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WATER RESOURCES OF UKRAINE: USAGE, QUALITIVE AND QUANTITATIVE ASSESMENT (WITH DETAILE DESCRIPTION OF ODESSA REGION)

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Abstract. The level of pollutant in river and reservoirs water in Ukraine is rather high. The assessment of the modern state of water resources in the different regions had been done. In generally it was determined that water infrastructure in Ukraine needs reconstruction. New State Program of Water Management Conception and new Law about water management up to 2020 had been approved. Nine basins committees were organized. Committees are composed of representatives of science, practical specialists and the public. The main directions of this Program were supported by World Summit on Sustainable Development.

Key worlds: Ukraine water resource, water quality, assessment, remediation

1. Introduction

The level of pollutant in river and reservoirs water in Ukraine is rather high. So, it is one the most important ecological problem. In Ukraine surface water objects embrace of 24,1 thousands km^2 (about 4 per cent from country area). The volume of potential fresh water recourses is 209,8 km^3 year^{-1}, 75 per cent from this volume is transit water coming from Russia, Byelorussia and Romania. It is necessary to organize optimal regime of water using, assessment and remediation.

2. Relevance and methodology

The problem of the drinking water quality is very important in Ukraine at present time. For the understanding of the modern situation and water resources status available data set was used, retrospective analyses was done according the laws of Ukraine and main directions of with New State Program of Water Management Conception.

3. Discussion

The water resources of Ukraine consist on surface and underground water. The surface water is 24,1 thousands km^2, it is 4 % from common area of Ukraine. There are rivers, lakes, water pools, reservoirs and canals. The most important objects are rivers. There are more then 63 thousands rivers in Ukraine. The big ones (the catchments area is more 50 thousands km^2) – 9, the middle (catchment area is from 2 to 50 thousands km^2) – 87. For population and economic needs 1103 artificial reservoirs (common volume is more 55 billions m^3), near 48 thousands reservoirs and 7 big canals 1021 km long have been done. Average volume of renewable water resources consists on 95,2 km^3 per year (2,01 thousands m3 per capita per year) They are include local runoff – 54 billions m3 per year and inflow – 40,5 billions m^{3}per year. The local formation river runoff for 1 km^2 is important index. In the most provided by water resources regions this index consists on 618–225 thousands km^3 per year (Zakarpatska, Ivano-Frankivska and Lvivska oblast). In the poor provided regions this index consists on 5–23 thousands km^3 per year (Mikolaevska, Zaporizhska, Odeska, Khersonska oblast). Water availability of 13 regions that cover 60 % of the country area is less than average level 86,8 thousands km^3 per year [1]. Forecast resources of underground water consist of thousands 71,7 m^3 per day including water with mineralization up to 1,5 g/dm^3 (drinking water) is 57,5 m^3 per day. There is 1,27 m^3 per day per capita from Forecast resources of underground water and 0,27 m^3 per day per capita as an operational stocks of underground water. [2].

Without Danube the total rivers run off is 87,7 km^3 year^{-1} (average data) in shallow water – 55,9 km year^{-1} (Fig. 1).

The Fig. 1 shows zoning Ukraine's area with main river basins [3]. There are 63119 rivers (including 9 big rivers, 81 – middle and 63029 – small), 1137 artificial reservoirs (with total volume about 55 billion m^3), 40000 artificial pools and 7 canals 1021 km long had been done [4].

In average per capita withdrawals consist on 1,9 thousands m^3, (without transit run off), in shallow wateryear – 1,22 thousands m^3. Per day in average it consist on 5,2 m^3.

There is water deficit in the south-eastern part (from 120 – 400 m^2 per person year^{-1}, ground water includes). It is to 15 – 20 times less than in the western part. The most clean water also in the western part of the country (Fig. 2).

