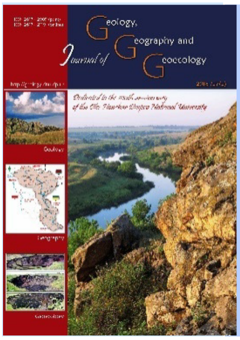

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Geospatial assessment of the Mokra Sura river ecological condition using remote sensing and *in situ* monitoring data

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Abstract. The use of remote sensing methods for environmental monitoring of the surface water quality is proved. Regression relationships are consistent with ground-based measurements at sampling sites in water bodies and are an effective tool for assessing the ecological status of water bodies. The state of the water bodies of the Mokra Sura river basin varies considerably. The best is the water quality in the upper part of the Mokra Sura river, the worst – in the middle and lower parts. The factors of water pollution are discharges of not enough treated wastewater of industrial enterprises of the Kamyans'koy and Dniprovs'koy industrial agglomeration. The purpose of our search included the following tasks: (a) calculation of integrated environmental water quality indices; b) obtaining satellite information, processing of multispectral satellite images of water bodies using appropriate applied software techniques; c) establishment of statistical dependencies between water quality indexes obtained for biotopically space images and data of actual in situ measurements. The results of systematic hydrochemical control of the Mokra Sura river basin from 2007 to 2011 years were initial data in 4 control areas located in the Dnipropetrovsk region: 1 – the Sursko-Litovske village; 2 – the Bratske village; 3 – the Novomykolayvka village; 4 – the Novooleksandryvka village. Environmental assessment of the water quality of the Mokra Sura river within the Dnipropetrovsk region was based on the calculation the integrated environmental index (IEI). Priority pollutants in this case are oil products and ions SO_4^{2-}, Mg^{2+}, Zn^{2+}, Cr^{6+}.

Two images with a difference in three years in April 2015 and May 2017 were used to determine the current changes in the land cover of the study area. Geomorphological assessment of the water network of the Morka Sura river was performed using satellite radar interferometry. Multispectral images of Landsat 5/TM (2007-2011) and Sentinel 2B/MSI (2017) satellite systems were used for remote assessment of water bodies in the study area of the Mokra Sura river basin. The multispectral index TCW (Tasseled Cap Wetness) was used to measure the spectral reflection of the aquatic environment along of the Mokra Sura river flow. The main advantage of the studies is a demonstration of remote sensing capabilities to estimate Mokra Sura river ecological status not only in individual sites, but also throughout the flow – from source to mouth. Follow the necessity to use water from the Mokra Sura river for irrigation, the level of soil water erosion can only increase and enhance the negative processes of eutrophication of reservoirs. Long term technogenic pollution requires information about the state of surface water of fishery, drinking and municipal water use facilities as an integral part of the aquatic ecosystem, the habitat of aquatic organisms and as a resource of drinking water supply. Over 80% of the Mokra Sura river basin surface (IEI 4-12) belong to the classes with the assessment of dirty, very and extremely dirty. The results of studies using remote sensing indicate the need to reduce the streams of not enough treated wastewater to the the Mokra Sura river. The obtained data can be used for ecological assessment of the current and retrospective state of water bodies, development of forecasts of rivers pollution.

Keywords: water bodies, industrial agglomeration, pollution, monitoring, remote sensing.

Геопросторова оцінка екологічного стану ріки Мокра Сура з використанням дистанційного зондування та даних моніторингу *in situ*

