REMOTE SENSING IN THE ASSESSMENT OF ECOLOGICAL AND ECONOMIC DAMAGES FROM OIL POLLUTION

Antonina S. Gordienko
Siberian State University of Geosystems and Technologies, 10, Plakhotnogo St., Novosibirsk, 630108, Russia, Ph. D., Associate Professor, Department of Photogrammetry and Remote Sensing, phone: (383)361-08-66, e-mail: a.s.gordienko@sgugit.ru

Ekaterina N. Kulik
Siberian State University of Geosystems and Technologies, 10, Plakhotnogo St., Novosibirsk, 630108, Russia, Ph. D., Associate Professor, Department of Photogrammetry and Remote Sensing, phone: (383)361-01-59, e-mail: e.n.kulik@sgugit.ru

The article presents the relevance of the issue of using remote sensing data in assessing environmental and economic damage from oil pollution. It describes the main approaches and methods of environmental and economic assessment of damage. It gives their advantages and disadvantages of the methods. It discusses the results of the study. The article also proposes the main factors influencing the economic and ecological consequences associated with environmental pollution by oil spills. It carries out the analysis of the capabilities of remote sensing data to determine the presented factors. And It proposes the directions of further research on the development of methods for determining the types and scales of oil pollution based on aerospace survey data, adapted for different natural-territorial complexes.

Keywords: results of oil spills, remote sensing data, environmental damage, economic damage, negative impact, oil pollution, radar images, multispectral images

REFERENCES

1. Apulu, O. G., Engeribo, T., & Engeribo, A. W. (2017). The impact of mining production on the environment. *Ekonomika i predprinimatel'stvo [Economy and Entrepreneurship]*, 7(84), 33–36 [in Russian].

2. Medvedeva, O., & Solovieva S. (2016). Methodology for the cost assessment of damage caused by atmospheric air pollution. *Voprosy otsenki [Assessment Questions]*, 4(86), 2–6 [in Russian].

3. Porfiryev, B. N., & Makarova E. A. (2014). Economic assessment of damage from natural disasters and catastrophes. *Vestnik Rossiyskoy akademii nauk [Bulletin of the Russian Academy of Sciences]*, *84*(12), 1059–1072 [in Russian].

4. Apulu, O. G. (2017). Reclamation of oil-contaminated lands in Nigeria. *Nauka i mir. Mezhdunarodnyy nauchnyy zhurnal [Science and World. International Scientific Journal]*, Vol. *1*, No. 2(42), 96–100 [in Russian].

5. Vitukhin, A. D., & Tulupov A. S. (2016). Information and analytical system of methodological support for assessing harm from violation of environmental legislation. In *Sbornik materialov V Mezhdunarodnogo Foruma "Rossiya v XXI veke: global'nye vyzovy i perspektivy razvitiya" [Proceedings of V International Forum "Russia in the XXI Century: Global Challenges and Development Prospects"]* (pp. 267–274). Moscow [in Russian].

6. Umnov, V. A., & Ebrahimi A. T. (2017). Analysis of ecological and economic risks at enterprises of the oil and gas sector of the economy. In *Sbornik statey Mezhdunarodnoy nauchnoy konferentsii "Aktual'nye problemy gosudarstvennogo i munitsipal'nogo upravleniya". IV Speranskie chteniya [Proceedings of International Scientific Conferences "Actual Problems of State and Municipal Management". IV Speranskie Readings]* (pp. 194–199). Moscow: Russian State University for the Humanities [in Russian].

7. Marzialetti, P., & Laneve, G. (2016). Oil spill monitoring on water surfaces by radar L, C and X band SAR imagery: A comparison of relevant characteristics. In *Proceedings of the 2015 IEEE*

International Geoscience and Remote Sensing Symposium (IGARSS), 10–15 July (pp. 7715–7717). Beijing, China.

8. Liu, P., Zhao, C., Li, X., He, M., & Pichel, W. (2010). Identification of ocean oil spills in SAR imagery based on fuzzy logic algorithm. *International Journal of Remote Sensing*, *31*, 4819 – 4833.