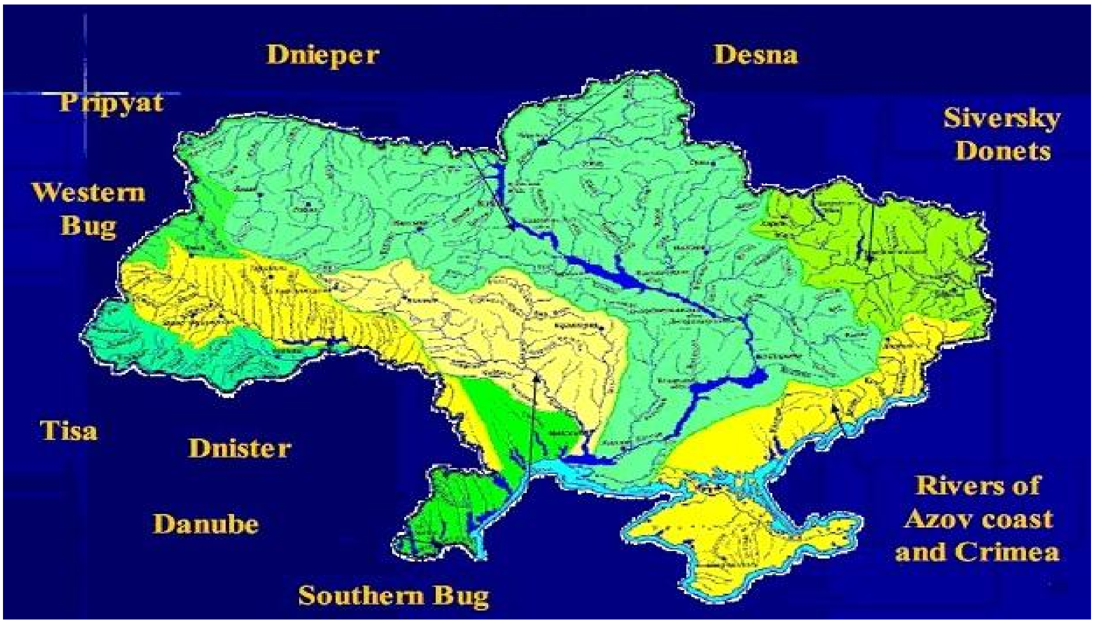


Fig. 1. Main river basins of Ukraine [3]

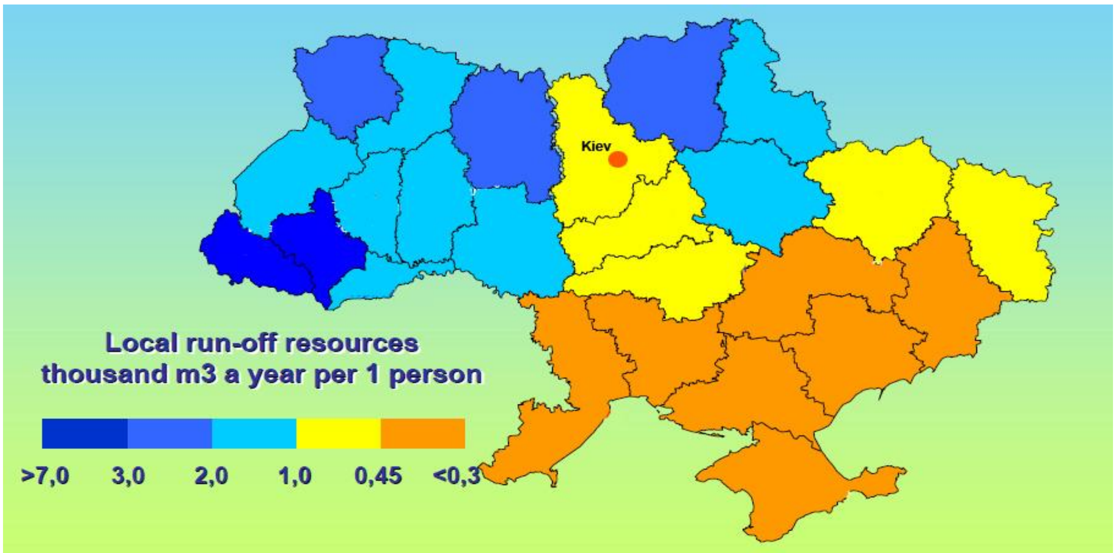


Fig. 2. Regionalized water supply, using data from [5]