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Анотація. Проведені дослідження засвідчують можливість застосування методів дистанційного зондування для виконання екологічного моніторингу стану якості поверхневих вод. Встановлені регресійні закономірності узгоджуються з даними наземних вимірів на постах відбору проб на водоймах і є ефективним засобом оцінки екологічного стану водойм. Стан водних об'єктів басейну ріки Мокра Сура істотно різниться. Найкращою є якість води у верхній частині ріки Мокра Сура, найгіршою – в середній та нижній частинах. Чинником забруднення є скиди недоочищених стічних вод промисловими підприємствами Камянської та Днпровської індустріальної агломерації. Мета наших досліджень була пов'язана із виконанням наступних завдань: а) з розрахунком комплексних екологічних індексів (КЕІ) якості води; б) з отриманням супутникової інформації, обробкою багатоспектральних космічних знімків водних об'єктів з використанням відповідних прикладних комп'ютерних методик; в) з встановленням статистичних залежностей між індексами якості води, отриманими за багатоспектральними космічними знімками і даними фактичних вимірювань *in situ*.Вихідними даними для екологічної оцінки якості води ріки Мокра Сура є результати систематичного гідрохімічного контролю басейну Мокрої Сури з 2007 по 2011 роки, в 4 контрольних створах, розташованих на території Дніпропетровської області: 1 – с. Сурсько-Литовське; 2 – с. Братське; 3 – с. Новомиколаївка; 4 – с. Новоолександрівка. Пріоритетними забруднювачами в цьому випадку виступають нафтопродукти та іони SO_4^{2-}, Mg^{2+}, Zn^{2-}, Cr^{6+} і Zn^{2+}. Для дистанційної оцінки водних об'єктів досліджуваної території басейну ріки Мокра Сура було використано багатоспектральні знімки супутникових систем Landsat 5/TM (2007-2011) та Sentinel 2B/MSI (2017). Мультиспектральний індекс TCW (Tasseled Cap Wetness) був використаний для вимірювання спектрального віддзеркалення стану водного об'єкту уздовж течії річки Мокра Сура. За умов використання води з річки Мокра Сура для зрошення рівень водної ерозії ґрунтів може тільки підвищитись і посилювати негативні процеси евтрофікації водойм. В умовах антропогенного забруднення актуальним є одержання інформації про стан поверхневих вод об'єктів рибогосподарського, господарсько-питного і культурно-побутового водокористування, як складової частини водної екосистеми, середовища існування гідробіонтів і як ресурсу питного водопостачання. Головною перевагою проведених на прикладі середньої річки Мокра Сура досліджень є демонстрація можливостей космічного моніторингу для контролю її екологічного стану не тільки по окремим створам, але й на протязі усієї течії – від витоку до гирла. Результати досліджень з використанням засобів ДЗЗ вказують на необхідність зменшення обсягів надходження у мережу ріки Мокра Суранеочищенних стічних вод. Майже 80% поверхні басейну ріки Мокра Сура (ІЕІ 4-12) належить до класів з оцінкою «брудна», «дуже та надзвичайно брудна». Отримані дані можуть бути використані для екологічної оцінки поточного та ретроспективного стану водних об'єктів, розробки прогнозів забруднення річок поллютантами.

Ключові слова: *водні об'єкти, індустріальна агломерація, забруднення, моніторинг, дистанційне зондування.*

Introduction. Every year, about 1.68 billion m^3 of waste water is supplied to the reservoirs of the Dnipropetrovsk region. Insufficiently treated or untreated discharges make up almost a third (Staruk, 2006). The volume of discharges for half a century increased a thousand times. As a result, the crisis hydro-environmental situation has developed. Unfortunately, the regenerative capacity of the Dnieper and its tributaries does not ensure the restoration of the disturbed ecological balance. In the ecosystems of the Dnieper river basin several factors of anthropogenic origin act together.

Eutrophication caused by high levels of biogens (nitrogen and phosphorus compounds). Saprobes process is associated with excessive concentration of organic substances in water. Chemical pollution is a factor of receipt in the reservoir of substances of inorganic and organic origin (Kharytonov, Anisimova, 2013). The Mokra Sura river is the largest tributary of the Dnieper river. The main source of pollution in the lower and middle part of the river are industrial enterprises of the cities of Dnepr and Kamyanske. The Mokra Sura riveris polluted by surface runoff. Mineral fertilizers and pesticides get into the river together with the mud fraction of the soil. Intensive processes of overgrowth and shallowing lead to secondary pollution of the river and adversely affect the state of its biodiversity (Stas', Kolesnyk, 2015). It is necessary to predict the forthcoming changes in water quality, to develop a full-fledged monitoring system and other measures to protect water bodies during the study of processes in aquatic ecosystems.

Long-term hydrochemical control of the Dnieper river basin in the Dnipropetrovsk region was made in chemical analytical laboratories, subordinated to the Ministry of ecology and environmental protection and the water management Committee of Ukraine from 1995 to 2011 years according to the established water sampling points (Kharytonov et al., 2012). In recent years, this regional monitoring program of the environmental quality of water bodies has been reduced. Therefore topical is the application of remote sensing techniques for the assessment of ecological status of water bodies, identification of "hot spots" – places of wastewater discharge for the further forecast of the possible risks of environmental pollution. The disadvantages of ground based monitoring of water bodies is unsatisfactory efficiency, the definition of water quality at individual points. It is not allow characterizing the quality in the open parts of reservoirs.

