VISUAL OBSERVATION TO DETECT MACROPLASTIC OBJECT IN RIVER: A REVIEW OF CURRENT KNOWLEDGE

Nani Anggraini[*], Irfan Tawakkal[2], Djusdil Akrim[3], Indriyani Rachman[1,4], Toru Matsumoto[1,5]

[1]Graduate Programs in Environmental Systems, The University of Kitakyushu, Japan
[2]Department of Urban and Regional Planning, Universitas Hasanuddin, Indonesia
[3]Department of Environmental Engineering, Universitas Bosowa, Indonesia
[4]Department of Natural Science Education, Universitas Pakuan Bogor, Indonesia
[5]Research Center for Urban Energy Management, The University of Kitakyushu, Japan

Abstract

Currently, the world is facing the problem of plastic pollution in water bodies. Plastic waste has become an abundant pollutant in the marine, coastal and river environments, making it a major threat to aquatic life. Visual Observation in plastic monitoring is a popular method used to measure quantity, composition, and distribution, identify emerging trends, and design preventive measures or mitigation strategies. This study attempts to review recent studies regarding visual observation for detecting macroplastic objects in terms of current research trends and methodologies and suggests promising future research directions. This study used a systematic method with a bibliometric approach and qualitative content analysis to identify and review 108 articles on detecting litter objects in the water. The study results show that automatic object detection is starting to become a trend in visual Observation by relying on artificial intelligence (AI) with UAV devices and cameras that are processed using Machine Learning and Deep Learning methods which provide promising accuracy results.

Keywords: *macroplastic, visual observation, object detection, water bodies, river*

Introduction

The issue of plastic pollution is currently a public concern (Miles-Board, n.d.), and the world is facing the problem of plastic pollution in water bodies. Plastics have become the dominant material in the consumer market, annual production of plastics of 460 million tonnes in 2019 (Ritchie & Roser, 2022). Recently, the use of single-use plastics has been increasing (Andrady & Neal, 2009), (Geyer et al., 2017), (Anggraini et al., 2021). Plastic waste has become a redundant pollutant in the marine, coastal and river environments, making it a major threat to aquatic life. Plastic production is expected to continue to increase and is directly proportional to environmental pollution (Lebreton & Andrady, 2019) and disturbing human life (Muis et al., 2021). In studying plastics in water, the scientific community pays more attention to microplastics, even though macroplastics are an important source of secondary microplastics due to degradation/fragmentation processes (Gewert et al., 2017). Recently, several scientists have started to develop studies on macroplastics in water bodies. Visual observation in macroplastic monitoring is a popular method used to measure quantity, composition, and distribution, identify emerging trends, and design preventive measures or mitigation strategies.

[*])Corresponding Author:
E-mail: nani.anggraini@universitasbosowa.ac.id

Received: 16 January 2024
Revised : 27 February 2024
Accepted: 16 March 2024
DOI: 10.23969/jcbeem.v8i1.12254

In addition, this method can automatically predict a new class of images from floating macroplastic objects with very high accuracy. Given the large volume of macro-plastic waste disposal, intelligent systems must take over the complex task of localizing floating plastic waste instead of relying on manual and time-consuming methods. The process of detecting macroplastic objects can be done automatically. There have been some studies using machine learning and deep learning methods that can provide a high level of accuracy. Deep learning is used extensively for automatic object detection and classification. This method can detect floating and riverbank plastic (Martin et al., 2018). Applying deep learning methods in the context of floating waste research can help create faster and more accurate waste detection and classification tools (LeCun et al., 2015).

The purpose of this study was to find out the development of research related to the topic "Visual Observation to Detect Macroplastic Objects in Waterbodies" in terms of the distribution of bibliometric maps and research/publication trends in the Scopus database using VOSviewer software. Bibliometrics is considered effective in providing useful datasets for researchers, policymakers, and other stakeholders to improve research quality (Nandiyanto et al., 2020), see research gaps, and see trends in future research directions. The distribution of the bibliometric map can consist of the topic areas studied, the type of publication, the journal where it was published, the researcher's country of origin, the method used, and the language used.

