced with food coupons and cash transfer the Chhattisgarh model provided some key lessons on making this system work. Similarly, Tamil Nadu instead of following a targeted approach follows a universal approach and more than 93% of the FPSs are under the hands of cooperative societies. Involvement of women-self help groups and others of the same village has checked corruption and leakage and has ensured safety, transparency and accessibility in the system (Paolo and Vandewaalle 2011). The state of Punjab too has renovated the PDS. Under the new system the farmers sell their produce to the 'artiyas' (foodgrain traders) who then sale the grains to market and from here the grains are packed in bags weighing 30 kg and transferred to the civil supplies inspector who distributes these grains to the beneficiaries. In the old PDS system the grains were procured from the farmers then transferred to the FCI's warehouses and then from here to the state warehouses and then to FPSs. This new system saved almost 190 per quintal of wheat distributed and it includes the savings on transportation, administrative costs and maintenance and custody charges. State of Punjab on an average distributes

8700 thousand tonnes annually and this new system of distribution leads to a saving of roughly 1.65 billion annually (Puri 2014). Thus instead of bringing cash transfer scheme in full fledge it is better to improve the existing PDS because one cannot ignore the above success stories and these already set examples and achievement can be extend across the country. Undoubtedly, there are benefits of cash transfer but the infrastructure required for mass transfer in cash would take a long time to build but PDS is already in the place so why not make use of a system already in place without delay. The main concern currently should not be on 'cash versus food' but to provide people with income support and social security as soon as possible (Dreze 2013). Through implementing the right administrative and process reform, the corruption, leakage, mismanagement wastage and inefficiencies can be checked.

Concerns with Checking the Corruption

It is mentioned in the NFSA that for checking the corruption and black marketing application of information and technology tools will be taken in order to prevent diversion. Aadhar Card (Unique Identification Card) will be used as unique identification and the entitled beneficiaries will be linked with biometric information for proper targeting and distribution of foodgrains. But the problem of linking entitlements with Aadhar card is that the entitled women or the person may be unable to go to a shop due to sickness or some emergency then they will be devoid-off the benefits. Keeping this point under consideration some of the scholars are of the opinion that instead of using Aadhar Card the government should provide food coupons to the beneficiaries. Producing these food coupons to any shop they could get the food and later the keeper of the shop after submitting the coupon to the respected government offices could get the money back.

Challenges related to Nutrition Security

As mentioned in the NFSA that it will provide 5 kg of foodgrains per person but the Indian Council of Medical Research recommends that an adult needs a minimum of 14 kg of

grains per month. Moreover, the Act seems to be giving priority to fine cereals (wheat and rice) and neglecting pulses, coarse cereals and oilseeds. Though the Act may prove good to provide food security but as far as the question of nutrition security is concerned the Act is unanswerable and fully ignores the nutritional security of the population. Pulses are given less emphasis under NFSA is because the production is low and demand is high and sometime for fulfilling the local demand need arise to import pulses. The reason is low MSP for the pulses but Shanta Kumar Committee has recommended that the MSP should be revised and the focus should be given on pulses and oilseeds. Moreover, Famous economist Jean Dreze said that the fundamental problem related to food in Indian context is of undernutrition and this act though protect everyone from hunger and can make a significant contribution to the elimination of undernutrition. But ending undernutrition apart from cereal availability also requires health care, safe water and sanitation. UNICEF too is of the opinion that the fundamental problem which India is currently facing is of malnutrition because there are 61 million children chronically undernourished and 8 million children suffering from severe acute malnutrition. Therefore, the focus of the planners and policy makers should be on right to adequate nutritional security rather than simply on food security (Jha 2013).

Impeachment Regarding Small and Marginal (S&M) Farmers

Agricultural Census of India 2010-11 reveals that S&M farmers (less than 2 hectares of land) account for 85% of the total 138.35 million operational holdings and 44.46% of the total cultivated area. Considering average five members in a family of small and marginal farmer 75% of the small and marginal families will qualify as beneficiaries under NFSA. According to the Working Group on Agricultural Marketing Infrastructure and Policy Required for Internal and External trade (Eleventh Plan), S&M farmers consume nearly 60% of their production and keeping 40% for market. Apart from one/third family consumptionthey too have to pay

for permanent and temporary farm labour, also for feeding farm animals, for payment in kind of farm equipment, customary dues, repayment of loans and irrigation charges etc from the same 60% which they have kept for the family consumption. Since most of S&M farmers are qualifying for NFSA beneficiary and will receive subsidised grains thus they will switch to crop cultivation other than foodgrain which will affect the 40% of foodgrain production which they are producing through using 44.46% of cultivated area. Thus, S&M farmers if covered under NFSA will shift their agriculture to commercial crops and horticulture affecting the foodgrain basket of India and the NFSA too (Kalkoti 2017). Farmer's organization too speaking against the bill said that since the larger share of their agricultural produce is purchased, stored and sold by the government leads to nationalisation of agriculture. This will also disturb the market mechanism and lessen the bargaining power of the farmers. Further present bill too do not have any provision for small and marginal farmers.

