

**Tampilaj OJS** Bukti Korespondensi pada Indonesian  
Journal Of Geography

## Archive

[ACTIVE](#) [ARCHIVE](#)

ID	MM-DD SUBMIT	SEC	AUTHORS	TITLE	STATUS
40519	11-05	ART	Faizal, Werorilangi, Samad	SPECTRAL CHARACTERISTICS OF PLASTIC DEBRIS IN THE BEACH...	Vol 52, No 1 (2020): Indonesian Journal of Geography

### JOURNAL CONTENT

Search

Search Scope

All

Search

Browse

- By Issue
- By Author
- By Title

## #40519 Summary

[SUMMARY](#) [REVIEW](#) [EDITING](#)

### Submission

Authors	Ahmad Faizal, Shinta Werorilangi, Wasir Samad
Title	Spectral Characteristics of Plastic Debris in the Beach: Case Study of Makassar Coastal Area
Original file	40519-107824-1-SM.DOC: 2018-11-05
Supp. files	40519-141822-1-SR.PDF: 2019-09-03 40519-141823-1-SR.PDF: 2019-09-03
Submitter	Mr Ahmad Faizal
Date submitted	November 5, 2019 - 10:48 AM
Section	Research Articles
Editor	Pramaditya Wicaksono
Author comments	The manuscript has been layout according to the article template provided
Abstract Views	2539

### Status

Status	Published Vol 52, No 1 (2020): Indonesian Journal of Geography
Initiated	2020-04-28
Last modified	2020-04-29

### JOURNAL CONTENT

Search

Search Scope

All

Search

Browse

- By Issue
- By Author
- By Title
- Other Journals

### USER

You are logged in as...

faizal79

- My Journals
- My Profile
- Log Out

### LINK

Menu

- Home
- About
- User Home
- Search
- Current
- Archives
- Announcements
- Statistics
- Indexing & Abstracting
- Author Guidelines
- Contact

Home > User > Author > Submissions > #40519 > Review

## #40519 Review

[SUMMARY](#) [REVIEW](#) [EDITING](#)

### Submission

Authors Ahmad Faizal, Shinta Werorilangi, Wasir Samad

Title Spectral Characteristics of Plastic Debris in the Beach: Case Study of Makassar Coastal Area

Section Research Articles

Editor Pramaditya Wicaksono

### Peer Review

#### Round 1

Review Version 40519-107831-2-RV.DOC 2018-11-28

Initiated 2018-11-28

Last modified 2019-01-03

Uploaded file Reviewer A 40519-112003-1-RV.DOC 2018-12-08

### Editor Decision

Decision Accept Submission 2020-03-05

Notify Editor Editor/Author Email Record 2020-03-05

Editor Version 40519-110666-1-ED.DOC 2018-11-28  
40519-110666-2-ED.DOCX 2020-03-05  
40519-110666-3-ED.DOCX 2020-03-05

Author Version 40519-119685-1-ED.DOC 2019-02-14 DELETE  
40519-119685-2-ED.DOCX 2019-03-27 DELETE  
40519-119685-3-ED.DOCX 2019-06-16 DELETE  
40519-119685-4-ED.DOCX 2019-09-03 DELETE  
40519-119685-5-ED.DOCX 2019-10-25 DELETE  
40519-119685-6-ED.DOCX 2020-01-19 DELETE  
40519-119685-7-ED.DOCX 2020-01-19 DELETE  
40519-119685-8-ED.DOCX 2020-03-04 DELETE

Upload Author Version  No file chosen

Accredited Journal, Based on Decree of the Minister of Research, Technology and Higher Education, Republic of Indonesia Number 30/E/KPT/2018, Vol 50 No 1 the Year 2018 - Vol 54 No 2 the Year 2022

ISSN 2354-9114 (online), ISSN 0024-9621 (print)

IJG STATISTIC

#### JOURNAL CONTENT

Search

Search Scope

All

Browse

- ▶ By Issue
- ▶ By Author
- ▶ By Title
- ▶ Other Journals

#### USER

You are logged in as...  
**faizal79**

- ▶ My Journals
- ▶ My Profile
- ▶ Log Out

#### LINK

- Author Fees
- Copyright Transfer Form
- Cover Letter
- Editorial Board
- Focus & Scope
- Journal History
- Online Submission
- Order Journal
- Publication Ethics
- Peer Reviewers
- Statement of Originality
- Screening For Plagiarism
- Visitor Statistics

#### TEMPLATE



Article

SUBMIT ARTIKEL

Tanggal 05-11-2018

NAMA FILE :

[40519-107824-1-SM.DOC](#)

# Spectral Characteristics of Plastic Debris in the Beach: Case Study of Makassar Coastal Water

Ahmad Faizal, Shinta Werorilangi, Wasir Samad

Departement of Marine Sciences, Faculty of Marine Sciences and Fishery, Hasanuddin University, Indonesia

ahmad.faizal@unhas.ac.id

**Abstract** Plastic debris becomes a global problem that threatens the coastal ecosystems, and the supralittoral area (beach) turns to be a place for plastic debris to accumulate. Data from the United Nation (UN) states that Indonesia is the second plastic debris contributor in world waters. This study aimed to examine the spectral characteristics of plastic debris accumulated in the beach. The data was collected from the coast of Makassar at 3 different stations: Jenneberang River estuary, Losari Beach and Tallo River estuary. The spectral sample was measured using a 4000 A spectroradiometer that works on a wavelength spectrum 340 - 1040 nm. The results showed that the spectral characteristics of the plastic debris in the beach had a spectral reflectance pattern with optimum value at the wavelength of 500-700 nm and the wavelength of 400-600 nm were used to identified the object using.

**Key words:** plastic debris, wavelenght, spectral

**Abstrak** Sampah plastik menjadi masalah global yang mengancam kondisi ekosistem pesisir, dan daerah supralittoral (pantai) menjadi tempat penumpukan sampah plastik. Data United Nation (UN) menyebutkan bahwa Indonesia menjadi penyumbang sampah plastik nomer dua di perairan dunia. Penelitian ini bertujuan untuk mengkaji karakteristik spektral dari sampah plastik yang terakumulasi di daerah pantai. Data dikoleksi dari pesisir pantai makassar pada 3 stasiun yang berbeda yaitu di muara Sungai Jenneberang, Pantai Losari dan Muara Sungai Tallo. Spektral sampel diukur dengan menggunakan spektrodiodometer 4000 A yang bekerja pada spektrum panjang gelombang 340 – 1040 nm. Hasil penelitian menunjukkan bahwa karakteritik spektral sampah plastik pada daerah pantai memiliki pola pantulan spektral dengan nilai optimum pada panjang gelombang 500 -700 nm dan indentifikasi obyek dengan memanfaatkan panjang gelombang 400-600 nm.

**Kata kunci :** Sampah plastik, Panjang Gelombang, spektral

## 1. Introduction

Marine debris is now a global problem that has affected all water bodies, especially the water surface in coastal areas. Its influence visibly shows towards the economy, ecology, public health, and environmental aesthetics. Marine debris pollution is no longer a regional problem but has scaled up into a global or international problem. Marine debris, especially plastic in waters, has transformed into agents that potentially bring pathogens to

1 human's health. Whilst microplastics that are largely invisible to humans and can accumulate in the food chain  
2 (Driedger et al., 2013).