Research Methodology

Data Collection and selection criteria

This study uses VOSviewer to generate robust co-occurrence and co-citation analyses. VOSviewer is software for data mining, mapping, and grouping articles retrieved from database sources (Xie et al., 2020). Science mapping has been used to visualize recent developments and gaps in the research area (Chen, 2017).

All articles analyzed in this study were taken from the Scopus database, where Scopus is one of the complete peer-reviewed journal databases and can provide good scientific, and academic information (Klapka & Slaby, 2018) with a good filtering system. The analysis activity in this study begins with identifying papers that strongly correlate with the study material (identification stage). Then, article data and citations from the Scopus database, accessed 4–5 July 2022, were selected based on the following criteria: (1) Four words, including "waste", "plastic", "detection", and "river" are used interchangeably for extract article metadata from the database, and (2) articles published from 2014 to 2023 in English (2,892 documents). At the screening stage, each article's title and abstract were reviewed to align with the research and check the availability of the full text in the database (317 documents). Microplastic is the most researched item excluded from the criteria, and health risks, biota, and unrelated keywords are excluded.

Figure 1. Method stages.

Approximately 108 documents were selected for substantial assessment at the feasibility stage. In this phase, papers that present weak methodology and limited relevance are excluded. Finally, 40 documents were selected for data analysis.

Data Analysis

The 40 selected articles were downloaded in *.ris format and processed using VOSviewer software. Furthermore, VOSviewer is used to visualize and analyze trends in the form of bibliometric maps (Van Eck & Waltman, 2010), (Nur et al., 2020). VOSviewer can create publication maps or journal maps based on networks (co-citation) or keyword maps based on shared networks (Nur et al., 2020) and co-author networks. Keyword frequency can be set as desired, and less relevant keywords can be removed. In bibliographical metadata, "keywords" represent words that carry important scientific information paper is usually used for indexing purposes (Ramadan et al., 2022). In mapping, the VOSviewer results are getting thicker links the stronger the relationship between terms. That visualization and network overlay was then analyzed qualitatively.

Results and Discussion

Visualization topic using VOSviewer

The analysis in this study used VOSviewer, and then 4 clusters were formed with different colors, namely red, green, blue, and yellow, which showed the relationship between one topic and another. From VOSviewer, people can view the bibliometric mapping with various visualizations consisting of network visualization (**Figure 2**) and overlay visualization (**Figure 3**). Furthermore, keywords are labeled with colored circles with circle sizes positively correlated with the occurrence of keywords in titles and abstracts. Furthermore, the size of the letters and circles is determined by the frequency of their appearance, where the more often the keywords appear, the larger the size of the letters and vice versa.

Based on the Vosviewer mapping results, it can be seen that "plastic waste" is the most common theme, with the largest circle on the map forming a network connected to various other keywords. In **Figure 2**, the clusters in each topic area were studied. The keywords "Object Detection", "Machine Learning", "Deep Learning", and "River" are in the same cluster as the red area; this shows that there is a close relationship between them. In addition, keywords such as "Macroplastic", "Unmanned Aerial Vehicle", and "Aerial Survey" are in the same cluster (green area).

Furthermore, **Figure 3** shows the trend from year to year related to this research; this shows that the new trend in detecting waste objects uses AI more than conventional methods, which are time-consuming and labour-intensive. The trend of detecting plastic waste objects in rivers using machine learning and deep learning methods or system learning has been used in recent studies, shown on the trend map in yellow. Artificial intelligence appears and is widely developed in the waste management industry, which has undergone a significant transformation (Fang et al., 2023) towards good efficiency.