The NFSA is an act of providing food aid to the people which in context of India though has kept people alive but it has little to address the underlying causes of food insecurity and the associated loss of productivity, cognition and good health. It is a matter of great concerns that providing food as an aid to the masses is the final solution to food insecurity. Is it not so that when people will receive food as an aid it will hamper their efficiency of doing work and contribute to the nation and economic development. On the one hand it is mentioned in NFSA, that an Antyodaya household (poorest of the poor) is eligible for 35 kg of foodgrain per household per month at a rate of Rs 3 per kg of rice and Rs 2 per kg of wheat. This means for purchasing 35 kg of grains a person requires a maximum of 105 Rs only. On the other hand MNREGA which was launched to guarantee at least 100 days of work a year for every household has improved the purchasing power of the rural household. Under MNREGA, the revised wages shows that the average wage is about 2.93 US$ (200 INR) per day (The Indian Express, 2016). Thus, if a person is getting 2.93 US$ (200

INR) per day and he spends only 1.54 US$ (105 INR) then he could easily purchase the ration for full month. So if a person is getting full month quota of grain only by working one day will he be going on to the field for rest of the six days a week is a matter of concern. This condition only prevails when the implementation of MNREGA is upto the mark. But there are studies which show that the number of jobs under MNREGA is less and the money which they get after the work is also below the fixed amount which is not sufficient for running their livelihood. Thus providing food as an aid is not the final solution because food aid will make people sick and lethargic and it will curtail their ability to do work. People getting food as an aid permanently or for a longer period of time makes them slaves of the system and even if they are getting employment for a shorter duration of time there is somewhere hidden in their mind that if the condition of food insecurity will prevail the governments, the authorities and organisations will look after them providing them food. Aid makes people deprive of taking initiative towards betterment, it undoes the teaching of self help and makes population spoon fed.

CONCLUSION

National Food Security Bill with the passage of time has now become an Act but the debate on its suitability and sustainability is open. The article concludes that there is wide range of variability regarding the cost of its implementation. However, the government is still moving ahead with an aim to eradicate hunger and food insecurity through updating the existing programmes like TPDA, ICDS and MDM which has earlier characterised by widespread corruption and improper implementation. Going through the weaknesses and virtue described above, the NFSA does not pledge to enhance the food and nutrition security of the country by decreasing the proportion of population suffering from hunger and food insecurity. However, NFSA tries to expand the existing programmes to cover more and more population under the umbrella of TPDS. The most important thing one should keep in mind that India is the second most populated country in the world after China thus a programme like NFSA cannot eliminate hunger and food insecurity in just one attempt. No programme in any field of development is free from challenges and it is clear that NFSA is also surrounded by challenges thus, as the new challenges are coming out a systematic reform is required for the better implementation and better outcome.

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OPPORTUNISTIC FUNGI IN THE POLLUTED SOILS OF KOLA PENINSULA

ABSTRACT. The species diversity and the structure of the opportunistic fungi complexes in the forest Albic Podzols under the impact of the Aluminum and Copper-Nickel Plants emissions, as well as in the Hortic Anthrosol contaminated by the oil products (diesel fuel, gas condensate, mazut) in the north-west region of Russia (the Kola Peninsula) have been investigated. The share of the opportunistic fungi increase up to 15% in the zones of the Aluminum and Copper-Nickel Plants emissions comparable to the background soil, and up to 20-25% in the soils contaminated by the oil products has been revealed. The majority of the fungi species belong to the following genera: Penicillium, Aspergillus, Mucor, Lecanicillium, Phoma and Cladosporium. The structure of the fungal complexes has changed in the polluted soil, that is, the species abundance and the frequency of the opportunistic fungi occurrence have increased. The strains of the fungi isolated from the contaminated soil reveal the potential pathogenicity in a greater degree, than the strains isolated from the clean soil. 55% of the total amount of fungi strains isolated from the soils contaminated by the Aluminum Plant emissions had the potential pathogenicity. The most dangerous for a human's health were Amorphotheca resinae, Aspergillus fumigatus, A. niger, Paecilomyces variotii, Penicillium commune, P. purpureogenum, Trichoderma viride isolated from the soils contaminated by the Aluminum Plant emissions; and P. aurantiogriseum, P. glabrum, P. commune, P. simplicissimum, Rhizopus nigricans isolated from the soils contaminated by the oil products. Those species revealed protease, phospholipase activity, as well as the growth ability at the temperature 37°C