To assess the state of water bodies, special remote indices are used, which are a combination of spectral bands of imaging systems. The most common were the indexes NDTI (Normalized Difference Turbidity Index), NDPI (Normalized Difference Pond Index), NDWI (Normalized Difference Water Index) etc (Shevchuk et al., 2014). The application of these indices makes it possible to visualize the spatial differences of the surface of water bodies better. Each of them has its own advantages and disadvantages (Gao et al., 2016). Meantime we pay attention to multispectral TCW (Tasseled Cap Wetness) index (Zhou et al., 2017). This index can be obtained after analyzing the water surface reflectance in six spectral bands (Cirst, 1985). It becomes possible not only to separate water and non-water bodies, but also to determine certain differences within water surface properties (Ouma,Tateishi, 2006). It is clear that the hydrological state of water during its flow through the river bed varies from laminar to turbulent. Jet streams change position with depth. Therefore, further application of methods of direct operational physical and chemical control of water pollution requires further development. At the same time, the inclusion in the remote sensing system of the validation stage of the data obtained with the previously performed analyses of surface water pollution significantly increases the reliability of the information obtained. The purpose of our research included the following tasks:

(a) calculation of integrated environmental water quality indices; b) obtaining satellite information, processing of multispectral satellite images of water bodies using appropriate applied software techniques; c) establishment of statistical dependencies between water quality indexes obtained for biotopically space images and data of actual in situ measurements.

Materials and methods. The Mokra Sura river is located in the subzone of the Northern steppe of the Dniester-Dnieper province, the region of the southern spurs of the Dnieper upland. The Mokra Sura river originates from the pond on the Northern edge of the Sokolyvka village Verkhnyodniprovskyi district at a height of 150.5 m above the sea level and flows into the Dnieper river near the Dnieprovo village of the Dniprovsky district, at the height of 51.2 m. The river basin is located in the territory of 5 districts of Dnipropetrovsk region.The openness of the Mokra Sura river basin is 62.2%, urbanization - 8%. Steppe vegetation occupies 1.9%, meadow vegetation – 7.6%, forests and forest belts – 2.5%, swamps – 0.3% in the basin territory. The Dnieper, Kam'yanske, Verkhivtseve cities, 6 urban-type settlements and 47 small villages are located in the river basin area.The Mokra Sura river has a very developed hydrographic network, which consists of a main riverbed with a length of 144 km and 28 tributaries with a total length of 505 km. The density of the river network is 0.23 km/km^2. 5 lakes (area 5 hectares) and 46 ponds (area 550 ha) are located in the upper area of the basin of the Mokra Sura river. The primary use of ponds are fishing, the watering of domestic animals, recreation. The valley of Mokra Sura river and its tributaries are mostly trapezoidal shape. The slopes of the right banks are steeper – 3-15º, the left slopes are flat – 1-8º. The width of the valleys from 1 to 4 km, the basis of erosion is 30-50 m. The slopes of the valleys are covered mainly with steppe vegetation. In gullies and ravines on the right slope of the valley of the Mokra Sura river remained forest. The floodplain of big ravins – tributaries the Mokra Sura river have a width of 150 m, mostly dry, in the headwaters are flooded.Water supply to the Mokra Sura river and its inflow in the sources is mainly snow and rain. Wellspring stream supports weak water flow during the summer-autumn-winter low water period. However, there is an outflow of groundwater from the valley of Mokra Sura to the Dnieper and the Samotkan river. The natural water regime of the Mokra Sura river is completely disrupted also by intensive water pumping from the Dnieper river in the area of the fishery ponds.

The method of surface water quality assessment used in this work (Romanenko et al., 1998) was the basis for:a) analysis of hydrochemical control data, characteristics of land surface water quality from ecological point of view;b) obtaining information on the state of the water body;c) identification of trends in water quality over time and space;d) study of the impact of anthropogenic load on ecosystems of water bodies; e) planning and implementation of water protection measures and assessment of their effectiveness.

Two images with a difference in three years in April 2015 and May 2017 were used to determine the current changes in the land cover of the study area.