3 Some time ago, it was estimated that around 10% of debris has been discharged into the waters (Van  
4 Cauwenberghe et al., 2013) Generally, marine debris with various forms (such as plastic, metal, wood, clothing,  
5 etc.) accumulates in coastal areas (NOAA, 2015). The main sources of debris in the waters are from recreational  
6 activities, wind or storm, illegal dumping, sewage treatment plants, and fishing industry (Driedger et al., 2013).

7 In 2010, it was predicted that around 4.8 to 12.7 million metric tons of plastic debris had entered the ocean, and  
8 this is equivalent to approximately between 4,762,000,000 - 12,700,000,000 kg from 192 countries and Indonesia  
9 is the second contributor to the sea debris after China. According to Jambeck et al. (2015) Indonesia contributed  
10 plastic debris to the sea by 1.29 million tons/year after China by 3.53 million tons/year in 2010 (Jambeck et al.,  
11 2015). With regards to this condition, plastic debris pollution will add to a very large environmental and socio-  
12 economic problems in Indonesian waters (Driedger et al., 2013).

13 Marine debris, especially plastic debris in the waters, due to hydro-oceanographic influences were stranded and  
14 accumulated in the beach including in the coastal city of Makassar (Maulana, 2016). Identification of marine  
15 debris has been carried out using traditional survey methods (Driedger et al., 2013) including in South Sulawesi  
16 (Maulana, 2016). Another alternative that might be used is to employ the remote sensing method (Driedger et  
17 al., 2013; Hörig et al., 2001; Pichel et al., 2007). This second alternative enables relatively cheaper cost and faster  
18 time. The study of remote sensing of plastic debris in coastal areas was still experimental. However, several  
19 researchers have tried to monitor marine debris in various parts of the world (Aoyama, 2014; Jambeck et al.,  
20 2015; Mace, 2012; Veenstra & Churnside, 2012). This study aimed to examine spectral characteristics of the  
21 plastic debris in the beach and will be used as a reference for identifying plastic debris in coastal areas using  
22 satellite imagery.

23

## 24 **2. The Methods**

25 This research was carried out in coastal areas, especially in the beach of Makassar City, South Sulawesi Province,  
26 at three stations with adequately different characteristics (Figure 1.). The sample analysis was done at the Marine  
27 Ecology Laboratory, Marine Sciences Department, Hasanuddin University and the Remote Sensing and Ecology  
28 Laboratory Seameo BIOTROP, Bogor.



1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16

Figure 1. Makassar Coastal Water; Study area and sampling station

The spectral identification of plastic debris in the beach refers to the method used by Murphy et al. (2018) and its development with the implementation stages as follows:

a) *Sample collection*: sample collection was conducted in the beach of the coast of Makassar City, at three stations; Station 1 around the Jenneberang River Estuary, Station 2 around Losari beach and Station 3 around the Tallo River Estuary up to the Paotere port. Furthermore, sorting of the collected sample was held in the Marine Ecology Laboratory, Marine Science Department with 10 plastic debris samples, with different characteristics.

b) *Sample Measurement*: The spectral value of the sample was measured using the Ocean Optics USB 4000 type spectrometer which works on a wavelength 340-1110 nm (nanometer). The spectral retrieval process involves spectrometers, light sources, optical fibers, and computers. One spectroradiometer part is connected to the light source and the other part is connected to the object being measured (Figure 2). The position of the light source does not directly face the sun but forms an angle of approximately 45° and 100 millisecond scanning time (Halma, 2008)



17  
18

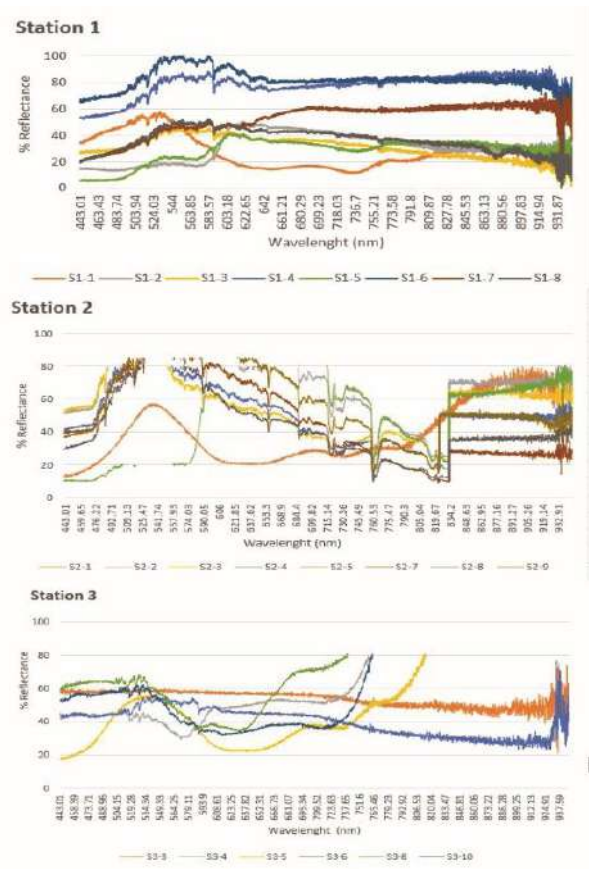
Figure2. Measurement of spectral values of samples.

1 3) *Recording Reflectance Values*: Replay values from samples are recorded using a computer equipped with  
 2 software spectra suites.  
 3 Data analysis used numeric data processing devices - MS Excel. The measurement data was classified by  
 4 eliminating error values and cutting off visible and near-infrared light waves. Furthermore, the data was made  
 5 into graphical form with smoothing graphs and compared with spectral reflectance curves from sand or soil.  
 6 (Hook, 2018)

7

8 **3. Result and Discussion**

9 Spectral measurement results of each sample at each station are presented in Figure 3. The spectral reflectance  
 10 curve of each sample shows the same reflectance pattern on each wavelength spectrum. Figure 3 shows a  
 11 tendency of an increase in spectral reflectance curves for each station. At station 1 there is an increase in spectral  
 12 curves at wavelengths of 500-625 nanometers (nm), at station 2 the tendency of the increase of spectral curves  
 13 occurs at wavelengths of 470-600 nm and at station 3 the tendency of the increase spectral curves happens at  
 14 wavelengths of 450-570 nm. The graph in Figure 3 shows the difference of the amount of data, this is due to  
 15 noise that occurred when the recording started so the spectral reflectance curve is smaller than 0%, the value is  
 16 eventually selected and considered as error data and not employed.



17

18

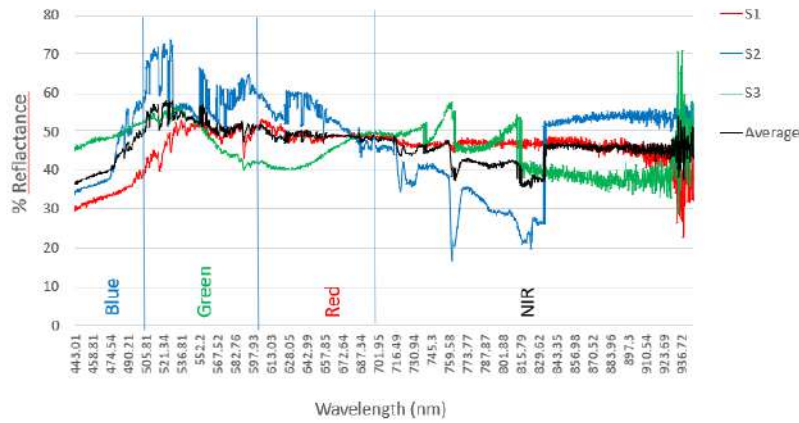
Figure3. Spectral Reflectance Curve of plastic debris for each sample at all stations.