9. Minchew, B., Jones, C. E., & Holt, B. (2012). Polarimetric analysis of backscatter from the Deepwater Horizon oil spill using L-band synthetic aperture radar. *IEEE Transaction on Geoscience and Remote Sensing*, *50*, 3812–3830.

10. Nunziata, F., Buono, A., & Migliaccio, M. (2016). A new look at the old sea oil slick observation problem: Opportunities and pitfalls of SAR polarimetry. In *Proceedings of the 2015 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), 10–15 July* (pp. 4027–4030). Beijing, China.

11. Collins, M. J., Denbina, M., Minchew, B., Jones, C. E., & Holt, B. (2015). On the Use of Simulated Airborne Compact Polarimetric SAR for Characterizing Oil-Water Mixing of the Deepwater Horizon Oil Spill. *IEEE Journal of Selected Topics Applied Earth Observations and Remote Sensing*, *8*, 1062–1077.

12. Guo, H., Wu, D., & An, J. (2017). Discrimination of Oil Slicks and Lookalikes in Polarimetric SAR Images using CNN. *Sensors*, *17*, 1837 p.

13. Chen, G., Li, Y., Sun, G., & Zhang, Y. (2017). Application of Deep Networks to Oil Spill Detection Using Polarimetric SAR Images. *Applied Sciences*, *7*, 968 p.

14. Khanna, S., Santos, M. J., Ustin, D. S. L., Koltunov, A., Kokaly, R. F., & Roberts, D. A. (2013). Detection of salt marsh vegetation stress after the Deepwater Horizon BP oil spill along the shoreline of gulf of Mexico using AVIRIS data. *PLoS ONE*, *8*, e78989.

15. Noomen, M., Smith, K. L., Colls, J. J., Stevens, M. D., Skidmore, A. K., & van der Meer, F. D. (2008). Hyperspectral indices for detecting changes in canopy reflectance as a result of underground natural gas leakage. *International Journal of Remote Sensing*, *29*(20), 5987–6008.

16. Hester, M. W., & Mendelssohn, I. A. (2000). Long-term recovery of a Louisiana brackish marsh plant community from oil-spill impact: Vegetation response and mitigating effects of marsh surface elevation. *Marine Environmental Research*, *49*, 233–254.

17. Khanna, S., Santos, M., Koltunov, A., Shapiro, K., Lay, M., & Ustin, S. (2017). Marsh Loss Due to Cumulative Impacts of Hurricane Isaac and the Deepwater Horizon Oil Spill in Louisiana. *Remote Sensing*, *9*, 169 p.

18. Tokareva, O. S., & Klimentiev, D. S. (2010). Assessment of the consequences of oil spills based on the data of remote sensing of the Earth. In *Sbornik materialov Interekspo GEO-Sibir'-2010: T. 4 [Proceedings of Interexpo GEO-Siberia-2010: Vol. 4]* (pp. 130–133). Novosibirsk: SSGA Publ. [in Russian].

19. Alekseeva, M. N., & Yashchenko, I. G. (2013). Using space images and geodata for assessing environmental risks in case of oil spills. In *Sbornik materialov SIBBEZOPASNOST''-SPASSIB-2013: Sovershenstvovanie sistemy upravleniya, predotvrashcheniya i dempfirovaniya posledstviy chrezvychaynykh situatsiy regionov i problemy bezopasnosti zhiznedeyatel'nosti naseleniya [Proceedings of SIBBEZOPASNOST-SPASSIB-2013: Improvement of the System of Management, Prevention and Damping of the Consequences of Emergency Situations in the Regions and Problems of Life Safety of the Population]* (pp. 3–7). Novosibirsk: SSGA Publ. [in Russian].

20. Efimova, M. V., Strikh, N. I., & Kurbanov, V. Sh. (2011). Impact of the oil and gas complex on the ecosystems of the Khanty-Mansiysk Autonomous Okrug-Yugra. *Regional'nye geosistemy [Regional Geosystems]*, Vol. *14*, No. 3-1(98), 110–114 [in Russian].