KEY WORDS: opportunistic fungi, potential pathogenicity, soil, pollution, industrial plant, oil products, Kola Peninsula

INTRODUCTION

All through our lifetime, we are in constant contact with the fungi which are present everywhere in the human environment. The main natural habitat of fungi is soil. Fungi migrate easily with air currents and are constantly present in the environment, mainly as spores, and sometimes as mycelium fragments. As decomposers, fungi grow on plant residues. They can also grow on the surfaces of different man-made facilities, such as buildings, roads, etc. Special hazard for humans may be represented by the fungi belonging to the group of opportunistic ones. The opportunistic fungi are the group of fungi that are able to provoke various mycotic diseases, allergic reactions for immunocompromised humans, and in the meantime retaining the ability to develop in other environments. Hoog et al. classified three groups of fungi according to their potential danger to the human health (BioSafety Level - i.e. fungi are related to a certain level of safety): BSL1, BSL2 and BSL3 (Hoog et al. 2011). The most dangerous mycoses are caused by the BSL3 group. Opportunistic fungi of the BSL2 and BSL1 groups can be found much more frequently in the environments, as most of them utilize a wide range of substrates. The important environmental factors for the growth of opportunistic fungi of these groups are: the availability of organics, the favorable range of moisture, the temperature, and the pH value in their habitat. The typical way of getting an infection by deep mycoses agents in the environment is breathing in their spores. In case of skin injuries the agents may get in also through wounds, often from soil.

Within recent years, more and more attention has been given to monitoring the fungi species in the environment, and the correlation between opportunistic fungi and the growth of diseases amount. The data of different scientific works confirm the increasing amount of the opportunistic fungi in the urbanized areas located close to the major industrial plants, oil products, motorways and agricultural areas. All these circumstances lead to the negative impact on human's health (Badiee and Hashemizadeh 2014; Evdokimova et al. 2013; Kireeva et al. 2005; Marfenina 2005; Pappas 2010). This can be explained by the opportunistic fungi habitat versatility, their wide range of tolerance towards unfavorable environment, as well as capability to utilize diverse substrata.

The opportunistic fungi are known to be characterized by certain properties: the growth ability at a temperature 37°C, as well as mycelia-yeasty dimorphism, cell melanism, capsule formation, the ability to adhesion and extra cell secretion of protease and phospholipase, etc. (Bogomolova et al. 2012; Fotedar and Al-Hedaithy 2005). Recently, much attention has been paid to the investigation of enzymatic fungi activity, which is considered to be human's clinical pathogens. However, there is lack of research dedicated to most likely pathogenicity of the fungi which are habitants in the soil, air and other environments. The protease activity makes possible the fungi to destroy the horny super layers of skin. As for the phospholipase fungi activity, it allows them to destruct the human's membranes of tissue cells and infest them extensively, that is, to promote deep fungal disease. At the same time, to determine the potential agents of the deep fungal disease, it is essential, first and foremost, to take into account their survival rate at the temperature 37°C.

The Murmansk region is a part of the onshore Arctic area of the Russian Federation (Fig. 1). The region under research is characterized by a unique combination of natural and anthropogenic factors: severe climatic conditions and intensive industrial development. The Kandalaksha Aluminum Plant and the Copper Nickel Plant «Severonickel» are known to be the industries in the Murmansk region which have the highest impact on the environment. The consequences of all the types of pollution – both on the environment and on human beings – have not been studied comprehensively yet. In the future, the development of oil and gas production in the Barents Sea in the Murmansk region may give place to additional risk of pollution with oil products on the terrestrial ecosystems of the Kola Peninsula. There is a necessity for studying the anthropogenic factors

impact on the fungi accumulation in the environment. Anthropogenic changes of the fungal complexes can change this relationship, and cause negative impact on the plants, animals and human beings.

The goal of this research is to study the species diversity and the structure of opportunistic fungi communities within the industrially polluted soils of the Kola Peninsula, and to determine the potential pathogenicity degree of the fungi strains on the basis of proteasic and phospholipase activity, and the growth ability at the temperature 37°C.

MATERIALS AND METHODS

The ecosystems are pine forests with associations of moss/dwarf shrubs and lichens/dwarf shrubs and in the ground cover. The sample collection took place in the summer-autumn period: June, September in 2000–2011 along the gradient of the pollution by the Aluminum Plant emissions (88 samples on each plots); June, September in 1999-2010 along the gradient of the pollution by the Copper-Nickel Plant emissions (88 samples on each plots); June, July, September in 2006-2011 in the model experiments with oil products (45 samples

on each plots). The type of soils is the Al-Fe-humus podzol (Albic Podzol according WRB) in the areas polluted by Aluminum and Copper-Nickel Plants emissions and the arable soil (Hortic Anthrosol according WRB) in the model experiment with oil product.

