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Monitoring of non-forest peat fires in the Lubny district of Poltava region using remote sensing methods

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SUMMARY

The article highlights the results of a study of non-forest peat fires that occurred during 2024 in the Lubny district of Poltava region, using modern geoinformation approaches and remote sensing (RS) methods. The main goal of the work was to identify active fire centers, determine their spatial location and boundaries, as well as to conduct a detailed analysis of the consequences of fires for the environment, in particular the state of soil and vegetation cover. Sentinel-2 satellite images of the L2A processing level (with atmospheric correction) were used for the study, which allowed obtaining highly accurate information about the dynamics of changes on the surface. Identification of fire sources was carried out based on visual decoding of images in combinations of SWIR and False Color channels, as well as by calculating the vegetation index NDVI and water index NDWI, which made it possible to assess the degree of vegetation degradation and decrease in soil moisture after fires. Particular attention is paid to the spatial and temporal characteristics of fire development - their duration, speed of spread, configuration of burns and impact on wetland ecosystems. The analysis results show that the areas of greatest activity are concentrated in the floodplains of the Uday and Sula rivers and their tributaries, which indicates the natural and geographical determinants of fire spread. The results obtained confirm the high informativeness of satellite images in monitoring peatland fires, allow for the formation of well-founded conclusions regarding the scale of ecological changes caused by fire, and serve as the basis for improving early warning systems. Separately, recommendations are considered for further monitoring of peat fires in the context of climate change and increasing the effectiveness of environmental protection measures.

Keywords: remote sensing of the Earth, peat fires, Sentinel-2, NDVI, NDWI, Lubny district, Poltava region, SWIR, False Color, burns.

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Introduction

Peat fires in the Lubenskyi district in 2024 were identified using operational data from regional news sources, as official statistics were unavailable at the time (Operational information on the main emergencies of a technogenic, natural and other nature in the territory of Poltava region per day, 2024). Based on reported fire locations and dates, relevant satellite images were selected and analyzed in various spectral composites, including NDVI and NDWI. Sentinel-2 imagery, available every 5 days under favorable conditions, enabled detection of fire origins, spread, and impacts. Between August and November 2024, eight out of ten recorded peat fires were identified (Ten peatlands in Poltava region are burning due to grass burning, 2024). Smaller fires (under 1 ha) were not visible, mainly due to their short duration or lack of satellite coverage during the burn period.

Method and Theory

The proposed study used open data from the Sentinel-2_L2A satellite (with atmospheric correction) to study peatland fires and also used as primary materials open satellite data obtained from the archives of the United States Geological Survey (USGS) – Landsat, SRTM and the European Space Agency (ESA) – Sentinel 2 (Lishchenko et al., 2022).

Results

Satellite images clearly demonstrate the effectiveness of remote sensing methods for detecting fires in non-forest peatlands (Mohylnyi et al., 2023). Figure 1 shows a Sentinel-2 image (28.09.2024) near the village of Zarechye in the SWIR combination of channels (B12–B8A–B04), which allows detecting fire sources and assessing vegetation moisture. The ignition source with signs of open fire is clearly visible. Figure 2 shows the consequences of the fire - a scorched area in the form of a dark brown area. Figures 3–4 show a fire on a peatland near the village of Netrativka (Uday River valley), recorded on September 23, 2024 and extinguished on September 30, 2024 on an area of 10 hectares (Peatlands are burning in three settlements of the Lubny district – State Emergency Service, 2024). Satellite images from Copernicus Browser in False color and SWIR (in this image, the dark brown color of the burn contrasts well with the green color of healthy biomass.) combinations were used for the analysis.

Figure. 1. *The beginning of the fire on the peat bog northeast of the village of Zarechye. Sentinel-2_L2A_SWIR satellite image from 28.09.2024*

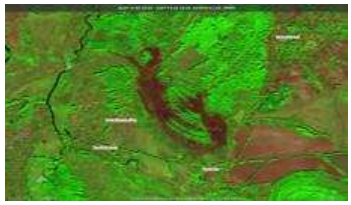

Figure. 2. *Fire on a peatland northeast of the village of Zarechye. Sentinel-2_L2A_SWIR satellite image from 20.10.2024*

Figure 3. *Fire on a peatland near the village of Netratovka. Sentinel-2_L2A_ False_color satellite image from 20.10.2024*

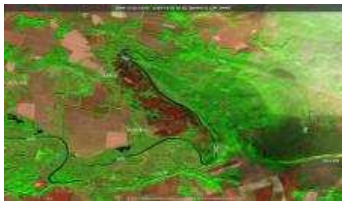

Figure 4. *Fire on a peat bog near the village of Netratovka. Sentinel-2_L2A_ SWIR satellite image from 20.10.2024*

The fire leads to a sharp deterioration in the state of vegetation, which is clearly visible in the NDVI images before (Fig. 5) and after the fire (Fig. 6). Before the fire, the area had high NDVI values (about 1.0, dark green color), after the fire, the index decreased to 0–0.2 (yellowish shades), which indicates a loss of biomass.