21. Yashchenko, I. G., & Peremitina, T. O. (2015). Monitoring of the ecological state of oil-producing territories of Western Siberia using remote sensing data. In *Sbornik materialov Interekspo GEO-Sibir'-2015: Mezhdunarodnoy nauchnoy konferentsii: T. 1. Distantsionnye metody zondirovaniya Zemli i fotogrammetriya, monitoring okruzhayushchey sredy, geoekologiya [Proceedings of Interexpo GEO-Siberia-2015: International Scientific Conference: Vol. 1. Remote Sensing Methods*

and Photogrammetry, Environmental Monitoring, Geoecology] (pp. 89–93). Novosibirsk: SSUGT Publ. [in Russian].

22. Razakova, M. G. (2017). Identification and mapping of oil pollution of soils using remote sensing data. *Problemy informatiki [Problems of Informatics]*, 4(37), 4–15 [in Russian].

23. Kuskov, A. P. (2017). Application of Earth Remote Sensing Data in Inventory of Oil-Contaminated Lands. *Nauka, tekhnika i obrazovanie [Science, Technology and Education]*, 7(37), 111–115 [in Russian].

24. Leifer, I., Lehr, B., Simecek-Beatty, D., Bradley, E., Clark, R., Dennison, P., Hu, Y.; Matheson, S., Jones, C., Holt, B., & et al. (2012). State of the art satellite and airborne oil spill remote sensing: Application to the BP DeepWater Horizon oil spill. *Remote Sensing of Environment*, *124*, 185–209.

25. Iler, A. L., & Hamilton, P. D. (2015). Detecting oil on water using polarimetric imaging. *Proceedings of SPIE – The International Society for Optical Engineering*, 9459 p.

26. Shen, H.-Y., Zhou, P.-C., & Feng, S.-R. (2011). Research on multi-angle near infrared spectral-polarimetric characteristic for polluted water by spilled oil. *Proceedings of SPIE – The International Society for Optical Engineering*, 8193 p.

27. Chenault, D. B., Vaden, J. P., Mitchell, D. A., & Demicco, E. D. (2016). Infrared polarimetric sensing of oil on water. *Proceedings of SPIE – The International Society for Optical Engineering*, 9999 p.

28. Pinel, N., Monnier, G., Sergievskaya, I., & Bourlier, C. (2015). Simulation of infrared emissivity and reflectivity of oil films on sea surfaces. *Proceedings of SPIE – The International Society for Optical Engineering*, 9638 p.

29. Shih, W.-C., & Andrews, A. B. (2008). Infrared contrast of crude-oil-covered water surfaces. *Optics Letters*, *33*, 3019 – 3021.

30. Kokaly, R. F., Couvillion, B. R., Holloway, J. M., Roberts, D. A., Ustin, S. L., Peterson, S. H., Khanna, S., & Piazza, S. C. (2013). Spectroscopic remote sensing of the distribution and persistence of oil from the Deepwater Horizon spill in Barataria Bay marshes. *Remote Sensing of Environment*, *129*, 210–230.

31. Sicot, G., Lennon, M., Miegebielle, V., & Dubucq, D. (2014). Analysis of the reflectance spectra of oil emulsion spilled on the sea surface. *Proceedings of SPIE – The International Society for Optical Engineering*, 9240 p.

32. Yin, D., Huang, X., Qian, W., Huang, X., Li, Y., & Feng, Q. (2010). Airborne validation of a new-style ultraviolet push-broom camera for ocean oil spill pollution surveillance. *Proceedings of SPIE – The International Society for Optical Engineering*, 7825 p.

33. Fingas, M., & Brown, C. (2018). Review of oil spill remote sensing. *Marine Pollution Bulletin*, *18*, 9–23.

34. Zhukov, D. V. (2016). Spectral signs for identification of typical pollution of sea water areas according to aerial and space survey data. *Optika atmosfery i okeana [Optics of the Atmosphere and Ocean]*, 29(07), 560–565 [in Russian].

Received 13.01.2021