The objects of our research are (see Fig. 1): 1) soil located in the area contaminated by the Kandalaksha Aluminum Plant; 2) soil located in the area contaminated by the «Severonickel» Copper- Nickel Plant; 3) soil polluted by oil products in field model experiment near Apatity; 4) unpolluted soil of the Kola Peninsula.

Soil and vegetation characteristics are described in detail in previously published articles (Evdokimova et al. 2011, 2013).There have been identified three environmental impact area zones related to the Kandalaksha Aluminum Plant in terms of fluorine content in the organic horizon (0–3(7) cm) and the condition of vegetation, too. The definitions of these three zones were identified: the zone of maximum pollution at the distances up to 2.5 km from the pollution source (F >1200 mg/kg; pine trees were significantly damaged by pollutants as indicated by multiple dead branches in the lower and middle parts of tree crowns and ground

Fig.1. The investigated sites

cover was presented by crowberry), the zone of intensive pollution – up to 13 km (F – 400–1200 mg/kg; pine trees were slightly damaged and no visible changes in the ground cover were recorded) and the zone of temperate pollution – up to 20 km (F – 200–400 mg/kg; vegetation had no visible features of the adverse effect of contamination). At the distances more than 20 km, the pollution did not affect the content of soil biota. In the area of the Copper - Nickel Plant, the influence zones were revealed: the maximum pollution was up to 5 km from the Plant (Cu – 600–1000, Ni – 1700–2600 mg/kg; vegetation was presented by sparse horsetails growing on sands, and crowberry located only at the bases of birch trees; wild rosemary, cowberry, and bilberry were represented by single plants), and the strong pollution was up to 15 km from the Plant (Cu –200–400, Ni – 500–1000 mg/kg; tree layer consists of pine and birch; dwarf shrubs are represented mainly by cowberry, bilberry, and bearberry; wild rosemary and crowberry are less frequent). The background plot was located at 50 km from the source of emissions (Cu – 40, Ni – 80 mg/kg). The pH water suspension of the organic horizon in the area of maximum pollution by the Copper-Nickel Plant was 4.0–4.1, for the Aluminum Plant, it was 5.6–5.7.

The soil samples for the mycological analysis were taken from the organic horizon of the Albic Podzol and layer 0-10 cm of the Hortic Anthrosol. The number of fungi was estimated by the plating method on the wort agar media with adding lactic acid. The fungal biodiversity analysis was carried out on the basis of cultural-morphological characteristics with the use of keys (Raper and Thom 1968; Domsh et al. 2007; Seifert et al. 2011). We have used three literature sources (Hoog et al. 2011; Satton et al. 2001; Sanitary… 2008) to determine whether the fungus belongs to the group of opportunistic.

The fungi protease activity was fulfilled on the nutrient media with the bovine serum albumen adding; the phospholipase activity was determined on the nutrient media with the egg yolk adding (Fotedar and Al-Hedaithy 2005). The Petri dishes were incubated for 10 days after the inoculation. Then the measurements of the colony diameter and the zone of lucid interval round the colonies (proteasic activity), as well as precipitation zone (phospholipase activity) took place. The activity ratio counting was carried out using the formula: $I=1-Dc/(Dc+3p)$, where I is an index of proteasic/phospholipase activity; Dc is a colony diameter, 3p is the zone of lucid interval/precipitation. The fungi growth capability was determined at a temperature 37°C against the 7th day (Bogomolova et al. 2007).

RESULTS

In total, 62 species of fungi (from 29 genera), which belong to the opportunistic ones, were identified in the polluted soils of the Kola Peninsula (Table 1). The largest number of the opportunistic fungi species belonged to the following genera: Penicillium (11), Aspergillus (8), Mucor (4), Phoma (4), Lecanicillium (3) and Cladosporium (3). Most fungi belong to the group BSL1, only 7 fungi species belong to the group BSL2. We did not isolate the fungi belonging to the BSL3 group. Also 17 species belong to opportunistic fungi according to (Satton et al. 2001) and (Sanitary… 2008).