Ukraine is one of the low-flow regions in Europe. In Ukraine in the Black sea lowland area there is water deficit problem for drinking, domestic and irrigated water using. Besides, the quality of surface and underground water sometimes is not good enough for drinking, domestic and irrigated water. It is linked with small hydrographic net, degradation of the small rivers (2000 small rivers disappeared), landscape and climatic features of steppe area, small part of fresh underground water and huge anthropogenic press to the water resources.

Per capita withdrawals Ukraine occupies the last place among the former Soviet republics, 70 per cent of population using surface water from the rivers, lakes and artificial reservoirs, 30 per cent – using ground water. The main source of the drinking water is the Dnieper River, but 70 per cent quality of the water does not meet health standards.

The agriculture area in Ukraine is 41576 southern hectares (68 per cent from the total country area). Irrigated area is 2175 southern hectares (5 per cent from the total country area). After Soviet period irrigated area is sharply decreasing (from 2175 to 600 southern hectares in 2010) [6]. It is necessary to increase the irrigated area in southern part of the country up to 1,5 million hectares avoiding dependence on climate condition. It is planning to use the rivers water. Mostly classification of water quality corresponds to the IV–V classes (by chemical and bacterial condition) [7]. The dirtiest regions (drinking water characteristics) are Dnieper river basin, Siversky Donets, Azov rivers basin, Dniester tributaries and Western Bug. The Fig. 3 shows fresh water consumption dynamics, it indicates strong decreasing tendency of water consumption for industrial sector and soft ones for agricultural and housing infrastructures since 1990 (Fig. 3) [5]. More detailed data for 2005–2010 is given in Table 1.

Table 1

Dynamics of water consumption in Ukraine in a period 2005–2010

Characteristics	Year						
	2005	2006	2007	2008	2009	2010	Average
The total amount of water used, km^3:	8,7218 *100 %*	8,5976 *100 %*	9,2201 *100 %*	8,580 *100 %*	8,7195 *100 %*	9,0942 *100 %*	8,8222 *100 %*
– Drinking water	2,409 *27,62 %*	2,298 *26,72 %*	2,192 *23,77 %*	2,103 *24,52 %*	1,956 *22,44 %*	1,917 *21,08 %*	2,145 *24,19 %*
– Industry	4,878 *55,93 %*	4,872 *56,68 %*	5,167 *56,04 %*	5,045 *58,80 %*	5,149 *59,05 %*	5,511 *60,62 %*	5,104 *56,35 %*
– Agriculture for irrigation	1,186 *14,00 %*	1,181 *13,74 %*	1,625 *17,63 %*	1,224 *14,26 %*	1,411 *16,18 %*	1,477 *16,23 %*	1,351 *15,34 %*
– Agriculture for water upply	0,2488 *2,85 %*	0,2466 *2,86 %*	0,2361 *2,56 %*	0,208 *2,42 %*	0,2035 *2,33 %*	0,1892 *2,07 %*	0,222 *2,52 %*