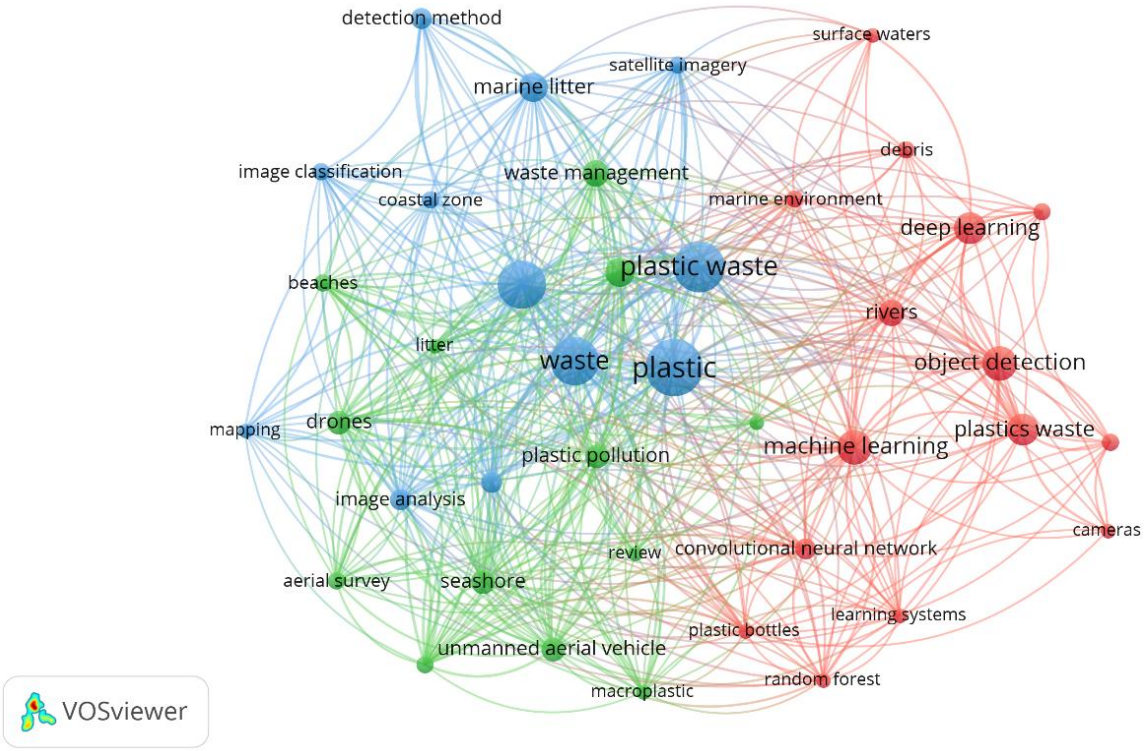

Figure 2. Visualization topic area using VOSviewer using network visualization.