19

20

The difference in the spectral characteristics of plastic debris at each station is shown in Figure 4. The characteristics of each station are obtained from the average spectral reflectance value of each sample at each

1 station. The average spectral reflectance value of each station shows the similarity of spectral reflectance  
 2 patterns. The spectral reflectance pattern of each station starts to show an increase in the wavelength of 500 nm  
 3 (blue wavelength) and decreases at a wavelength of 700 nm (red wavelength).



4  
 5 Figure 4. Comparison of Spectral Reflectance Curves for each station with average reflectances and divisions  
 6 based on wavelength.

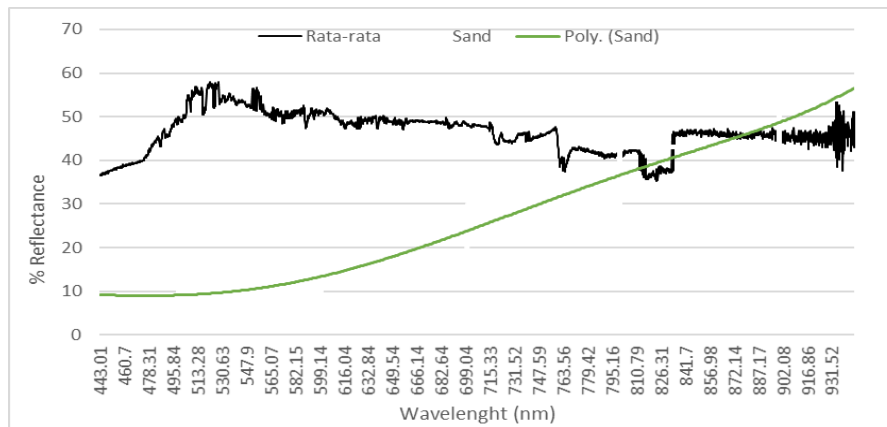
7 Figure 3 denotes the difference in spectral reflectance curves between each sample with the same pattern  
 8 tendency. The difference in spectral reflectance curves of each object is influenced by several factors;  
 9 characteristics of object or sample, the amount of light penetration received by objects (Murphy et al., 2018).  
 10 Plastics found at the study site have different chemical compositions which will give different reflectances,  
 11 plastic debris consists of several types; polyethylene (PE), poly-propylene (PP), polyvinylchloride (PVC), poly-  
 12 amide (nylon) and polystyrene (PS) (Andrady, 2015). Different chemical compositions resulted in different  
 13 spectral reflectance values as well (Imhof et al., 2017). Another factor is because the found samples have been  
 14 degraded and have weathered naturally or partially fragmented into microplastic (GESAMP, 2015; Shah et al.,  
 15 2008; Thevenon F., 2014). In different time and weather conditions, the sunlight's penetration that reaches to the  
 16 earth's surface also varies, the number of wavelengths that reach the earth's surface or the object is affected by  
 17 the amount of scattering and absorption of particles in the atmosphere (Lillesand et al., 2015; Murphy et al.,  
 18 2018).

19 The tendency of reflectance pattern of each sample at every station (Figure 3) is almost the same, this is due to  
 20 similarity of the main chemical component of the plastic (Andrady, 2015). In several hyperspectral studies with  
 21 different objects and similar main components, have similar spectral patterns, such as vegetation (Huete, 1988),  
 22 coral reefs (Hochberg et al., 2003), soil (Lillesand et al., 2015) and others.

23 The spectral reflectance pattern of plastic debris found in the beach at all observation stations (Figure 4) shows  
 24 various spectral values with optimum spectral reflectance values at 500 - 700 nm. Based on wavelengths  
 25 division, that range is at the visible wavelength (400 - 700 nm). In detail, the visible wavelength is divided into 3  
 26 wavelengths; Blue (400 - 500 nm), Green (500 - 600 nm) and Red (600 - 700 nm) (Lillesand et al., 2015), the best  
 27 spectral reflectance is in the green and red wavelengths. In some types of polymers that have high reflectance

1 values at visible wavelengths, the higher the polymer content of the sample, the higher the reflectance value  
2 (Garaba & Dierssen, 2018)).

3 Object identification by using remote sensing data is based on reflectance of the object with the location where  
4 the object is. The research result that we have carried out in the beach with the sand substrate is compiled with  
5 spectral values of sand (Hook, 2018) as presented in Figure 5



6  
7 Figure 5. Comparison of the average value of plastic reflectance with sand reflectance

8 Our research result indicates that identification of plastic debris in the beach is very possible using the  
9 wavelength of 400-600 nm or using the blue and green visible waves. The significant difference in spectral value  
10 between sand as a substrate and plastic debris as an object becomes a reference in object identification.

11

#### 12 4. Conclusion

13 Spectral characteristics of plastic debris in the beach have a spectral reflectance pattern between stations with an  
14 average optimum value at a wavelength of 500-700 nm and Identification of plastic debris in the beach with  
15 hyperspectral technology can be carried out using a wavelength of 400 - 600 nm

16

#### 17 Acknowledgement

18 This research was done with research funding from the Competency-Based Research Scheme (Penelitian  
19 Berbasis Kompetensi) with Contract Number L 1715 / UN4.21 / PL.00.00 / 2018. This research, in addition, was  
20 also carried out with participation of Widodo, Researcher in the Laboratory of Remote Sensing and Ecology,  
21 SEAMEO Biotrop, also Sunarto and Muhammad Ilham from the Faculty of Marine and Fisheries, Hasanuddin  
22 University.

23

#### 24 References

25 Andrady, A. L. (2015). Persistence of plastic litter in the oceans. In M. In: Bergmann, Gutow, L., Klages, M (Ed.),  
26 *Marine Anthropogenic Litter* (pp. 57-22): Springer International Publishing AG Switzerland.  
27 Aoyama, T. (2014). *Monitoring of marine debris in the sea of Japan using multi-spectral satellite images* Paper  
28 presented at the SPIE Asia-Pacific Remote Sensing.  
29 Driedger, H. Durr, K. Mitchel, J. Flannery, E. Brancazi, & Cappelen, P. V. (2013). *Plastic Debris; Remote sensing*  
30 *and characterization*. Canada: University of Waterloo.