The results of systematic hydrochemical control of the Mokra Sura river basin from 2007 to 2011 years were initial data in 4 control areas located in the Dnipropetrovsk region: 1 – the Sursko-Litovske village; 2 – the Bratske village; 3 – the Novomykolayvka village; 4 – the Novooleksandryvka village.The system of ecological quality classification of surface waters includes three groups of indicators: 1) indicators of the salt composition; 2) tropho-saprobiological (environmental and sanitary);2A – hydro-phisical – suspended solids, transparency; 2B – hydro-chemical (pH, concentration of ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, phosphates, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand) ; 3) substances of toxic action.

Integrated environment index(I_e) was calculated by formula:

$$I_e = \frac{(I_a + I_b + I_c)}{3}, \quad (1)$$

where I_a, I_b, I_c arefactor indices due to the maximum excess of one of the characteristics in each group of indicators. According to integrated environmental index (IEI) values, classes and categories of water quality are distinguished by their degree of pollution (table.1): and class 1 category – very clean; II class 2 category – clean, 3 category – moderately polluted III class 4 category - contaminated, 5 category – dirty; IV class 6 category – very dirty; V class 7 category – extremely dirty. The Mokra Sura river water quality estimated by the values of the maximum permissible concentrations of pollutants for fishery waters (MPC_{fish}) and the values of maximum permissible concentrations of pollutants for water bodies of municipal use ($MPC_{municip}$).

Table 1. The value of an integrated environmental index to determine the class and category of water pollution

Class	I	II		III		IV	V
Category	**1**	**2**	**3**	**4**	**5**	**6**	**7**
IEI	0,2	0,3– 1,0	1,1–2,0	2,1–4,0	4,1–6,0	6,1–10,0	>10,0

Environmental assessment of the water quality of the Mokra Sura river within the Dnipropetrovsk region was based on the calculation the integrated environmental index (IEI).

Geomorphological assessment of the water network of the Morka Sura river was performed using satellite radar interferometry. Multispectral images of Landsat 5/TM (2007-2011) and Sentinel 2B/MSI (2017) satellite systems were used for remote assessment of water bodies in the study area of the Mokra Sura river basin. The multispectral index TCW (Tasseled Cap Wetness) (Crist, 1985) was used to measure the spectral reflection of the aquatic environment along of the Mokra Sura river flow.

Results and discussion. Two terrain elevation maps were acquired to extract the branch of the hydro-network and the features of the land cover in the Mokra Sura river basin (Fig 1 a, b).

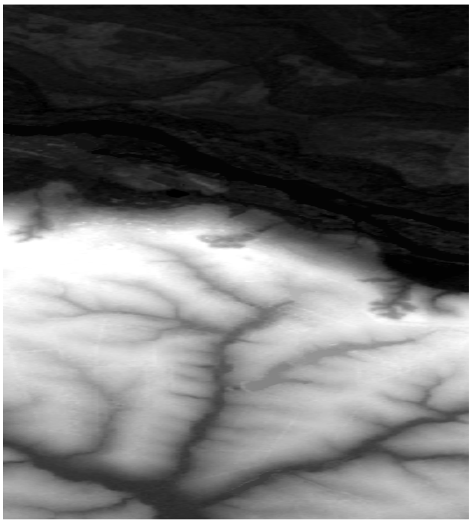

Fig. 1. Changes in terrain elevation in the basin of the Mokra Sura river by Sentinel-1A/InSAR data processing
a) Digital terrain elevation map of the hydrographic network in the area of the river;
b) terrain elevation changes during 2015.04 – 2017.05

Terrain elevation maps was created using the radar interferometry (Stankevich et al, 2017) by combining the two pairs of Sentinel-1A images for the April 2015 and May 2017 time spans. The dynamics of terrain elevation for this period of the study area are described by table 2 data.

The data on terrain elevation change are shown in the table 1. Two classes of essential changing were fixed (code 4 and 6). The data obtained reflect the three years process of eluvia-diluvium soil deposits transfer caused with wind and water erosion. About 90% of the total area of farmland are plowed and used for cereals (wheat, barley, corn, oats), forages and technical crops (sunflower and rape) cultivation. Lower slopes and bottoms of the ravines are used for haymaking and grazing.