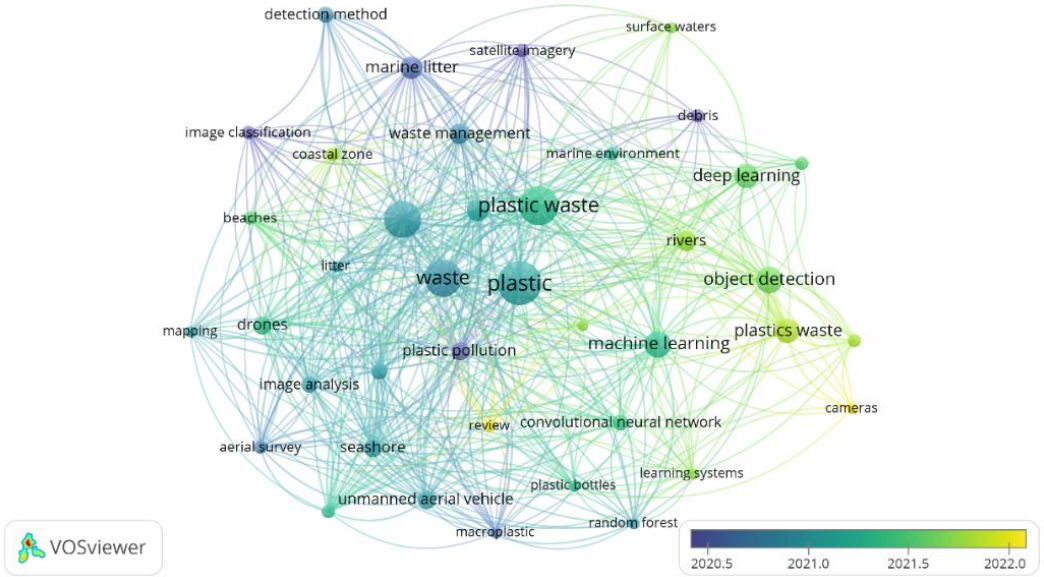

Figure 3. Visualization topic area using VOSviewer using overlay visualization.

Visualization of Macroplastic Topic

In several studies on plastic waste, macroplastic has become a topic of discussion, as shown in **Figure 4** in the VOSviewer mapping. A survey device in the form of a UAV (Unmanned Aerial Vehicle) or drone for aerial surveys has been used. UAVs offer promising new possibilities for monitoring river plastic (Geraeds et al., 2019) which could cover larger and more remote survey areas. The image processing analysis

method uses Machine Learning, Deep Learning (CNN/Conventional neural network) with research locations in river and sea environments and coastlines. The river discussed is a large main river, and no one has conducted research on densely populated urban rivers/channels which are smaller in size than the main river.

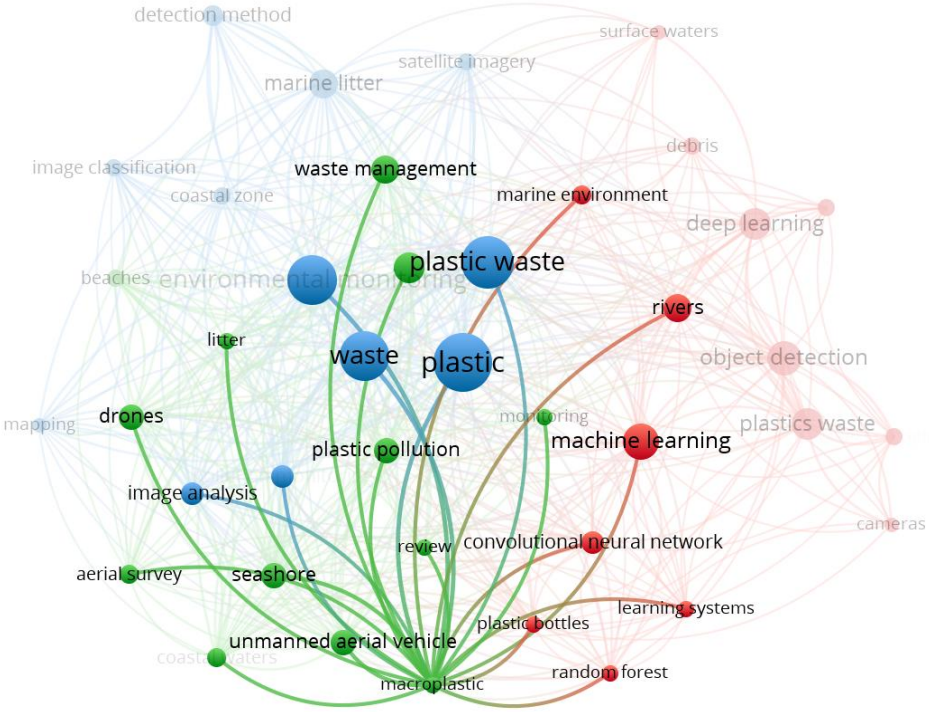

Figure 4. Visualization of Macroplastic" topic using network visualization.

Some researchers who use UAVs as survey devices are Martin et al. (Martin et al., 2018) who conducted a study on the beach, Geraeds et al. (Geraeds et al., 2019) conducted a study on the main river; and Fallati et al. (Fallati et al., 2019), beach area studies. It is still rare to find research sites in narrow urban canals and urban rivers, especially in the Southeast Asia region, which allegedly has a lot of macroplastic waste pollution. It takes challenges to fly UAVs automatically in dense areas and requires further study of UAV protocols in dense areas.