- 1 Garaba, S. P., & Dierssen, H. M. (2018). An airborne remote sensing case study of synthetic hydrocarbon  
2 detection using short wave infrared absorption features identified from marine-harvested macro- and  
3 microplastics. *Remote Sensing of Environment*, 205, 224-235.  
4 doi:<https://doi.org/10.1016/j.rse.2017.11.023>
- 5 GESAMP. (2015). *Sources, fate and effects of microplastics in the marine environment: Part two of a global*  
6 *assessment* (P. J. K. a. C. M. Rochman Ed.). 4 Albert Embankment, London SE1 7SR:  
7 INTERNATIONAL MARITIME ORRGANIZATION.
- 8 Halma, C. (2008). USB4000 Fiber Optic Spectrometer: Instalation and Operation Manual. Retrieved from  
9 [www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf](http://www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf)
- 10 Hochberg, E. J., Atkinson, M. J., & Andréfouët, S. (2003). Spectral reflectance of coral reef bottom-types  
11 worldwide and implications for coral reef remote sensing. *Remote Sensing of Environment*, 85(2), 159-  
12 173. doi:[https://doi.org/10.1016/S0034-4257\(02\)00201-8](https://doi.org/10.1016/S0034-4257(02)00201-8)
- 13 Hook, S. J. (2018). ECOSTRESS Spectral Library - Version 1.0 — ECOSTRESS Speclib. Retrieved from  
14 <https://speclib.jpl.nasa.gov/library/ecospeclibinteractive>
- 15 Hörig, B., Kühn, F., Oschütz, F., & Lehmann, F. (2001). HyMap hyperspectral remote sensing to detect  
16 hydrocarbons. *International Journal of Remote Sensing*, 22(8), 1413-1422.  
17 doi:10.1080/01431160120909
- 18 Huete, A. R. (1988). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, 25(3), 295-309.  
19 doi:[https://doi.org/10.1016/0034-4257\(88\)90106-X](https://doi.org/10.1016/0034-4257(88)90106-X)
- 20 Imhof, H. K., Sigl, R., Brauer, E., Feyl, S., Giesemann, P., Klink, S., Leupolz, K., Loder, M.G.J., Löschel, L.A.,  
21 Missun, Jan Muszynski, S., Ramsperger, A.F. R. M., Schrank, I., Speck, S., Steibl, S., Trotter, B., Winter,  
22 I., Laforsch, C. (2017). Spatial and temporal variation of macro-, meso- and microplastic abundance on  
23 a remote coral island of the Maldives, Indian Ocean. *Marine Pollution Bulletin*, 116(1), 340-347.  
24 doi:<https://doi.org/10.1016/j.marpolbul.2017.01.010>
- 25 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., Law, K. L. (2015).  
26 Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771. doi:10.1126/science.1260352
- 27 Lillesand, Ralph W. Kiefer , & Chipman, J. (2015). *Remote Sensing and Image Interpretation*: John Wiley and  
28 Sons.
- 29 Mace, T. H. (2012). At-sea detection of marine debris: Overview of technologies, processes, issues, and options.  
30 *Marine Pollution Bulletin*, 65(1), 23-27. doi:<https://doi.org/10.1016/j.marpolbul.2011.08.042>
- 31 Maulana, F. (2016). *Identifikasi sampah laut di kawasan wisata pantai Kota Makassar*. (Skripsi), Universitas  
32 Hasanuddin, Makassar.
- 33 Murphy, L. G., Peters, S., van Sebille, E., James, N. A., & Gibb, S. (2018). Concept for a hyperspectral remote  
34 sensing algorithm for floating marine macro plastics. *Marine Pollution Bulletin*, 126, 255-262.  
35 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.011>
- 36 NOAA. (2015). *Turning The Tide On Trash. A Learning Guide On Marine Debris*: NOAA PIFSC CRED.
- 37 Pichel, W. G., Churnside, J. H., Veenstra, T. S., Foley, D. G., Friedman, K. S., Brainard, R. E., Nicoll, J.B., Zheng,  
38 Q., Clemente-Colón, P. (2007). Marine debris collects within the North Pacific Subtropical  
39 Convergence Zone. *Marine Pollution Bulletin*, 54(8), 1207-1211.  
40 doi:<https://doi.org/10.1016/j.marpolbul.2007.04.010>
- 41 Shah, A. A., Hasan, F., Hameed, A., & Ahmed, S. (2008). Biological degradation of plastics: A comprehensive  
42 review. *Biotechnology Advances*, 26(3), 246-265. doi:<https://doi.org/10.1016/j.biotechadv.2007.12.005>
- 43 Thevenon F., C. C., Sousa J. (2014). *Plastic Debris in the Ocean. The Characterization of Marine Plastics and*  
44 *their Environmental Impacts. Situation Analysis Report*. Gland, Switzerland: IUCN
- 45 Van Cauwenberghe, L., Claessens, M., Vandegehuchte, M. B., Mees, J., & Janssen, C. R. (2013). Assessment of  
46 marine debris on the Belgian Continental Shelf. *Marine Pollution Bulletin*, 73(1), 161-169.  
47 doi:<https://doi.org/10.1016/j.marpolbul.2013.05.026>
- 48 Veenstra, T. S., & Churnside, J. H. (2012). Airborne sensors for detecting large marine debris at sea. *Marine*  
49 *Pollution Bulletin*, 65(1), 63-68. doi:<https://doi.org/10.1016/j.marpolbul.2010.11.018>

**Bukti Korespondensi 1; Saran Perbaikan  
dari reviewer**

**3 -01-2019**

Editor/Author Correspondence - Google Chrome

journal.ugm.ac.id/ijg/author/viewEditorDecisionComments/40519#27245

Editor/Author Correspondence

Editor  
2019-01-03 10:37 PM

Subject: [IJG] Editor Decision [DELETE](#)

Dear Mr. Ahmad Faizal,

After considering reviewer's comments (see the attached file and the attachment in your OJS account), we have reached the decision to: Accept your manuscript with major revision.

You should improve the quality of your manuscript by revising your manuscript according to reviewer's comments. Please carefully respond to reviewer's comments when submitting the revision and please clearly indicate the changes that you made (or highlight them) to address reviewer's comments. Or, you can directly reply to reviewer's comments in the comments box wrote by the reviewer. You should also use the template attached below. We will not process any revised paper without specific response to each reviewer's comments.

Once again, thank you for submitting your manuscript to the Indonesian Journal of Geography and I look forward to receiving your revision before 15 February 2019. If you failed to meet the deadline, we may have to consider your paper rejected.

NB: Please use the follow the guideline in the attached template for your revision.

Best wishes,  
Dr. Pramaditya Wicaksono  
ID SCOPUS: 54279699900, Faculty of Geography Universitas Gadjah Mada, Yogyakarta  
Phone +6281391179917  
Fax +62274569595  
prama.wicaksono@geo.ugm.ac.id

Section Editor  
Indonesian Journal of Geography  
Faculty of Geography, Universitas Gadjah Mada, Yogyakarta  
-----

Reviewer A:

Authors should not only present the results of their research but also its relevancy to the problem well

## Selengkapnya sebagai berikut

Editor [DELETE](#)

2019-01-03 10:37 PM Subject: [IJG] Editor Decision

Dear Mr. Ahmad Faizal,

After considering reviewer's comments (see the attached file and the attachment in your OJS account), we have reached the decision to: Accept your manuscript with major revision.

You should improve the quality of your manuscript by revising your manuscript according to reviewer's comments. Please carefully respond to reviewer's comments when submitting the revision and please clearly indicate the changes that you made (or highlight them) to address reviewer's comments. Or, you can directly reply to reviewer's comments in the comments box wrote by the reviewer. You should also use the template attached below. We will not process any revised paper without specific response to each reviewer's comments.

Once again, thank you for submitting your manuscript to the Indonesian Journal of Geography and I look forward to receiving your revision before 15 February 2019. If you failed to meet the deadline, we may have to consider your paper rejected.

NB: Please use the follow the guideline in the attached template for your revision.