Table 2. Terrain elevation changes inside the Mokra Sura river basin

Color code	Class	Terrain elevation change, m	Percent of area
	Unclassified	no data	0.000
	Very Strong Down	< –0.6	0.001
	Strong Down	–0.6 .. –0.3	0.200
	Moderate Down	–0.3 .. –0.15	2.408
	Weak Down	–0.15 .. –0.05	16.267
	No Change	–0.05 .. 0.05	64.292
	Low Rise	0.05 .. 0.15	14.986
	Medium Rise	0.15 .. 0.3	1.680
	High Rise	0.3 .. 0.6	0.161
	Very High Rise	> 0.6	0.005

The data on terrain elevation change are shown in the table 1. Two classes of essential changing were fixed (code 4 and 6). The data obtained reflect the three years process of eluvia- diluvium soil deposits transfer caused with wind and water erosion. About 90% of the total area of farmland are plowed and used for cereals (wheat, barley, corn, oats), forages and technical crops (sunflower and rape) cultivation. Lower slopes and bottoms of the ravines are used for haymaking and grazing.

Follow the necessity to use water from the Mokra Sura river for irrigation, the level of soil water erosion can only increase and enhance the negative processes of eutrophication of reservoirs. Long term technogenic pollution requires information about the state of surface water of fishery, drinking and municipal water use facilities as an integral part of the aquatic ecosystem, the habitat of aquatic organisms and as a resource of drinking water supply. Based on the values of the maximum excess of the maximum permissible concentrations (MPC) in each of the three blocks of indicators in the controlled areas of the Mokra Sura river for 2007, an integrated environment index (IEI) with respect to the MPC for fishing (I_{e1}) and municipal (I_{e2}) goals (table 3).

Table 3. The value of the integrated environmental index inside the control areas of the Mokra Sura river during 2007

Village	I_{e1} / I_{e2}	**Factor indexes (for *Ie*)**						Class and category of water quality
		I_a		I_b		I_c		
Sursko-Litovske	**4.0** 2.7	**1.6** 7.8	**Ca^{2+}** Mg^{2+}	**1.7** 0.03	**COD*** NO_2^-	**8.1** 0.24	**Fe^{2+}** Cr^{6+}	**III cl, 4 cat** III cl. 4 cat
Bratske	**4.8** 2.6	**3.4** 7.7	**SO_4^{2-}** Mg^{2+}	**1.9** 0.12	**COD** NO_2^-	**9.0** 0.02	**oil** Zn^{2+}	**III cl. 5 cat** III cl. 4 cat
Novomykolayvka	**6.0** 3.0	**4.0** 9.0	**SO_4^{2-}** Mg^{2+}	**1.8** 0.05	**COD** NO_2^-	**12.0** 0.02	**oil** Zn^{2+}	**III cl. 5 cat** III cl. 4 cat
Novooleksandryvka	**13.0** 2.6	**1.5** 7.7	**Ca^{2+}** Mg^{2+}	**3.4** 0.05	**COD** NH_3^-	**34,0** 0.005	**oil** Zn^{2+}	**V cl., 7 cat.** III cl. 4 cat

*Chemical Oxigen Demand

Priority pollutants in this case are oil products and ions SO_4^{2-}, Mg^{2+}, Zn^{2+}, Cr^{6+}. The river water between sampling sites in the Sursko-Litovskoe and Novomykolayvka villages assesses as "dirty" using IEI for fishing. It should be noted that within the limits of water intake in the village of Novooleksandryvka the condition of the water is dirty. Environmental assessment of the quality of the waters of the Mokra Sura river as a water object of municipal and domestic water use is dirty as well. The results of IEI and factor indices calculations for 2011 are given in table 4.

Table 4. The value of the integrated environmental index inside the control areas of the Mokra Sura river during 2011

Village	I_{e1} / I_{e2}	**Factor indexes (for *Ie*)**						Class and category of water quality
		I_a		I_b		I_c		
Sursko-Litovske	**4.5** / 2.3	**3.9** / 7.0	**SO_4^{2-}** / Mg^{2+}	**1.8** / 0.03	**COD** / NO_2^-	**7.8** / 0.01	**oil** / Zn^{2-}	**III cl. 5 cat** / III cl. 4 cat
Bratske	**4.1** / 3.0	**1.7** / 9.0	**Ca^{2+}** / Mg^{2+}	**1.9** / 0.1	**COD** / NO_2^-	**8.6** / 0.01	**oil** / Zn^{2-}	**III cl. 5 cat** / III cl. 4 cat
Novomykolayvka	**4.3** / 2.7	**5.1** / 8.0	**SO_4^{2-}** / Mg^{2+}	**1.9** / 0.09	**COD** / NO_2^-	**6.0** / 0.14	**oil** / Cr(VI)	**III cl. 5 cat** / III cl. 4 cat
Novooleksandryvka	**10.7** / 2.7	**1.5** / 8.0	**Ca^{2+}** / Mg^{2+}	**3.7** / 0.31	**COD** / NH_3^-	**27.0** / 0.001	**oil** / Zn^{2-}	**V cl. 7 cat.** / III cl. 4 cat