Opportunistic fungi in the area of the Aluminum Plant emissions

In the polluted soil of the Aluminum Plant emission 34 opportunistic fungi species were revealed. In the polluted soils, the share of the opportunistic fungi increased up to 50% compared to the background soil, where it made 35% of the total number of the identified species. Among them, there are agents of mycoses and also the fungi causing diseases of respiratory and digestive systems from genera Acremonium, Alternaria, Amorphotheca, Aspergillus, Aureobasidium, Cladosporium, Fusarium, Mucor, Myxotrichum, Paecilomyces, Penicillium, Phoma, Rhizopus, Sarocladium, Scopulariopsis, Stachybotris, Trichoderma. The largest number of species belonged to g. Penicillium (6) (see Table 1). Some changes were noticed in the species composition of the opportunistic fungal complexes. Trichoderma viride and Penicillium canescens dominated in the polluted soil, and rarely

Table 1. The list of opportunistic fungi isolated from the contaminated soils of the Kola Peninsula, and diseases caused by them

Species	Caused diseases	KAP[1]	Severo-nickel	Oil roducts
According to (Hoog et al. 2011)				
BSL1 group				
Acremonium rutilum W.Gams	Onichomikosis, ulcer of a cornea of an eye, endophthalmitis, meningitis, endocarditis	+	+	+
Alternaria alternata (Fr.)Keissl.	Keratomikoz, onichomikosis, sinusitis	+		+
A. botrytis (Preuss) Woudenberg & Crous	Onichomikosis	+		
Amorphotheca resinae Parbery	Onichomikosis, skin infections	+		
Aspergillus glaucus (L.) Link	Onichomikosis, otitis, orofacial infection	+		
A. niger Tiegh.	Infections of respiratory system, inhalant aspergilloma, otomycosis, onichomikosis, peritonitis, endophthalmitis, endocarditis	+	+	
A. flavus Link	Onichomikosis	+		
A. sydowi (Bainier et Sartory) Thom et Church	Onichomikosis, aspergillosis, keratomikoz	+		
A. versicolor (Vuill.) Tirab.	Onichomikosis, osteomielitis	+		
A. ustus (Bainier) Thom et Church	Infections of respiratory system, skin infections, middle otitis, disseminated and burn infections		+	
Aureobasidium pullulans (de Bary et Lowenthal) G.Arnaud	Infections of respiratory system, keratitis, peritonitis, alveolitis	+	+	+
Cladosporium cladosporioides (Fresen.) G.A. de Vries	Infections of respiratory system, skin infections		+	

C.oxysporum Berk. Et M.A. Curtis	Ceratit cutaneous infection	+		
C. herbarum (Pers.) Link	Asthma, keratomikoz, keratitis, rhinitis	+		
Gongronella butleri (Lendn.) Peyronel et Dal Vesco	Asthma, keratomikoz		+	
Mucor circinelloides Tiegh	Skin infections			+
M. plumbeus Bonord.	Skin infections			+
M. racemosus Fresen.	Infections of respiratory system, skin infections	+		
Penicillium aurantiogriseum Dierckx	Asthma, rhinitis, alveolitis	+	+	+
P. canescens Sopp	Asthma, rhinitis, alveolitis	+	+	+
P. citrinumThom	Asthma, rhinitis, alveolitis		+	
P. commune Thom	Asthma, rhinitis, alveolitis		+	
P. chrysogenum Thom	Keratitis, endophthalmitis, otomycosis		+	
P. decumbens Thom	Alveolitis	+		
P. glabrum (Wehmer) Westling	Alveolitis	+	+	
P. miczynskii K. M. Zalessky	Asthma, rhinitis, alveolitis			+
P. purpureogenum Stoll	Asthma, rhinitis, alveolitis		+	
P. spinulosum Thom	Asthma, rhinitis, alveolitis	+	+	+
Pseudogymnoascus pannorum (Link) Minnis & D.L. Lindner	Onichomikosis			+
Purpureocillium lilacinum (Thom) Luangsa-ard, Houbraken, Hywel-Jones & Samson	Onichomikosis, infections of respiratory system		+	
Rhizopus stolonifer (Ehrenb.) Vuill.	Dermatomycosis, rhinocerebral mycosis	+	+	+
Rhodotorula sp.	Fungemia, endocarditis meningitis, pyocephalus, peritonitis			+
Sarocladium kiliense (Grütz) Summerb.	Noduloso hyalohyphomycosis, keratitis	+		
S. strictum (W. Gams) Summerb	Skin mycosis, onichomikosis	+	+	