Visualization of Object Detection Topic

Object detection is a technique for identifying or finding objects in images or videos. Detection of macroplastic waste objects in rivers is used to determine the presence of macroplastic waste, the amount, type, and even density distribution. Based on the VOSviewer mapping, information is obtained that the survey device used in object detection is a camera, with the research location being seas and rivers. The research object has yet to examine macroplastics in general. However, the keywords plastic bottles are already available, as shown in the network map in **Figure 5**.

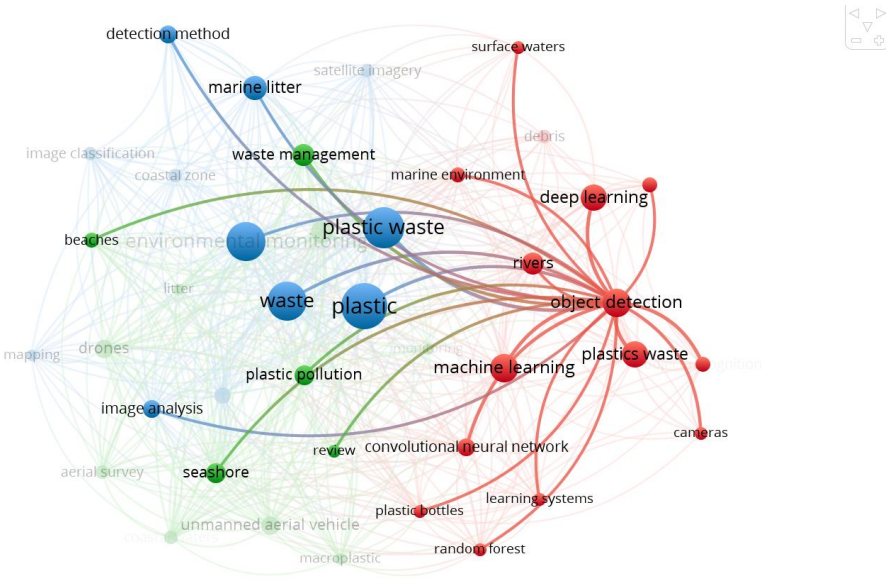

Figure 5. Visualization of "Object Detection" topic using network visualization.

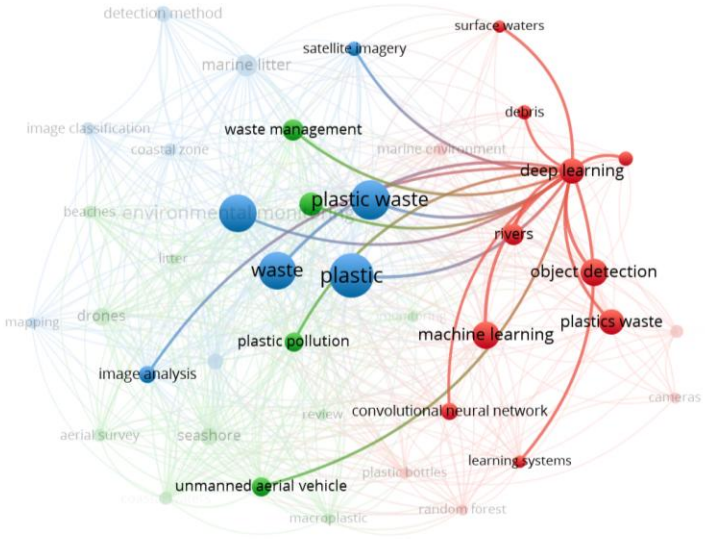

Figure 6. Visualization of "Deep Learning" topic using network visualization.