Analysis calculations of the integrated ecological index for 2011year in relation to the MPC_{fish} showed the deterioration of the river water near the Sursko-Litovske village. There is the transition in the evaluation of the fourth (contaminated) to the fifth (dirty) category. Priority pollutants in this case are ions of sulphates, magnesium, zinc, chromium and petroleum products. At the same time, the assessment of river water from the point of view of municipal $MPC_{municip}$ has not changed.

The data of the calculations of two types of integrated environmental index for 2007-2011 are shown in figure 2.

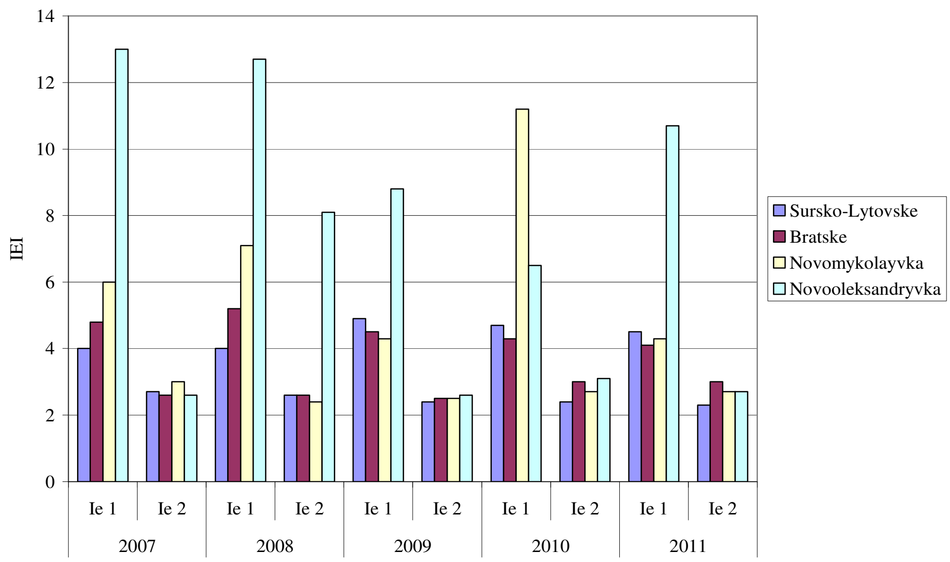

Fig. 2. Hydrecologicalestimation of Mokra Sura river

I_{e1} – IEI forfishing; I_{e2} – household IEI

The analysis of the IEI changing dynamics found a temporary reduction of water pollution near Novooleksandrovka almost 1.5 times. Meantime, at whole, the environmental quality of river water remained at the level of "dirty" and "very polluted".

A time series of Landsat-5 images was built in 2007-2011years to assess the state of the surface waters of the Mokra Sura river by remote sensing. After that, the optimal spline regression between the remote spectral index TCW and two integral indices (I_{e1} and I_{e2}) was constructed on the *in situ* measurements base. Regression dependence between the indices of the TCW, I_{e1} and I_{e2} is shown in Fig.3.

The coefficients of determination of regression between TCW, I_{e1} and I_{e2} are 0.53 and 0.64 accordingly. These indices estimation by the Sentinel-2B/MSI satellite image for 19 September 2017 year (Fig.4) were carried out in order to further forecast the environmental situation with water pollution within the Mokra Sura river basin.

Using the Fig. 3 regressions,the I_{e1} and I_{e2} indices values were restored for all water surfaces within the study area in the Mokra Sura river basin at the same time. The results are shown in Fig.5.