Best wishes,  
Dr. Pramaditya Wicaksono  
ID SCOPUS: 54279699900, Faculty of Geography Universitas  
Gadjah Mada, Yogyakarta  
Phone +6281391179917  
Fax +62274569595  
prama.wicaksono@geo.ugm.ac.id

Section Editor  
Indonesian Journal of Geography  
Faculty of Geography, Universitas Gadjah Mada, Yogyakarta  
-----

Reviewer A:

Authors should not only present the results of their research but also its relevancy to the problem well-mentioned in the background/introduction section.

It was found that some region of wavelength are good to distinguish plastic debris with sand. Some questions need to be asked and answered, therefore added to the paper:

-So what?

-Is it applicable to wide area plastic debris detection?

-If yes, how?

-If no, why?

-Is there any potential obstacle related to data specification difference? (spectral resolution, spatial resolution)

Pinpoint comments are available in uploaded file.

---

Chief Editor  
Indonesian Journal of Geography  
<http://jurnal.ugm.ac.id/index.php/ijg>  
0024-9521 (print), 2354-9114 (online)  
Phone: +62 812-2711-480

## **Saran Perbaikan dari Reviewer**

Reviewer [40519-112003-1-RV.DOC](#) 2018-12-08

# 1 Spectral Characteristics of Plastic Debris in the Beach: Case Study 2 of Makassar Coastal Water

3  
4 **Abstract** Plastic debris becomes a global problem that threatens the coastal ecosystems, and the supralittoral area (beach)  
5 turns to be a place for plastic debris to accumulate. Data from the United Nation (UN) states that Indonesia is the second  
6 plastic debris contributor in world waters. This study aimed to examine the spectral characteristics of plastic debris  
7 accumulated in the beach. The data was collected from the coast of Makassar at 3 different stations: Jenneberang River  
8 estuary, Losari Beach and Tallo River estuary. The spectral sample was measured using a 4000 A spectroradiometer that  
9 works on a wavelength spectrum 340 - 1040 nm. The results showed that the spectral characteristics of the plastic debris in  
10 the beach had a spectral reflectance pattern with optimum value at the wavelength of 500-700 nm and the wavelength of 400-  
11 600 nm were used to identified the object using.

12  
13 **Key words:** plastic debris, wavelenght, spectral

14  
15 **Abstrak** Sampah plastik menjadi masalah global yang mengancam kondisi ekosistem pesisir, dan daerah supralittoral  
16 (pantai) menjadi tempat penumpukan sampah plastik. Data United Nation (UN) menyebutkan bahwa Indonesia menjadi  
17 penyumbang sampah plastik nomer dua di perairan dunia. Penelitian ini bertujuan untuk mengkaji karakteristik spektral  
18 dari sampah plastik yang terakumulasi di daerah pantai. Data dikoleksi dari pesisir pantai makassar pada 3 stasiun yang  
19 berbeda yaitu di muara Sungai Jenneberang, Pantai Losari dan Muara Sungai Tallo. Spektral sampel diukur dengan  
20 menggunakan spektoradiometer 4000 A yang bekerja pada spektrum panjang gelombang 340 – 1040 nm. Hasil penelitian  
21 menunjukkan bahwa karakteritik spektral sampah plastik pada daerah pantai memiliki pola pantulan spektral dengan nilai  
22 optimum pada panjang gelombang 500 -700 nm dan indentifikasi obyek dengan memanfaatkan panjang gelombang 400-600  
23 nm.

24  
25 **Kata kunci :** Sampah plastik, Panjang Gelombang, spektral

## 26 27 1. Introduction

28 Marine debris is now a global problem that has affected all water bodies, especially the water surface in coastal  
29 areas. Its influence visibly shows towards the economy, ecology, public health, and environmental aesthetics.  
30 Marine debris pollution is no longer a regional problem but has scaled up into a global or international problem.  
31 Marine debris, especially plastic in waters, has transformed into agents that potentially bring pathogens to  
32 human's health. Whilst microplastics that are largely invisible to humans and can accumulate in the food chain  
33 (Driedger et al., 2013).

34 Some time ago, it was estimated that around 10% of debris has been discharged into the waters (Van  
35 Cauwenberghe et al., 2013) Generally, marine debris with various forms (such as plastic, metal, wood, clothing,  
36 etc.) accumulates in coastal areas (NOAA, 2015). The main sources of debris in the waters are from recreational  
37 activities, wind or storm, illegal dumping, sewage treatment plants, and fishing industry (Driedger et al., 2013).

**Commented [A1]:** Please finish the sentence.

**Commented [A2]:** Apparently, plastic debris in the sea are lethal to wildlife and fisheries. Mentioning this issues prior to explaining the cycle until it reaches human would be more appropriate.

1 In 2010, it was predicted that around 4.8 to 12.7 million metric tons of plastic debris had entered the ocean, and  
 2 this is equivalent to approximately between 4,762,000,000 - 12,700,000,000 kg from 192 countries and Indonesia  
 3 is the second contributor to the sea debris after China. According to Jambeck et al. (2015) Indonesia contributed  
 4 plastic debris to the sea by 1.29 million tons/year after China by 3.53 million tons/year in 2010 (Jambeck et al.,  
 5 2015). With regards to this condition, plastic debris pollution will add to a very large environmental and socio-  
 6 economic problems in Indonesian waters (Driedger et al., 2013).  
 7 Marine debris, especially plastic debris in the waters, due to hydro-oceanographic influences were stranded and  
 8 accumulated in the beach including in the coastal city of Makassar (Maulana, 2016). Identification of marine  
 9 debris has been carried out using traditional survey methods (Driedger et al., 2013) including in South Sulawesi  
 10 (Maulana, 2016). Another alternative that might be used is to employ the remote sensing method (Driedger et  
 11 al., 2013; Horig et al., 2001; Pichel et al., 2007). This second alternative enables relatively cheaper cost and faster  
 12 time. The study of remote sensing of plastic debris in coastal areas was still experimental. However, several  
 13 researchers have tried to monitor marine debris in various parts of the world (Aoyama, 2014; Jambeck et al.,  
 14 2015; Mace, 2012; Veenstra & Churnside, 2012). This study aimed to examine spectral characteristics of the  
 15 plastic debris in the beach and will be used as a reference for identifying plastic debris in coastal areas using  
 16 satellite imagery.

17

## 18 2. The Methods

19 This research was carried out in coastal areas, especially in the beach of Makassar City, South Sulawesi Province,  
 20 at three stations with adequately different characteristics (Figure 1.). The sample analysis was done at the Marine  
 21 Ecology Laboratory, Marine Sciences Department, Hasanuddin University and the Remote Sensing and Ecology  
 22 Laboratory Seameo BIOTROP, Bogor.



23

24

Figure 1. Makassar Coastal Water; Study area and sampling station

**Commented [A3]:** Please consider to change the measurement unit into ton

**Commented [A4]:** Providing a brief explanation on how remote sensing data are used to identify coastal-marine debris would be appropriate prior to mentioning objective of the study.

**Commented [A5]:** Brief explanation of each sampling site's characteristics and why it were selected should be provided in this section.

**Commented [A6]:** 1.Referring the map in the above text body is not helping the reader(s) in understanding the characteristics of three sampling sites.

2.It is more appropriate to label the blue area as 'water bodies' rather than 'river' as the sea is also present.

3.Please change the background of lower right map to blue to match two other maps.