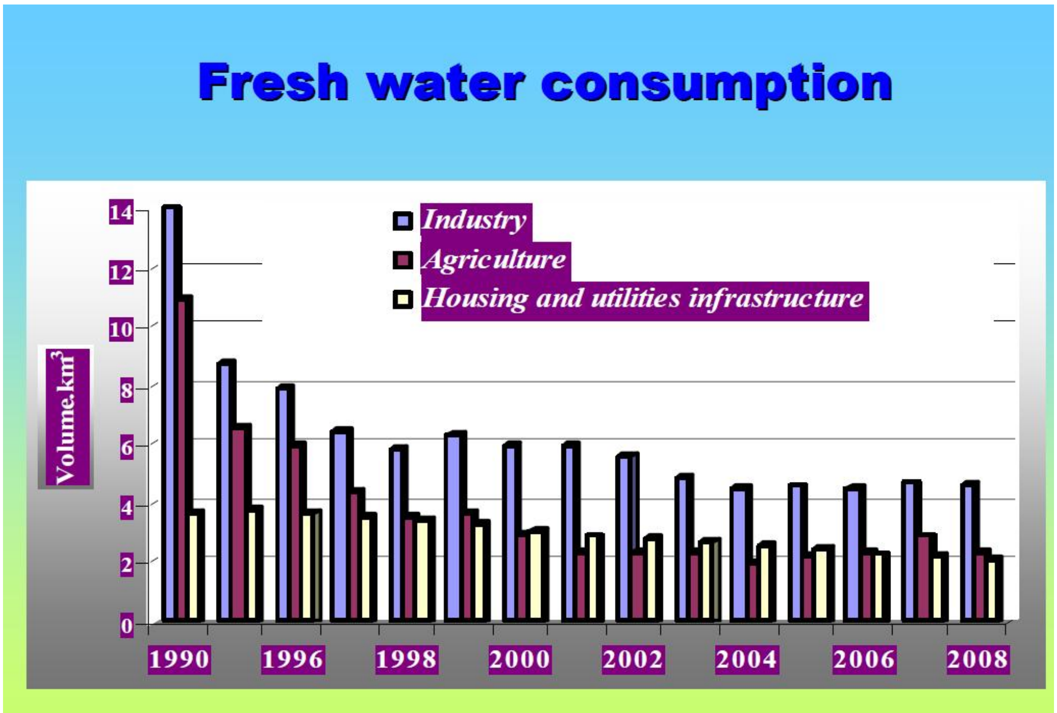


Fig. 3. Fresh water consumption, using data from [5]

According to the National Report of Ukraine 2013, water resources for economic needs are 15 – 16 billions m^3 annually. The main consumers of water are industry – 36 %, agriculture – 41 %, utilities – 23 %.

According to the National Report (Kiev. Ministry of Housing of Ukraine. Drinking Water Quality and State of Water Supply in Ukraine. 2009. National report. 2010. – 710 p. [7] "The consequences of climate change. Ukraine" the air temperature in Ukraine rise by 5–8 °C the problem with deficit water will be take place. Increasing of precipitation in winter and droughts – in warm period will take place also as a result of climate change. Decreasing of underground water provokes deterioration of water quality. In the southern regions extremely hot summers provokes intensity euthrophication processes that limits the normal function of wastewater treatment plants. The degree of pollution of surface waters is shown on Fig. 4 [8].