The reduction of above-ground vegetation negatively affects the state of the wetland ecosystem, its ability to purify water, retain carbon, and preserve biodiversity. Figure 7 shows the primary fire source, Figure 8 shows a large conflagration in the SWIR composite image. The interval between satellite images is 5 days, indicating a high rate of fire spread. Figures 9-10 show the same thing, but in a custom image viewing setting (B12 + B11 + B8A). Satellite images (Fig. 11-12) show a significant decrease in soil moisture in the burned area near the village of Yerkivtsi. Low NDWI values indicate a lack of moisture and the absence of active vegetation. The contours of the area with low moisture coincide with the boundaries of the burned area. The reasons are evaporation of moisture, deep water penetration and loss of plant capacity to retain it. NDWI recovery is possible only after vegetation cover is restored.

Figure 5. *Area near Netrativka village – before the peatland fire. Sentinel-2_L2A_NDVI satellite image from 28.09.2024*

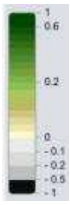

Figure 6. *Area near Netrativka village after peatland fire. Sentinel-2_L2A_NDVI satellite image from 20.10.2024*

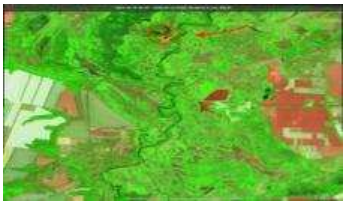

Figure 7. *Primary source of fire in a peat bog near the village of Yerkivtsi. Sentinel-2_L2A_ SWIR satellite image from 15.09.2024*

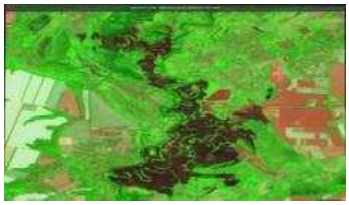

Figure 8. *Fire on a peatland near the village of Yerkivtsi. Sentinel-2_L2A_ SWIR satellite image from 20.09.2024*

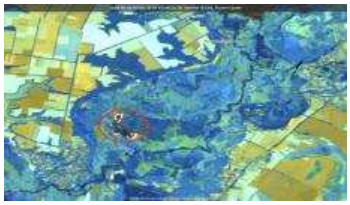

Figure 9. *Primary focus of the fire south of the village of Matskova Luchka Sentinel-2_L2A_Custom_12-11-8A from 28.09.2024*

Figure 10. *Burn from a fire in peatlands south of the village of Matskova Luchka Sentinel-2_L2A_12-11-8A from 10.10.2024*

Figure 11. *NDWI index before the start of the fire in the peat bog near the village of Yerkivtsi. Sentinel-2_L2A_ NDWI satellite image from 15.09.2024*

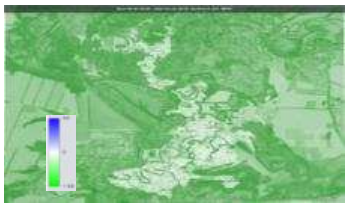

Figure 12. *NDWI index after a fire in a peatland near the village of Yerkivtsi. Sentinel-2_L2A_NDWI satellite image from 20.09.2024*

When investigating peatland fires, it is advisable to use natural-color images. In the case of a large fire with heavy smoke, the ignition source is clearly visible (Fig. 13). The direction of smoke in the wind can indicate the possible spread of the fire, and its density and shape can indicate the intensity of the burning and the features of the terrain. A large-scale fire that began on September 28, 2024 between the villages of Kolodna

and Matskova Luchka was detected using SWIR images (Fig. 14–15). A comparison of NDVI before and after the fire (Fig. 16–17) shows a significant decrease in soil moisture and loss of vegetation - in the affected areas the index is close to zero, which is manifested by light spots in the image. The fire near the village of Staroavramivka is depicted in SWIR composite images (Fig.18) and NDWI index (Fig. 19). The coincidence of the contours of the burn confirms the effectiveness of NDWI for determining the boundaries of the fire. The decrease in NDVI is illustrated in the control area (Fig. 20) with a graph of its dynamics (Fig. 21).