4.Pay attention to the color intensity of the symbol in the legend and what was draw on the map as they are different.

1 The spectral identification of plastic debris in the beach refers to the method used by Murphy et al. (2018) and  
2 its development with the implementation stages as follows:

3 a) *Sample collection*: sample collection was conducted in the beach of the coast of Makassar City, at three  
4 stations; Station 1 around the Jenneberang River Estuary, Station 2 around Losari beach and Station 3 around  
5 the Tallo River Estuary up to the Paotere port. Furthermore, sorting of the collected sample was held in the  
6 Marine Ecology Laboratory, Marine Science Department with 10 plastic debris samples, with different  
7 characteristics.

8 b) *Sample Measurement* The spectral value of the sample was measured using the Ocean Optics USB 4000 type  
9 spectrometer which works on a wavelength 340-1110 nm (nanometer). The spectral retrieval process involves  
10 spectrometers, light sources, optical fibers, and computers. One spectroradiometer part is connected to the light  
11 source and the other part is connected to the object being measured (Figure 2). The position of the light source  
12 does not directly face the sun but forms an angle of approximately 45° and 100 millisecond scanning time  
13 (Halma, 2008)

14



15  
16 Figure2. Measurement of spectral values of samples.

17 3) *Recording Reflectance Values* Replay values from samples are recorded using a computer equipped with  
18 software **spectra suites**.

19 Data analysis used numeric data processing devices - **MS** Excel. The measurement data was classified by  
20 eliminating error values and cutting off visible and near-infrared light waves. Furthermore, the data was made  
21 into graphical form with smoothing graphs and compared with spectral reflectance curves from **sand or soil**.  
22 (Hook, 2018)

23

### 24 3. Result and Discussion

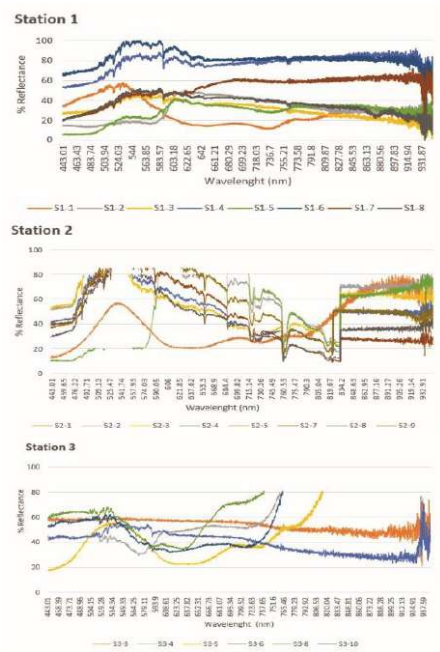
25 Spectral measurement results of each sample at each station are presented in Figure 3. The spectral reflectance  
26 curve of each sample shows the same reflectance pattern on each wavelength spectrum. Figure 3 shows a  
27 tendency of an increase in spectral reflectance curves for each station. At station 1 there is an increase in spectral  
28 curves at wavelengths of 500-625 nanometers (nm), at station 2 the tendency of the increase of spectral curves  
29 occurs at wavelengths of 470-600 nm and at station 3 the tendency of the increase spectral curves happens at  
30 wavelengths of 450-570 nm. The graph in Figure 3 shows the difference of the amount of data, this is due to

**Commented [A7]:** Name should be written in Proper Case.

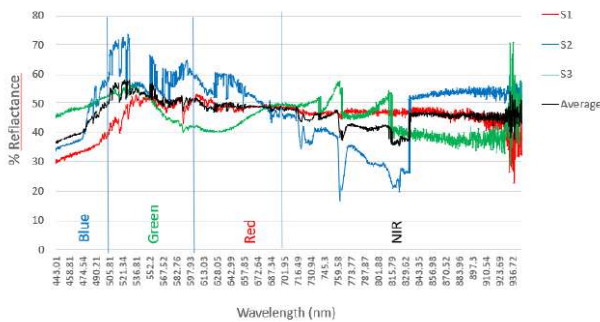
**Commented [A8]:** It is not essential to be mentioned.

**Commented [A9]:** Please explain whether the sand or soil's spectral reflectance are also recorded with the equipment or obtained from existing spectral library.

- 1 noise that occurred when the recording started so the spectral reflectance curve is smaller than 0%, the value is
- 2 eventually selected and considered as error data and not employed.



- 3
- 4 **Figure3. Spectral Reflectance Curve of plastic debris for each sample at all stations.**
- 5 The difference in the spectral characteristics of plastic debris at each station is shown in Figure 4. The
- 6 characteristics of each station are obtained from the average spectral reflectance value of each sample at each
- 7 station. The average spectral reflectance value of each station shows the similarity of spectral reflectance
- 8 patterns. The spectral reflectance pattern of each station starts to show an increase in the wavelength of 500 nm
- 9 (blue wavelength) and decreases at a wavelength of 700 nm (red wavelength).



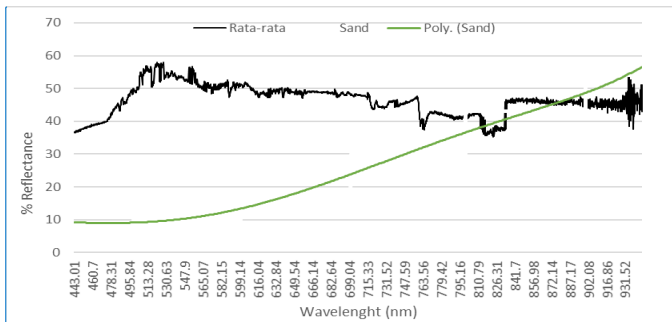
1 Figure 4. Comparison of Spectral Reflectance Curves for each station with average reflectances and divisions  
2 based on wavelength.

3 Figure 3 denotes the difference in spectral reflectance curves between each sample with the same pattern  
4 tendency. The difference in spectral reflectance curves of each object is influenced by several factors;  
5 characteristics of object or sample, the amount of light penetration received by objects (Murphy et al., 2018).  
6 Plastics found at the study site have different chemical compositions which will give different reflectances,  
7 plastic debris consists of several types; polyethylene (PE), poly-propylene (PP), polyvinylchloride (PVC), poly-  
8 amide (nylon) and polystyrene (PS) (Andrady, 2015). Different chemical compositions resulted in different  
9 spectral reflectance values as well (Imhof et al., 2017). Another factor is because the found samples have been  
10 degraded and have weathered naturally or partially fragmented into microplastic (GESAMP, 2015; Shah et al.,  
11 2008; Thevenon F., 2014). In different time and weather conditions, the sunlight's penetration that reaches to the  
12 earth's surface also varies, the number of wavelengths that reach the earth's surface or the object is affected by  
13 the amount of scattering and absorption of particles in the atmosphere (Lillesand et al., 2015; Murphy et al.,  
14 2018).

15 The tendency of reflectance pattern of each sample at every station (Figure 3) is almost the same, this is due to  
16 similarity of the main chemical component of the plastic (Andrady, 2015). In several hyperspectral studies with  
17 different objects and similar main components, have similar spectral patterns, such as vegetation (Huete, 1988),  
18 coral reefs (Hochberg et al., 2003), soil (Lillesand et al., 2015) and others.