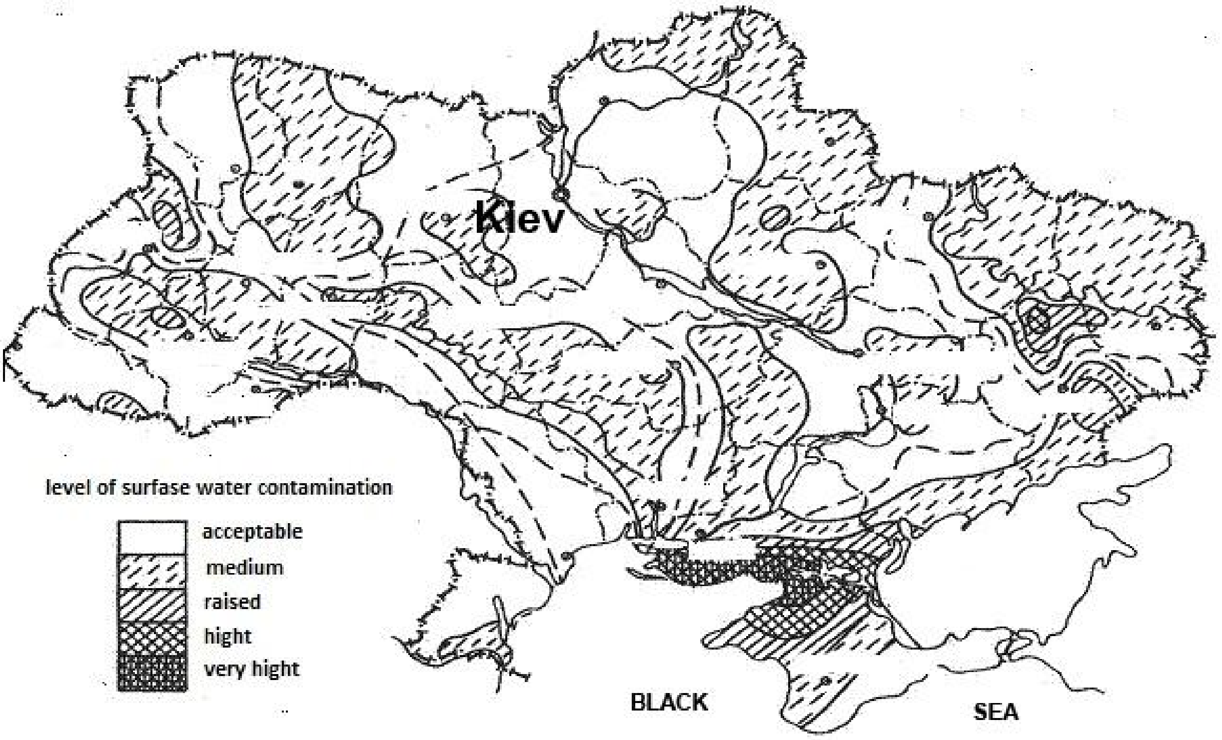
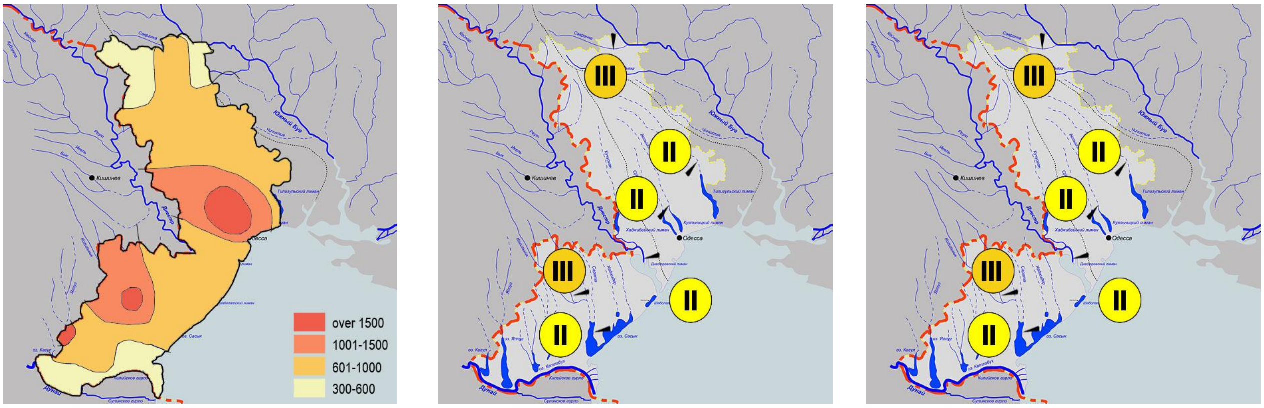


Fig. 4. The degree of pollution of surface waters [8]

The system of water conditioning does not meet modern requirements. For instance, the main method of water disinfection is water chlorination. It is linked with the formation of organochlorine compounds that is very dangerous for the human health. In all the cities of Ukraine deterioration (age progress) of water supply systems achieved 60–70 per cent. As a result of constant interruptions to the supply of water are the secondary contamination of drinking water and the cause of proliferation of harmful microorganisms, blue-green algae, development of corrosion.