Scopulariopsis communis Bainier	Pulmonary infection	+		
Talaromyces purpurogenus (Stoll) Samson, Yilmaz, Frisvad et Seifert	Infections of respiratory system		+	
Trichoderma koningii Oudem.	Infections of respiratory system, keratomikoz, rhinitis		+	+
Tr. viride Pers.	Infections of respiratory system, keratomikoz, rhinitis	+	+	+
BSL2 group				
Aspergillus fumigatus Fresen.	Asthma, alveolitis, rhinitis, aspergillosis, which leads to infections of respiratory, nasal, bone systems	+	+	+
A. terreus Thom	Bronchopulmonary aspergillosis, optic disseminated mycosis, keratitis, otitis, arthritis		+	
Codaphora melinii Nannf. Conant	Phaeohyphomycosis, chromoblastomycosis		+	
Fusarium oxysporum Schltdl.	Keratomikoz, keratitis, peritonitis	+		+
F. solani (Mart.) Sacc	Keratomikoz, keratitis	+		
Paecilomyces variotii Bainier	Pneumonia, asthma, keratomikoz, nephritis, rhinitis, endocarditis, alveolitis	+		
Scopulariopsis brumptii Salv.-Duval	Pulmonary infection	+		
According to (Satton et al. 2001; Sanitary… 2008)				
Collariella bostrychodes (Zopf) X.Wei Wang et Samson	Onichomikosis, skin infections, peritonitis		+	
Clonostachys rosea (Link) Schroers, Samuels, Seifert & W. Gams	Keratitis	+		
Fusarium fujikuroi (Sawada.) Wollenw.	Disseminated mycosis, keratitis, endophthalmitis			+
Humicola grisea Traaen	Infections of respiratory system, mycosis			+

Lecanicillium sp.	Keratitis		+	
L. lecanii (Zimm.) Zare et W. Gams	Keratitis			+
L. psalliotae (Treschew)Zare et W. Gams	Keratitis			+
Mucor hiemalis Wehmer	Infections of respiratory system, skin infections			+
Myxotrichum deflexum Berk.	Skin infections	+		
Oidiodendron flavum Svilv.	Neurodermatitis		+	
O. griseum Robak	Neurodermatitis		+	
Penicillium. simplicissimum (Oudem.) Thom	Asthma, rhinitis, alveolitis	+	+	+
Phoma eupyrena Sacc.	Skin mycosis			+
Ph. glomerata (Corda)Wollenw. et Hochapfel	Skin mycosis			+
Ph. herbarum Westend	Skin mycosis	+	+	
Ph. medicaginis Malbr. et Roum.	Skin mycosis	+		
Stachybotrys chartarum (Ehrenb.) S. Hughes	Dermatomycosis	+	+	

[1]Kandalaksha Aluminum Plant

in the background soil. On the contrary, Aureobasidium pullulans was rarely revealed in the polluted soil, but prevailed in the background one. Aspergillus fumigatus, P. glabrum are related to the group of occurrence frequency in the soils of all the plots. It should be noted that the opportunistic fungi species, such as A. niger, Cladosporium herbarum, Fusarium oxysporum, Paecilomyces variotii, P. simplicissimum and Phoma medicaginis were found only in the soil of the polluted plots.

Opportunistic fungi in the area of the Copper-Nickel Plant emissions

In the polluted soil of the Copper-Nickel Plant emissions, 30 fungi species belonging to opportunistic fungi were isolated. Their share in the polluted soil is 45%, and in the background soil is 30% of the total number identified species. In the soils of both plots, the opportunistic fungi group is represented with the following genera Acremonium, Aspergillus, Aureobasidium, Collariella, Cladosporium, Gongronella, Lecanicillium, Oidiodendron, Penicillium, Codaphora, Phoma, Purpureocillium, Rhizopus, Sarocladium, Stachybotris, Talaromyces and Trichoderma. Most species belong to Penicillium (9), Aspergillus (4), Oidiodendron and Trichoderma (2); the rest of the genera have only one (see Table 1). One can observe the increase in the number of g. Aspergillus species in the soil polluted by the emissions from the Copper- Nickel Plant in comparison with the background soil. Most species of this genus belong to opportunistic ones, and take place mainly in the soils of the southern regions. At the same time, different authors speak about the increase in the number of "southern" fungi in the polluted soils of the Northern part of Russia (Kireeva et al. 2005; Marfenina 2005; Evdokimova et al. 2013). The changes in the structure of the opportunistic fungi complexes were also noticed. Such species as Penicillium simplicissimum, Trichoderma koningii and T. viride dominated, and P. glabrum also often occurred in the polluted soil, but in the background soil all of

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them belonged to rare species. It should be noticed that the opportunistic species, such as Aspergillus fumigatus, A. terreus, A.ustus, P. aurantiogriseum and Codaphora melini were not found in the background soil, but they were revealed in the polluted one.

Opportunistic fungi in the soil contaminated by the oil products

The increase of the opportunistic fungi share in the soils contaminated by different types of oil products in various concentrations was revealed. In the clean soil, the share of opportunistic fungi was 45% of the total number of species; in the soils both with low and high diesel fuel content, the share amounted to 65%; in the soils with gas condensate it was 70%; and in the soils with the mixture of mazut and diesel fuel, the amount reached 55%.