Figure 13. *The beginning of a peatland fire with visible smoke south of the village of Kolodna. Sentinel-2_L2A_True from September 28, 2024*

Figure 14. *The beginning of the peatland fire south of the village of Kolodnat. Sentinel-2_L2A_SWIR from 28.09.2024*

Figure 15. *Burnt peatland fire from the village of Kolodna to the village of Matskowa Luchka. Sentinel-2_L2A_SWIR from 23.10.2024*

Figure 16. *The beginning of the peatland fire near the village of Kolodna. Sentinel-2_L2A_NDVI from 28.09.2024*

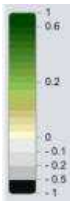

Figure 17. *Burn from a peatland fire near the village of Kolodna. Sentinel-2_L2A_NDVI from 23.10.2024*

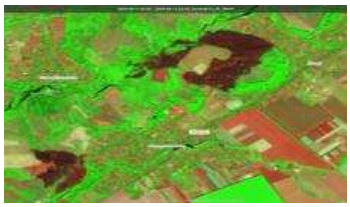

Figure 18. *Burnt area from a fire in a peat bog near the village of Staroavramivka. Sentinel-2_L2A_SWIR satellite image from 15.09.2024*

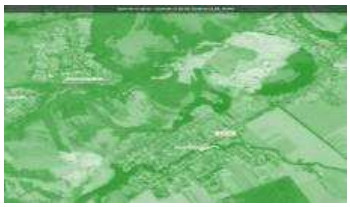

Figure 19. *Peatland fire near the village of Staroavramivka. Sentinel-2_L2A_NDWI satellite image from 20.09.2024 clearly demonstrates the decrease in the humidity index within the burn area*

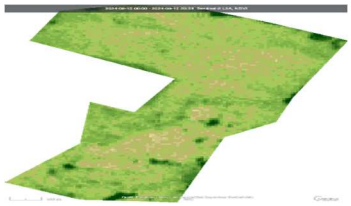

Figure 20. *Control area within the burn area east of the village of Staroavramivka, in the NDVI index image from 15.09.2024*

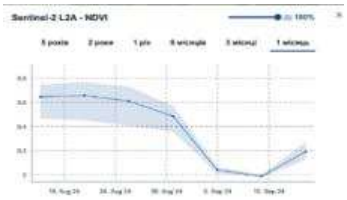

Figure 21. *Graph of the dynamics of the NDVI index during the month (August-September 2024) in the control area east of the village of Staroavramivka*

The rate of vegetation recovery depends on the extent of topsoil damage, organic matter loss, and changes in microclimatic conditions. Long-term monitoring using satellite data is necessary to assess the effectiveness of natural recovery or reclamation measures. In addition to the previously mentioned peat fire cases, fires near the village of Butivtsi, which began on August 17, 2024, and near the village of Lomaki, which started on September 10, 2024 (In the Lubny region, rescuers continue to fight peatland fires, 2024), were visualized in satellite images using the SWIR composite (Fig. 22–23).

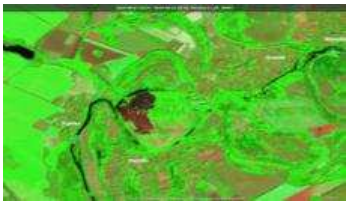

Figure 22. *Peatland fire southwest of the village of Butivtsi. Sentinel-2_L2A_SWIR satellite image from 20.08.2024*

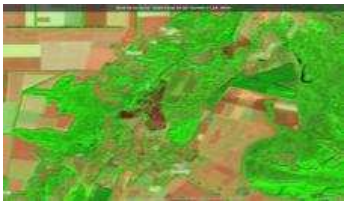

Figure 23. *Peat field fire north of the village of Lomaki. Sentinel-2_L2A_SWIR satellite image from 20.09.2024*

Conclusions

Thus, a study of fires in non-forest peatlands of the Lubny district using remote sensing data has established that the intensity of these phenomena largely depends on climate change and anthropogenic impact. An increase in average air temperature leads to an increase in the frequency and scale of fires. Analysis of satellite imagery shows that the main fire areas are confined to river floodplains and low-lying areas. Viewing the imagery in False color and SWIR composites helped identify burned areas and determine the area. The use of NDVI and NDWI indices allowed us to assess the impact of fires on vegetation and soil moisture. The results confirm the need to use remote sensing methods in the study and prevention of fires in non-forest peatlands.

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