Visualization of Deep Learning Topic

Deep learning is an AI method that uses computers to process data in ways inspired by the human brain (Soori et al., 2023). Deep learning models can recognize complex patterns in images and other data to generate accurate insights and predictions (LeCun et al., 2015). In VOSviewer mapping **Figure 6**, it is known that Deep Learning generally uses a survey tool in the form of a UAV/drone to perform image analysis with the location of detecting plastic waste in the river. The type of Deep Learning used is CNN or Conventional Neural Networks. There is an object detection study using small boat-mounted video cameras. This study can detect the presence of plastic using an object detection algorithm with an accuracy of 95.2% (Armitage et al., 2022).

The "Train & Consumption Model" is the most challenging part of the automated object

detection process. This process was usually done in Python, but now ArcGIS Pro has developed new tools to do deep learning workflows from start to finish through ArcGIS Pro, which has been used in the agriculture and transport field. It does not rule out being used in detecting floating garbage objects, which has never been done by many scientists before.

The trend of using AI in object detection is very reasonable in the current era of advances in science and technology and is still being developed with better accuracy to provide convenience compared to conventional methods.

Visualization of Author using density visualization

Another general search via Google Scholar was carried out, and 271 documents related to the research topic were obtained after the screening process. Then the pdf file of the journal is imported into the Zotero application. Then the file is exported as a *RIS file. Files in the form of *RIS are then mapped into VOSviewer to see the "Author" mapping, and the results can be seen in **Figure 7**. It is found that Tim Van Emmerik is the author who has written the most and cited paper with the topic of plastic waste in waters, especially rivers.

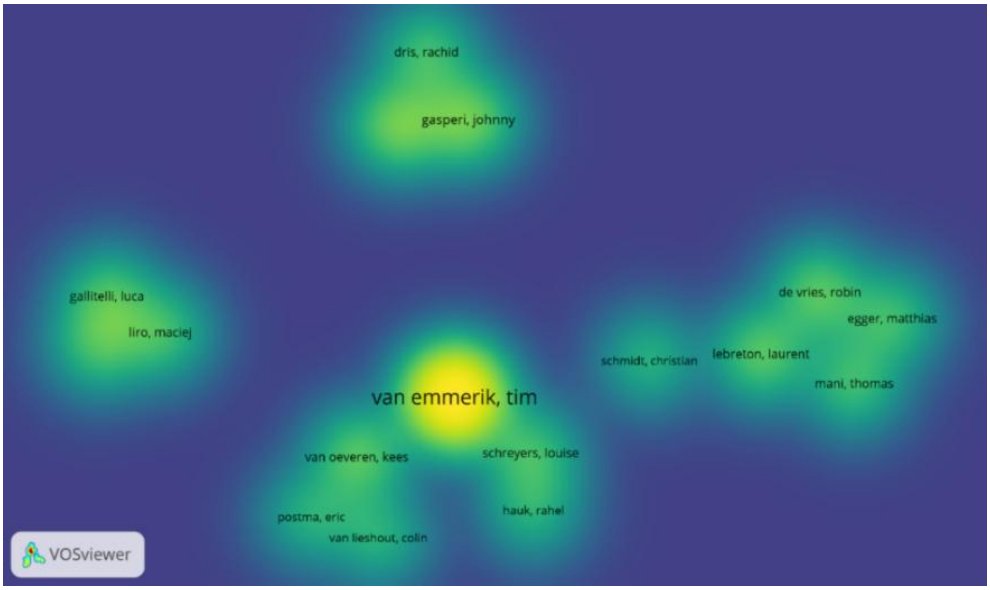

Figure 7. Visualization of Author using density visualization.

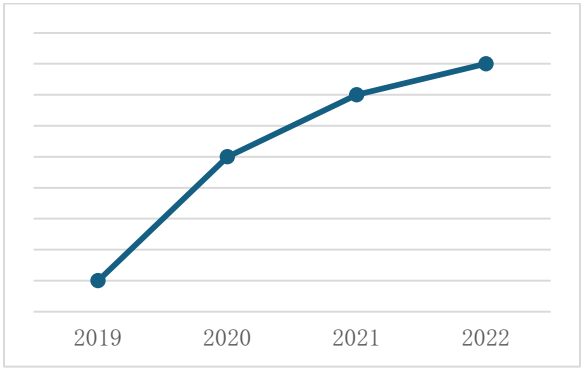

Figure 8. The **t**rend of articles.