While adding diesel fuel to soil, the richest diversity of the opportunistic fungi group was observed: 21 species out of 24 were isolated in the soils polluted with different oil products, in the soil with gas condensate there were 9 species and in the soil with a mixture of mazut and diesel fuel were 13 species. The following genera belonged to the opportunistic fungi group; they were isolated from the soil contaminated with diesel fuel: Acremonium, Alternaria, Aspergillus, Aureobasidium, Fusarium, Humicola, Lecanicillium, Mucor, Penicillium, Phoma, Rhizopus, Pseudogymnoascus, Rhodotorula, and Trichoderma. The species gg. Fusarium, Mucor, Penicillium and Trichoderma occurred in soils both with low and high diesel fuel concentrations; while the species g. Lecanicillium was isolated only from the soil with high diesel fuel doses. The genera Alternaria, Aspergillus, Aureobasidium, Humicola, Phoma, Pseudogymnoascus and Rhizopus occurred only in the soil with low concentration of diesel fuel. Most species belonged to Penicillium (5), Mucor (3), Lecanicillium, Phoma and Trichoderma (2), while other genera were presented by one species.

In the soil polluted with gas condensate, the opportunistic fungi group was represented by such genera as Acremonium, Lecanicillium, Mucor, Penicillium, Pseudogymnoascus,

Rhizopus, Trichoderma. In the soil with the mixture of mazut and diesel fuel, gg. Acremonium, Aureobasidium, Mucor, Penicillium, Phoma, Pseudogymnoascus, Rhizopus, Rhodotorula, Trichoderma were found. Genera Mucor, Penicillium, Trichoderma occurred at both low and high oil product concentrations; while the fungi of gg. Acremonium, Aureobasidium, Rhodotorula, Phoma were isolated only at high concentrations. As for gg. Pseudogymnoascus, Rhizopus, they were revealed only at low concentrations.

Some changes in the structure of opportunistic fungi complexes in the polluted soil compared to the background soil were revealed. The increase of these species abundance and frequency of occurrence in the polluted soil were observed. That can be explained by good adaptability of opportunistic fungi to the environmental conditions. The fungi of Fusarium oxysporum, Penicillium simplicissimum, Phoma eupyrena, Trichoderma koningii and T. viride were identified as a group of rare species in the background soil. They were frequent and abundant in the soil polluted with diesel fuel. P. miczynskii became the dominant species at high diesel fuel concentrations. This type is the most resistant species of fungi with respect to all studied opportunistic fungi types. In the soils with gas condensate, such species as P. canescens and T. koningii became dominant, and Rhizopus stolonifer was frequent, while in the background soil they were rare. P. canescens was identified as frequent species in the background soil. It became the dominant species in the soils polluted by the mixture of diesel fuel and mazut. Mucor hiemalis was a frequent species in the background soil, but it became a rare species in the soils under contamination by all types of oil products, and that indices its sensitivity to this type of pollution.

Potential pathogenicity of the opportunistic fungi

41 fungi strains (55%) revealed the protease activity among the fungi isolated from polluted soil by Aluminum Plant emissions. The protease activity coefficient changed from 0 up to 0.4. 16 strains displayed the

most significant coefficient values (0.2-0.4). The most active strains were Aspergillus fumigatus, A. versicolor, Cladosporium herbarum, Penicillium commune. 20 isolates (27%) revealed the phospholipase activity. The phospholipase activity coefficient value changed from 0.1 up to 0.3. Such strains as Aspergillus fumigatus, A. niger, Paecilomyces variotii, Penicillium decumbens, P. commune, P. purpurogenum, Rhizopus stolonifer, Lecanicillium lecanii exhibited the most coefficient values. 31 strains (41%) out of 75 tested, indicated the growth activity at a temperature 37°C.

The protease activity was discovered in 17 isolates (49%) among the strains, isolated from the soil contaminated with oil products. The following species Mucor circineloides, Penicillium decumbens, P. glabrum, P. simplicissimum, Trichoderma viride revealed the greatest protease activity coefficient value. Only 8 cultures (23%) testified their phospholipase activity. The isolates of this group belonged to such species as Penicillium aurantiogriseum, P. decumbens, P. glabrum, P. commune, P. simplicissimum, P. spinulosum, Rhizopus stolonifer. All the rest cultures did not exhibit their phospholipase activity. Consequently, they are not able to penetrate deep into the tissues and provoke considerable mycosis. The growth activity was marked within 21 species (60%) out of 35 tested ones, at the temperature 37°C.

Judging by the research results, 7 fungi strains were the most dangerous for a human. They were revealed from the soils contaminated by the Aluminum Plant emissions: Amorphotheca resinae, Aspergillus fumigatus, A. niger, Paecilomyces variotii, Penicillium commune, P. purpureogenum, Trichoderma viride, and 5 species revealed from the soils contaminated by the oil products Penicillium aurantiogriseum, P. glabrum, P. commune, P. simplicissimum, Rhizopus stolonifer. Those species revealed all the investigated factors of the potential pathogenicity. They possessed both the proteasic and phospholipase activity, as well as the growth capability at the temperature 37°C.