Since the southern part of Ukraine has the worst water supplies it is necessary to implement local water quality and quantity assessment for a region within this area. The Odessa region is located in the Southern part of Ukraine. Mild climate and Black Sea make prosperous environment for development of different economic sectors. However from on the other hand these circumstances lead to increasing of anthropogenic influence on the environment. It is significant that water bodies are among different environment components are affected with anthropogenic influence as well.

In general Odessa region's hydrographic network covers basins of several rivers: Danube (24 per cent), Dniester (16 per cent), Uzhny Bug (8 per cent). At the same time water supplies distribution is very irregular, moreover the water supply of 50 % region population lives in Dniester region. It is possible to describe water quality by two sides it should include conditions of surface water and ground water. Water quality can describe with some indexes that indicate mineralization, tropho-saprobiological and toxic pollution. The highest mineralization level was measured in Kuialnitskiy, Hadzhibeevskiy firths (liman – local names) and in the of Sasik Lake. Toxic tropho-saprobiological indexes of water correspond to the second and the third quality classes (the first class is the best quality, the fifth **-** is the worst) that means the water quality in the Odessa region is satisfactorily (Fig. 5).



a) b) c)

Fig. 5. Water quality indexes: a – mineralization levels; b – tropho-saprobiological indexes of water quality; c – toxic pollution indexes of water quality

The water supply quality in Odessa city depends on water level at Dniester River and has annual periodicity. For example in 2009 high water levels were registered in April – May and low water levels were registered in August – October (Fig. 6) [10]. As for majority indexes Dniester water quality corresponded to the second quality class it means that the fresh water supply needs prior purification.

Regarding provision of the population with expected drinking groundwater resources, the Odessa and Mykolayiv provinces (Oblasts) have the lowest values, and the Kherson Oblast – the highest values (second only to the Chernihiv Oblast): the Odessa province – 0.28 m^3 daily per capita, the Mykolayiv Oblast – 0,33 m^3 daily per capita, the Kherson Oblast – 4.01 m^3 daily per capita (the average for Ukraine is 1.27 m^3 daily per capita). As regards provision of the population with commercial drinking groundwater resources, the Odessa and Mykolayiv Oblasts are also characterized by the lowest rates, and the Kherson Oblast – by the highest rates in Ukraine: the Odessa Oblast – 0.18 m^3 daily per capita, the Mykolaiv Oblast – 0,06 m^3 daily per capita, the Kherson Oblast – 0,74 m^3 daily per capita (the average for Ukraine is 0,33 m^3 daily per capita) [9].

The hygienic aspect of drinking groundwater safety and quality can be defined by the indices of epidemic safety, sanitary, chemical and radiation indices, as well as the optimal content of mineral substances, i.e. a mineral composition adequate to the physiological need of a human organism: total hardness, total alkalinity, the content of iodine, potassium, calcium, magnesium, sodium, solid residual and fluorine. Deviation from optimal value range is typical for almost all the identifiable parameters of balanced mineral composition of groundwater in the industrial-and-urban agglomerations of the Northwestern Black Sea Regions (Odeska, Mikolaevska, Khersonska oblast), yet after the groundwater treatment calcium, magnesium and sodium concentrations are significantly decreased, which further provokes development of the diseases associated with deficiency of these elements. Additional treatment of groundwater only partially solves the problem of balancing the mineral components of drinking water, and in some cases may even aggravate the problem. Fluoride concentration in drinking water from surface and ground sources of water-supply does not reach the minimum standards that require substantiation of appropriateness to perform the water fluorination, use fluorinated toothpastes and other means of prevention of caries and other diseases among public at large. Long-term consumption of drinking groundwater with an imbalance of the mineral composition can be one of the negative impact factors for the public health, so there is a need for further special studies [11].