On June 20, 2023, another search was carried out on scopus.com by entering the same keywords as before, but the data was limited to only four years (2019-2022), and the results obtained 23 documents that were closely related to the topic. The trend shows an increasing graph in the last four years, so it can be concluded that this topic is quite promising to be discussed in future journals by filling in existing research gaps because AI will continue to develop.

Conclusions

Through visual Observation, this study analyzes qualitative content to identify and review 108 articles related to macroplastic detection in waters. Based on the distribution of bibliometric maps obtained from the Scopus database and processed in the VOSviewer software, information is obtained that research related to the topic "Visual Observations for Detecting Macroplastic Objects in Fresh Water Bodies" is currently a trend for automatic detection with AI. The devices used are UAVs and cameras processed using Machine Learning and Deep Learning methods. Developments in the last four years (2019-2022) have shown a positive trend, so it is quite promising to continue to be studied in the future by taking advantage of the existing gaps.

Acknowledgment

Our thanks and appreciation to the Matsumoto Laboratory, Graduate Programs in Environmental Systems, Graduate School of Environmental Engineering, The University of Kitakyushu, Japan for support so that this research can be carried out. We also Do not forget to thank all those who have given support the implementation of this research.

References

A. B. D. Nandiyanto, M. K. Biddinika, and F. Triawan, "How bibliographic dataset portrays decreasing number of scientific publication from Indonesia," *Indones. J. Sci. Technol.*, vol. 5, no. 1, pp. 154–175, Feb. 2020, doi: 10.17509/ijost.v5i1.22265.

A. L. Andrady and M. A. Neal, "Applications and societal benefits of plastics," *Philos. Trans. R. Soc. B Biol. Sci.*, vol. 364, no. 1526, pp. 1977–1984, Jul. 2009, doi: 10.1098/rstb.2008.0304.

B. Fang *et al.*, "Artificial intelligence for waste management in smart cities: a review," *Environ. Chem. Lett.*, vol. 21, no. 4, pp. 1959–1989, Aug. 2023, doi: 10.1007/s10311-023-01604-3.

B. Gewert, M. Ogonowski, A. Barth, and M. MacLeod, "Abundance and composition of near surface microplastics and plastic debris in the Stockholm Archipelago, Baltic Sea," *Mar. Pollut. Bull.*, vol. 120, no. 1–2, pp. 292–302, Jul. 2017, doi: 10.1016/j.marpolbul.2017.04.062.

B. S. Ramadan, I. Rachman, N. Ikhlas, S. B. Kurniawan, M. F. Miftahadi, and T. Matsumoto, "A comprehensive review of domestic-open waste burning: recent trends, methodology comparison, and factors assessment," *J. Mater. Cycles Waste Manag.*, vol. 24, no. 5, pp. 1633–1647, Sep. 2022, doi: 10.1007/s10163-022-01430-9.

C. Chen, "Science Mapping: A Systematic Review of the Literature," *J. Data Inf. Sci.*, vol. 2, no. 2, pp. 1–40, Mar. 2017, doi: 10.1515/jdis-2017-0006.

C. Martin, S. Parkes, Q. Zhang, X. Zhang, M. F. McCabe, and C. M. Duarte, "Use of unmanned aerial vehicles for efficient beach litter monitoring," *Mar. Pollut. Bull.*, vol. 131, pp. 662–673, Jun. 2018, doi: 10.1016/j.marpolbul.2018.04.045.

H. Ritchie and M. Roser, "Plastic Pollution," *Plastic Pollution*, 2022. https://ourworldindata.org/plastic-pollution

L. Fallati, A. Polidori, C. Salvatore, L. Saponari, A. Savini, and P. Galli, "Anthropogenic Marine Debris assessment with Unmanned Aerial Vehicle imagery and deep learning: A case study along the beaches of the Republic of Maldives," *Sci. Total Environ.*, vol. 693, p. 133581, Nov. 2019, doi: 10.1016/j.scitotenv.2019.133581.