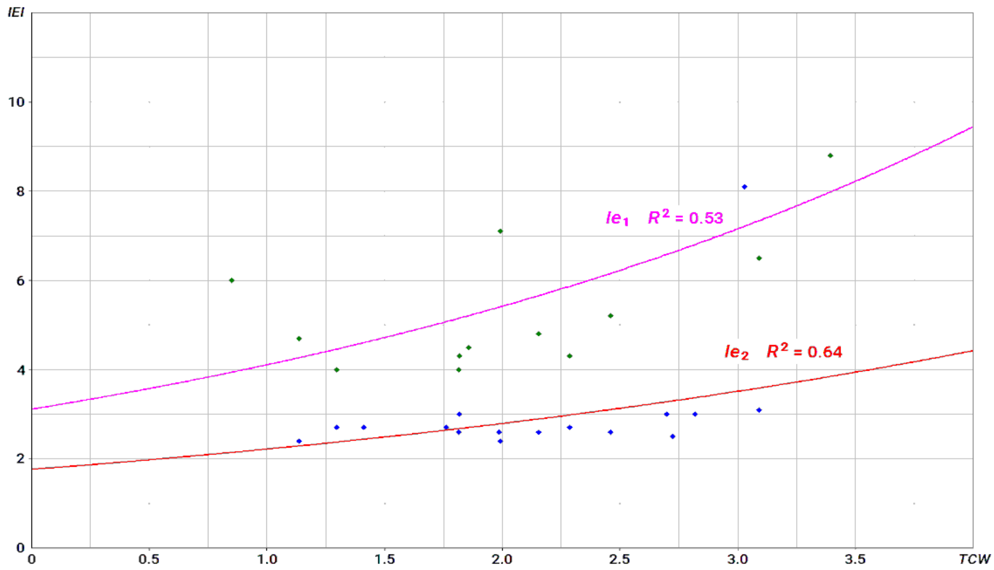

Fig. 3. Regression dependence between the I_{e1}/I_{e2} indices and the TCW

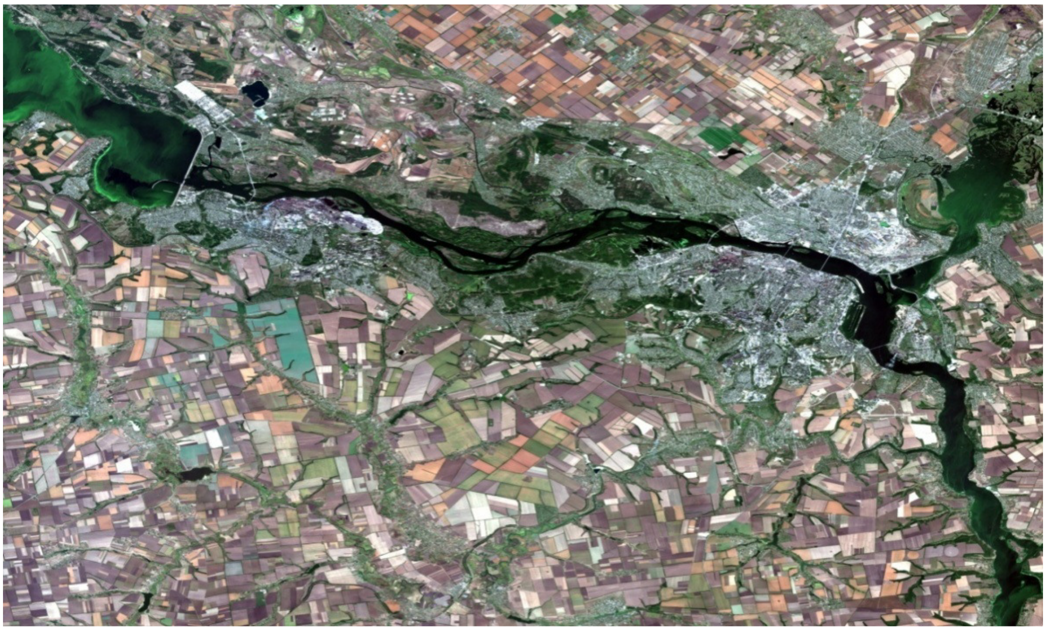

Fig. 4. Sentinel-2B/MSI multispectral satellite image over the Mokra Sura river area for 2017.09.19, 13 spectral bands, 10 m spatial resolution

Using the Fig. 3 regressions, the I_{e1} and I_{e2} indices values were restored for all water surfaces within the study area in the Mokra Sura river basin at the same time. The results are shown in Fig.5.

According to the remote assessment of the Mokra Sura river basin water pollution, calculations of surface water area classes were made using the data of both IEI (Table 5). According to the calculations, the ratio of the corresponding Table 1 categories turns out that at this time from 80 to 90% of Mokra Sura river basin surface (IEI 4-12) belong to the classes with the assessment of dirty, very and extremely dirty.