19 The spectral reflectance pattern of plastic debris found in the beach at all observation stations (Figure 4) shows  
20 various spectral values with optimum spectral reflectance values at 500 - 700 nm. Based on wavelengths  
21 division, that range is at the visible wavelength (400 - 700 nm). In detail, the visible wavelength is divided into 3  
22 wavelengths; Blue (400 - 500 nm), Green (500 - 600 nm) and Red (600 - 700 nm) (Lillesand et al., 2015), the best  
23 spectral reflectance is in the green and red wavelengths. In some types of polymers that have high reflectance  
24 values at visible wavelengths, the higher the polymer content of the sample, the higher the reflectance value  
25 (Garaba & Dierssen, 2018)).

26 Object identification by using remote sensing data is based on reflectance of the object with the location where  
27 the object is. The research result that we have carried out in the beach with the sand substrate is compiled with  
28 spectral values of sand (Hook, 2018) as presented in Figure 5



29

Commented [A10]: Please consider to change this sentence as it promotes ambiguity.

Commented [A11]: Provide brief explanation of this statement.

Commented [A12]: This sentence has no correlation with its successor sentence. Please change it or provide more details that connect this sentence to the other sentences in the paragraph.

Commented [A13]: Please use english for graphic legends.

1 Figure 5. Comparison of the average value of plastic reflectance with sand reflectance

2 Our research result indicates that identification of plastic debris in the beach is very possible using the  
3 wavelength of 400-600 nm or using the blue and green visible waves. The significant difference in spectral value  
4 between sand as a substrate and plastic debris as an object becomes a reference in object identification.

#### 6 4. Conclusion

7 Spectral characteristics of plastic debris in the beach have a spectral reflectance pattern between stations with an  
8 average optimum value at a wavelength of 500-700 nm and Identification of plastic debris in the beach with  
9 hyperspectral technology can be carried out using a wavelength of 400 - 600 nm

#### 11 Acknowledgement

12 This research was done with research funding from the Competency-Based Research Scheme (Penelitian  
13 Berbasis Kompetensi) with Contract Number L 1715 / UN4.21 / PL.00.00 / 2018. This research, in addition, was  
14 also carried out with participation of Widodo, Researcher in the Laboratory of Remote Sensing and Ecology,  
15 SEAMEO Biotrop, also Sunarto and Muhammad Ilham from the Faculty of Marine and Fisheries, Hasanuddin  
16 University.

#### 18 References

- 19 Andrady, A. L. (2015). Persistence of plastic litter in the oceans. In M. In: Bergmann, Gutow, L., Klages, M (Ed.),  
20 *Marine Anthropogenic Litter* (pp. 57-22): Springer International Publishing AG Switzerland.
- 21 Aoyama, T. (2014). *Monitoring of marine debris in the sea of Japan using multi-spectral satellite images* Paper  
22 presented at the SPIE Asia-Pacific Remote Sensing.
- 23 Driedger, H. Durr, K. Mitchel, J. Flannery, E. Brancazi, & Cappelen, P. V. (2013). *Plastic Debris; Remote sensing  
24 and characterization*. Canada: University of Waterloo.
- 25 Garaba, S. P., & Dierssen, H. M. (2018). An airborne remote sensing case study of synthetic hydrocarbon  
26 detection using short wave infrared absorption features identified from marine-harvested macro- and  
27 microplastics. *Remote Sensing of Environment*, 205, 224-235.  
28 doi:<https://doi.org/10.1016/j.rse.2017.11.023>
- 29 GESAMP. (2015). *Sources, fate and effects of microplastics in the marine environment: Part two of a global  
30 assessment* (P. J. K. a. C. M. Rochman Ed.). 4 Albert Embankment, London SE1 7SR:  
31 INTERNATIONAL MARITIME ORRGANIZATION.
- 32 Halma, C. (2008). USB4000 Fiber Optic Spectrometer: Instalation and Operation Manual. Retrieved from  
33 [www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf](http://www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf)
- 34 Hochberg, E. J., Atkinson, M. J., & Andréfouët, S. (2003). Spectral reflectance of coral reef bottom-types  
35 worldwide and implications for coral reef remote sensing. *Remote Sensing of Environment*, 85(2), 159-  
36 173. doi:[https://doi.org/10.1016/S0034-4257\(02\)00201-8](https://doi.org/10.1016/S0034-4257(02)00201-8)
- 37 Hook, S. J. (2018). ECOSTRESS Spectral Library - Version 1.0 — ECOSTRESS Speclib. Retrieved from  
38 <https://speclib.jpl.nasa.gov/library/ecospeclibinteractive>
- 39 Hörig, B., Kühn, F., Oschütz, F., & Lehmann, F. (2001). HyMap hyperspectral remote sensing to detect  
40 hydrocarbons. *International Journal of Remote Sensing*, 22(8), 1413-1422.  
41 doi:10.1080/01431160120909
- 42 Huete, A. R. (1988). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, 25(3), 295-309.  
43 doi:[https://doi.org/10.1016/0034-4257\(88\)90106-X](https://doi.org/10.1016/0034-4257(88)90106-X)

**Commented [A14]:** Conclusion should not only contain summary of what was written, but should correlate or promote the study relevancy with nowadays problems and/or the study continuity (e.g. as potential source of remote-sensing based debris identification).

- 1 Imhof, H. K., Sigl, R., Brauer, E., Feyl, S., Gieseemann, P., Klink, S., Leupolz, K., Loder, M.G.J., Löschel, L.A.,  
2 Missun, Jan Muszynski, S., Ramsperger, A.F. R. M., Schrank, I., Speck, S., Steibl, S., Trotter, B., Winter,  
3 I., Laforsch, C. (2017). Spatial and temporal variation of macro-, meso- and microplastic abundance on  
4 a remote coral island of the Maldives, Indian Ocean. *Marine Pollution Bulletin*, 116(1), 340-347.  
5 doi:<https://doi.org/10.1016/j.marpolbul.2017.01.010>
- 6 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., Law, K. L. (2015).  
7 Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771. doi:10.1126/science.1260352
- 8 Lillesand, Ralph W. Kiefer, & Chipman, J. (2015). *Remote Sensing and Image Interpretation*. John Wiley and  
9 Sons.
- 10 Mace, T. H. (2012). At-sea detection of marine debris: Overview of technologies, processes, issues, and options.  
11 *Marine Pollution Bulletin*, 65(1), 23-27. doi:<https://doi.org/10.1016/j.marpolbul.2011.08.042>
- 12 Maulana, F. (2016). *Identifikasi sampah laut di kawasan wisata pantai Kota Makassar*. (Skripsi), Universitas  
13 Hasanuddin, Makassar.
- 14 Murphy, L. G., Peters, S., van Sebille, E., James, N. A., & Gibb, S. (2018). Concept for a hyperspectral remote  
15 sensing algorithm for floating marine macro plastics. *Marine Pollution Bulletin*, 126, 255-262.  
16 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.011>
- 17 NOAA. (2015). *Turning The Tide On Trash. A Learning Guide On Marine Debris*. NOAA PIFSC CRED.
- 18 Pichel, W. G., Churnside, J. H., Veenstra, T. S., Foley, D. G., Friedman, K. S., Brainard, R. E., Nicoll, J.B., Zheng,  
19 Q., Clemente-Colón, P. (2007). Marine debris collects within the North Pacific Subtropical  
20 Convergence Zone. *Marine Pollution Bulletin*, 54(8), 1207-1211.  
21 doi:<https://doi.org/10.1016/j.marpolbul.2007.04.010>
- 22 Shah, A. A., Hasan, F., Hameed, A., & Ahmed, S. (2008). Biological degradation of plastics: A comprehensive  
23 review. *Biotechnology Advances*, 26(3), 246-265. doi:<https://doi.org/10.1016/j.biotechadv.2007.12.005>
- 24 Thevenon F., C. C., Sousa J. (2014). *Plastic Debris in the Ocean. The Characterization of Marine Plastics and  
25 their Environmental Impacts. Situation Analysis Report*. Gland, Switzerland: IUCN
- 26 Van Cauwenbergh, L., Claessens, M., Vandegheuchte, M. B., Mees, J., & Janssen, C. R. (2013). Assessment of  
27 marine debris on the Belgian Continental Shelf. *Marine Pollution Bulletin*, 73(1), 161-169.  
28 doi:<https://doi.org/10.1016/j.marpolbul.2013.05.026>
- 29 Veenstra, T. S., & Churnside, J. H. (2012). Airborne sensors for detecting large marine debris at sea. *Marine  
30 Pollution Bulletin*, 65(1), 63-68. doi:<https://doi.org/10.1016/j.marpolbul.2010.11.018>