L. Lebreton and A. Andrady, "Future scenarios of global plastic waste generation and disposal," *Palgrave Commun.*, vol. 5, no. 1, p. 6, Jan. 2019, doi: 10.1057/s41599-018-0212-7.

L. Xie, Z. Chen, H. Wang, C. Zheng, and J. Jiang, "Bibliometric and Visualized Analysis of Scientific Publications on Atlantoaxial Spine Surgery Based on Web of Science and VOSviewer," *World Neurosurg.*, vol. 137, pp. 435-442.e4, May 2020, doi: 10.1016/j.wneu.2020.01.171.

M. Geraeds, T. Van Emmerik, R. De Vries, and M. S. Bin Ab Razak, "Riverine Plastic Litter Monitoring Using Unmanned Aerial Vehicles (UAVs)," *Remote Sens.*, vol. 11, no. 17, p. 2045, Aug. 2019, doi: 10.3390/rs11172045.

M. Nur, I. Hamidah*, A. Permanasari, A. Gafar, I. Rachman, and T. Matsumoto, "Low Carbon Education: A Review and Bibliometric Analysis," *Eur. J. Educ. Res.*, vol. 9, no. 1, pp. 319–329, Jan. 2020, doi: 10.12973/eu-jer.9.1.319.

M. Soori, B. Arezoo, and R. Dastres, "Artificial intelligence, machine learning and deep learning in advanced robotics, a review," *Cogn. Robot.*, vol. 3, pp. 54–70, 2023, doi: 10.1016/j.cogr.2023.04.001.

N. Anggraini, R. Muis, F. Ariani, S. Yunus, and . S., "Model of Solid Waste Management (SWM) in Coastal Slum Settlement: Evidence for Makassar City," *Nat. Environ. Pollut. Technol.*, vol. 20, no. 2, Jun. 2021, doi: 10.46488/NEPT.2021.v20i02.002.

N. J. Van Eck and L. Waltman, "Software survey: VOSviewer, a computer program for bibliometric mapping," *Scientometrics*, vol. 84, no. 2, pp. 523–538, Aug. 2010, doi: 10.1007/s11192-009-0146-3.

O. Klapka and A. Slaby, "Visual Analysis of Search Results in Scopus Database," in *Digital Libraries for Open Knowledge*, E. Méndez, F. Crestani, C. Ribeiro, G. David, and J. C. Lopes, Eds., in Lecture Notes in Computer Science, vol. 11057. Cham: Springer International Publishing, 2018, pp. 340–343. doi: 10.1007/978-3-030-00066-0_36.

R. Geyer, J. R. Jambeck, and K. L. Law, "Production, use, and fate of all plastics ever made," *Sci. Adv.*, vol. 3, no. 7, p. e1700782, Jul. 2017, doi: 10.1126/sciadv.1700782.

R. Muis, N. Anggraini, F. Ariani, S. Yunus, and . Z., "Survey of Environmental Baseline in the Nunukan Agriculture Area, Indonesia," *Nat. Environ. Pollut. Technol.*, vol. 20, no. 1, pp. 237–242, Mar. 2021, doi: 10.46488/NEPT.2021.v20i01.025.

S. Armitage, K. Awty-Carroll, D. Clewley, and V. Martinez-Vicente, "Detection and

Classification of Floating Plastic Litter Using a Vessel-Mounted Video Camera and Deep Learning," *Remote Sens.*, vol. 14, no. 14, p. 3425, Jul. 2022, doi: 10.3390/rs14143425.

T. Miles-Board, "From people to reefs: marine debris and plastic pollution in North Queensland".

Y. LeCun, Y. Bengio, and G. Hinton, "Deep learning," *Nature*, vol. 521, no. 7553, pp. 436–444, May 2015, doi: 10.1038/nature14539.