Conclusion. The studies confirm the possibility of using remote sensing methods for environmental monitoring of the surface water quality state. The regression relationships are consistent with the data of direct measurements at the sampling points and are an effective means of assessing the ecological state of the water bodies. The state of the water bodies of the Mokra Sura river basin varies considerably. The best is the water quality in the upper part of the river Mokra Sura, the worst – in the middle and lower parts, as a result of discharge with industrial enterprises Kamenske and Dniprovske industrial agglomeration not enough treated wastewater. The main advantage of the studies carried out on the example of the Mokra Sura river is the demonstration of the possibilities of operational remote monitoring to making control its environmental condition throughout the flow –

from the source to the mouth. Due to remote sensing procedure it was shown that over 80% of Mokra Sura river basin surface (*IEI* 4-12) belong to the classes with the assessment of dirty, very and extremely dirty.

The results of studies using remote sensing indicate the need to reduce the volume of not fully treated wastewater to the Mokra Sura river. The obtained data can be used for environment assessment of the current and retrospective state of water bodies, development of forecasts of rivers pollution. However, they are pre-oriented and necessarily subject to independent *in-situ* reviews.

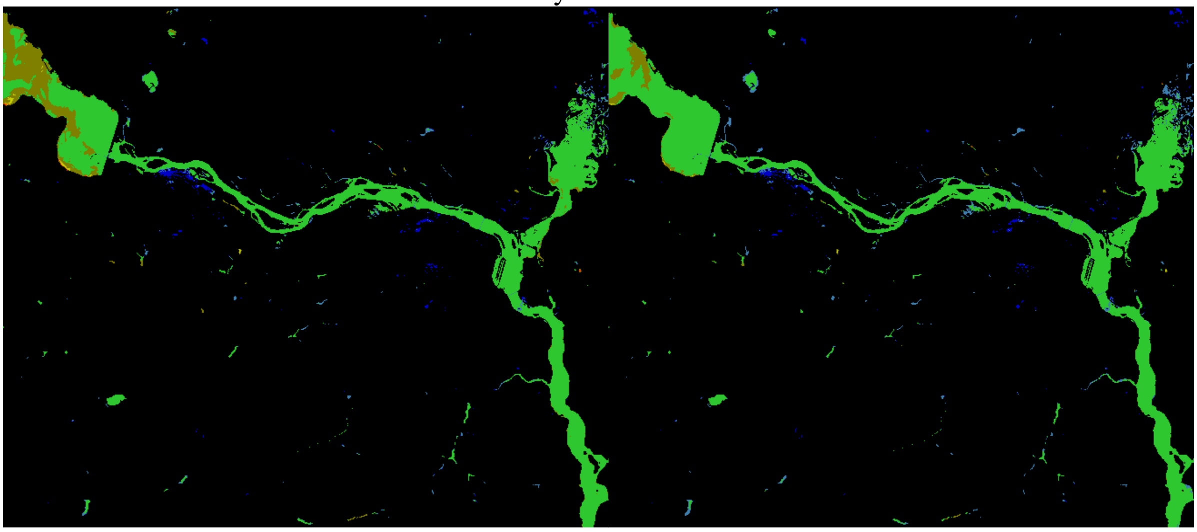

Fig. 5. Water pollution I_{e1} (*a*) and I_{e2} (*b*) indices distributions within the Mokra Sura river basin for 19 September 2017 by multispectral remote sensing

Table 5. The area of the water surface of the Mokra Sura river basin according to the integrated environmental index, %

Color code	I_{e1} Class	I_{e1}, percent of area	I_{e2} Class	I_{e2}, percent of area
	Non-Water (Black)	92.0374	Non-Water (Black)	92.0374
	0 .. 4 (Medium Blue)	0.3956	0 .. 2 (Medium Blue)	0.3463
	4 .. 8 (Steel Blue)	0.6332	2 .. 4 (Steel Blue)	0.8584
	8 .. 12 (Lime Green)	5.7835	4 .. 6 (Lime Green)	6.4100
	12 .. 16 (Olive)	1.0952	6 .. 8 (Olive)	0.3262
	16 .. 20 (Gold)	0.0372	8 .. 10 (Gold)	0.0152
	Over 20 (Orange Red)	0.0179	Over 10 (Orange Red)	0.0065

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