The ground water is more protected from the different anthropogenic impacts in comparing with surface water bodies. It is gives some advantages for usage ground water as fresh water supply. The assessment of ground water is more difficult in comparison to surface water. So it is necessary to distinguish ground water into two categories: potential supplies and exploited supplies. The surface and ground water supply in the Odessa region are distributed irregularly as well as. The reason is the Odessa region has various geological structures. The assessment of potential water supplies of Ukraine is about 0.19 m^3 day^{-1} per capita. Zoning of the Odessa region by potential and exploited ground water supply was implemented with cluster analysis and revealed that

Southern part of the region including Odessa city had better exploited but worst potential ground water supply (Fig. 7, 8). In general (for 2005) exploited supplies were 405010 m^3 day^{-1} and potential supply was 805500 m^3 day^{-1}. It is also very significant that ground water supply has also irregular vertical distribution.

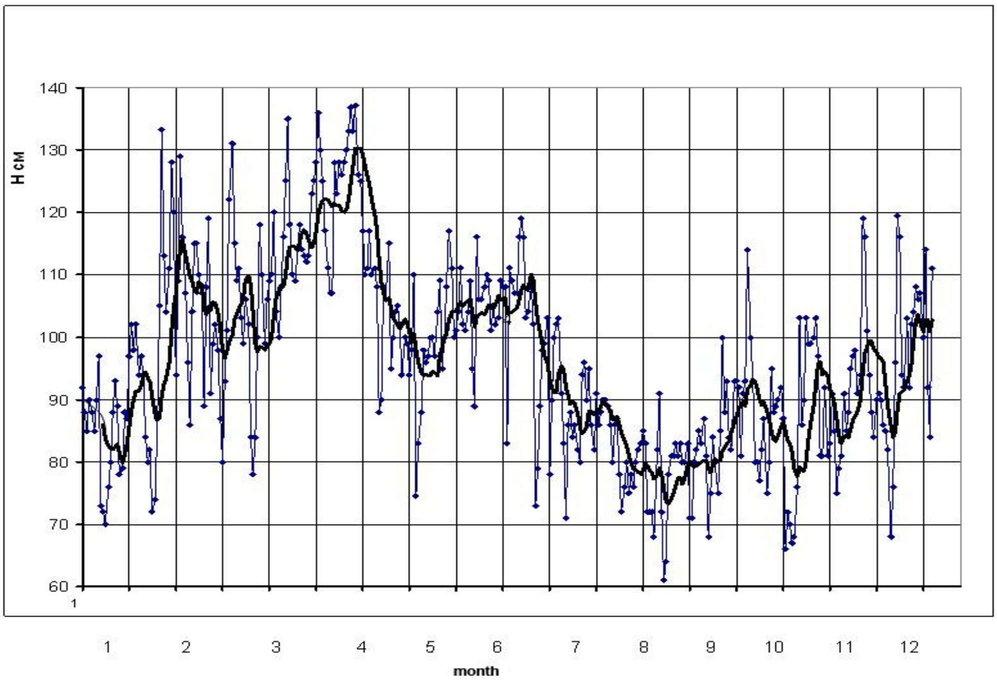


Fig. 6. Daily average water levels of Dniester river in 2009 (Measurement point in Mayaki village) [10]

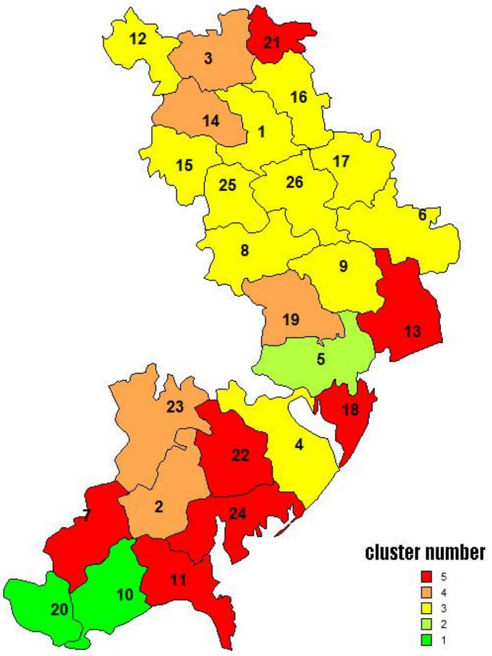


Fig. 7. Zoning of Odessa oblast's potential ground water supply by cluster analysis