To compare and estimate the degree of the fungi strains potential pathogenicity, 22 species (44 strains) of fungi revealed from the clean and contaminated by the Aluminum Plant emissions soils were tested (Table 2). Five species (23% of the total number) Penicillium glabrum, P. simplicissimum, Pseudogymnoascus pannorum, Rhizopus stolonifer, Trichoderma koningii did not reveal the difference in 3 specifications under test, depending on the presence of contamination in the soil. The strains of 11 species (50% of the total number) Amorphotheca resinae, Aspergillus fumigatus, A. versicolor, Cladosporium herbarum, Lecanicillium lecanii, Mucor hiemalis, Paecilomyces variotii, Penicillium aurantiogriseum, P. miczynskii, Phoma glomerata, Trichoderma viride isolated from the contaminated soil revealed either the appearance or intensification of one of the specifications, characterizing the potential fungi danger for a human being.

Thus, under the human's activity impact, the share of opportunistic fungi in soil has increased. In the Albic Podzol soils, in the impact areas of the Aluminum and Copper-Nickel Plants the number of opportunistic fungi increased up to 15%, as compared to that in the background soil. The share of the opportunistic fungi increased up to 20-25% in the Hortic Anthrosol polluted by the diesel fuel and gas condensate. That can be caused by the habitat versatility of the opportunistic fungi and their wide range of tolerance towards the unfavorable environmental conditions, as well as better capability to utilize diverse substratum. Most of them found in the polluted soils of the Kola Peninsula belonged to gg. Penicillium, Aspergillus, Mucor, Lecanicillium, Cladosporium and Phoma. Such species as Acremonium rutilum, Aspergillus fumigatus, Aureobasidium pullulans, Penicillium aurantiogriseum, P. canescens, P. simplicissimum, P. spinulosum, Rhizopus stolonifer, Trichoderma viride were found under all types of pollution. Penicillium miczynskii proved to be the most resistant species to all studied oil products, while Mucor hiemalis appeared to be the most sensitive one. The common tendencies for all types of studied pollutions in the fungi species composition have been identified: drifting of species from the rare group in the

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Table 2. The results of the fungi cultural testing, isolated from the soils of the Kola Peninsula

Fungi species	Activity		Grow ability at t=37°C
	Proteasic	Phospholipase	
Amorphotheca resinae Parbery	+/−[1]	+/+	+/−
Aspergillus fumigatus Fresen.	+/−	+/−	+/+
A. versicolor (Vuill.)Tirab.	+/−	+/+	−/−
Cladosporium herbarum (Pers.)Link	+/−	−/−	+/−
Clonostachys rosea (Link) Schroers, Samuels, Seifert & W. Gams	−/+	−/−	−/+
Lecanicillium lecanii (Zimm.) Zare et W. Gams)	−/−	−/−	+/−
Mucor hiemalis Wehmer	+/−	−/−	−/−
Myxotrichum cancellatum W. Phillips	+/−	−/−	−/−
Paecilomyces variotii Bainier	+/−	+/−	+/+
Penicillium aurantiogriseum Dierckx	+/−	+/−	−/−
P. canescens Sopp	+/+	−/+	−/−
P. decumbens Thom	+/+	−/+	−/−
P. glabrum (Wehmer) Westling	+/+	−/−	−/−
P. miczynskii K.M. Zaleski	+/−	+/+	−/−
P. simplicissimum (Oudem.) Thom	+/+	−/−	−/−
P. spinulosum Thom	+/+	−/+	−/−
Phoma glomerata (Corda) Wollenw. et Hochapfel	+/−	−/−	−/−
Pseudogymnoascus pannorum (Link) Minnis & D.L. Lindner	+/+	−/−	+/+
Rhizopus stolonifer (Ehrenb.) Vuill.	+/+	−/−	+/+
Scopulariopsis communis Bainier	+/+	−/+	−/−
Trichoderma viride Pers.	+/+	+/+	+/−
T. koningii Oudem.	+/+	−/−	+/+

[1] in contaminated soil/in uncontaminated soil

background soil to the frequent group in the contaminated one.

The fungi isolated from the soil can be dangerous to human health, since many of them exhibit potential pathogenicity, to some extent. The strains of the fungi isolated from the contaminated soil reveal the potentially pathogenicity in a greater degree, than the strains isolated from the clean soil. 55% of the total amount of fungi strains isolated from the soils contaminated by the Aluminum Plant emissions had the potentially pathogenicity. It is necessary to conduct regular monitoring studies to identify potentially dangerous microscopic fungi species.

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