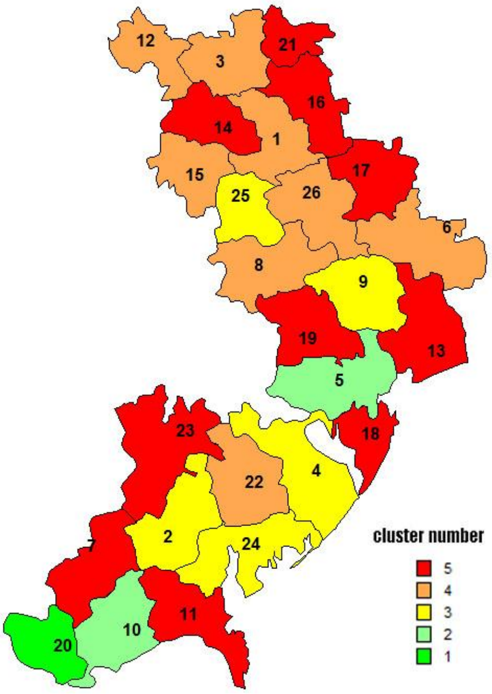


Fig. 8. Zoning of Odessa oblast's exploited ground water supply by cluster analysis

Numbers correspond administrative districts: 1 – Ananivskiy, 2 – Arcizckiy, 3 – Baltskiy, 4 – B-Dnistrovskiy, 5 – Biliaevskiy, 6 – Berezivskiy, 7 – Bolgradskiy, 8 – Velikomichailovskiy, 9 – Ivanivskiy, 10 – Izmailskiy, 11 – Kiliyskiy, 12 – Kodimskiy, 13 – Kominternivskiy, 14 – Kotovskiy, 15 – Krasnooknianskiy, 16 – Lubashivskiy, 17 – Mikolaevskiy, 18 – Ovidiopolskiy, 19 – Rozdilnianskiy, 20 – Reniyskiy, 21 – Savranskiy, 22 – Saratskiy, 23 – Tarutinskiy, 24 – Tatarbunarskiy, 25 – Frunzovskiy, 26 – Shiriaevskiy

The water supply infrastructure in the Odessa region is based on surface water bodies and ground water as well. For example in 2009 water consumption was distributed between fresh water consumption – 37,8 per cent; irrigation – 22,1 per cent; industry needs – 18,9 per cent, fishery needs – 16,9 per cent, agricultur**e** – 3,8 per cent, other – 0,5 per cent.

The wastewater amount (2009) was about 303,4 million m^3. The pollution comes to water bodies mainly from municipal sector that was about 53,2 per cent of total wastewater amount. Contamination of surface and ground water reflects on the Black Sea. About 82,7 million m^3 of the Odessa city sewage comes to Black Sea without proper purification. Unfortunately centralized wastewater management system functioned in a proper way only in 45,1 per cent of towns in the Odessa region according to 2010 statistical survey.

4. Conclusion

The main conclusions can be defined with three points:

At present time Water Infrastructure in Ukraine needs reconstruction. The fist task is water quality. It is necessary to coordinate efforts for the problem decision with international institutions, UN and EU to organize monitoring and water management.

The government of Ukraine approved New State Program of Water Management Conception and new Law about water management up to 2020. This document is the practical tool of realization the sate politic for water protection (surface, ground- and sea water), water ecosystems and management of water resources.

Nine basins committees were organized. Committees are composed of representatives of science, practical specialists and the public. The main directions of this Program were supported by World Summit on Sustainable Development.

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