Perbaikan atas review artikel 1

[40519-119685-1-ED.DOC](#)

2019-02-14

# 1 Spectral Characteristics of Plastic Debris in the Beach: Case Study

## 2 of Makassar Coastal Area

3  
4 **Abstract** Plastic debris becomes a global problem that threatens the coastal ecosystems, and the supralittoral area (beach)  
5 turns to be a place for plastic debris to accumulate. Data from the United Nation (UN) states that Indonesia is the second  
6 plastic debris contributor in world waters. This study aimed to examine the spectral characteristics of plastic debris  
7 accumulated in the beach. The data was collected from the coast of Makassar at 3 different stations: Jenneberang River  
8 estuary, Losari Beach and Tallo River estuary. The spectral sample was measured using a 4000 A spectroradiometer that  
9 works on a wavelength spectrum 340 - 1040 nm. The results showed that the spectral characteristics of the plastic debris in  
10 the beach had a spectral reflectance pattern with optimum value at the wavelength of 500-700 nm and the object  
11 identification used the wavelength of 500-785 nm.

12  
13 **Key words:** plastic debris, wavelength, spectral

14  
15 **Abstrak** Sampah plastik menjadi masalah global yang mengancam kondisi ekosistem pesisir, dan daerah supralittoral  
16 (pantai) menjadi tempat penumpukan sampah plastik. Data United Nation (UN) menyebutkan bahwa Indonesia menjadi  
17 penyumbang sampah plastik nomor dua di perairan dunia. Penelitian ini bertujuan untuk mengkaji karakteristik spektral  
18 dari sampah plastik yang terakumulasi di daerah pantai. Data dikoleksi dari pesisir pantai makassar pada 3 stasiun yang  
19 berbeda yaitu di muara Sungai Jenneberang, Pantai Losari dan Muara Sungai Tallo. Spektral sampel diukur dengan  
20 menggunakan spektroskop 4000 A yang bekerja pada spektrum panjang gelombang 340 – 1040 nm. Hasil penelitian  
21 menunjukkan bahwa karakteristik spektral sampah plastik pada daerah pantai memiliki pola pantulan spektral dengan nilai  
22 optimum pada panjang gelombang 500 -700 nm dan indentifikasi obyek dengan memanfaatkan panjang gelombang 500-785  
23 nm.

24  
25 **Kata kunci :** Sampah plastik, Panjang Gelombang, spektral

### 26 27 1. Introduction

28 Marine debris is now a global problem that has affected all water bodies, especially the water surface in coastal  
29 areas. Its influence visibly shows towards the economy, ecology, public health, and environmental aesthetics.  
30 Marine debris pollution is no longer a regional problem but has scaled up into a global or international problem.  
31 Marine debris, especially plastic in waters, has transformed into agents that potentially bring toxic chemicals,  
32 such as PCBs and heavy metals to human. Whilst microplastics, fragmented from larger plastic debris, that are  
33 largely invisible to humans, can also accumulate in the food chain (Driedger et al., 2013).

34 Some time ago, it was estimated that around 10% of debris has been discharged into the waters (Van  
35 Cauwenbergh et al., 2013) Generally, marine debris with various forms (such as plastic, metal, wood, clothing  
36 etc.) accumulates in coastal areas (NOAA, 2015). The main sources of debris in the waters are from recreational  
37 activities, wind or storm, illegal dumping, sewage treatment plants, and fishing industry (Driedger et al., 2013).

Commented [A1]: This is the revised incomplete sentence

Commented [A2]: Apparently, plastic debris in the sea are lethal to wildlife and fisheries. Mentioning this issues prior to explaining the cycle until it reaches human would be more appropriate.

Commented [A3R2]: We already revised this sentence into the more appropriate one. In the first sentence what we mean is plastic debris can bring toxic chemical and in the second sentence we meant that fragmented plastic debris can also accumulated through food chain. So, it could have double impacts.

1 In 2010, it was predicted that around 4.8 to 12.7 million metric tons of plastic debris had entered the ocean, from  
2 192 countries and Indonesia is the second contributor to the sea debris after China. According to Jambeck et al.  
3 (2015) Indonesia contributed plastic debris to the sea by 1.29 million tons/year after China by 3.53 million  
4 tons/year in 2010. With regards to this condition, plastic debris pollution will add to a very large environmental  
5 and socio-economic problems in Indonesian waters (Driedger et al., 2013).  
6 Marine debris, especially plastic debris in the waters, due to hydro-oceanographic influences were stranded and  
7 accumulated in the beach including in the coastal city of Makassar (Maulana, 2016). Identification of marine  
8 debris has been carried out using traditional survey methods (Driedger et al., 2013) including in South Sulawesi  
9 (Maulana, 2016). Another alternative that might be used is to employ the remote sensing method. The  
10 identification of objects using this method is generally based on the spectral characteristics of the object, each  
11 different material will give a different spectral curve, including plastic debris will give a different reflection  
12 curve to the surrounding object (Driedger et al., 2013; Hørig et al., 2001; Pichel et al., 2007). This second  
13 alternative enables relatively cheaper cost and faster time. The study of remote sensing of plastic debris in coastal  
14 areas was still experimental. However, several researchers have tried to monitor marine debris in various parts of  
15 the world (Aoyama, 2014; Jambeck et al., 2015; Mace, 2012; Veenstra & Churnside, 2012). This study aimed to  
16 examine spectral characteristics of the plastic debris in the beach and will be used as a reference for identifying  
17 plastic debris in coastal areas using satellite imagery.

## 19 2. The Methods

20 This research was carried out in coastal areas, especially in the beach of Makassar City, South Sulawesi Province,  
21 at three stations with adequately different characteristics (Figure 1.). All stations were connected to the water  
22 ways that comes from the city of Makassar that would potentially bring marine debris to the sea: Station 1,  
23 estuary of Jeneberang River, represented the water influenced by Jeneberang River with substrate type of alluvial  
24 sand; station 2, Losari Beach, represented the water influenced by the city small canals disembugue along Losari  
25 Beach with sandy calcareous type sediment; and station 3, estuary of Tallo River, which represented the water  
26 influenced by Paotere Canal and Tallo River with sandy loam type of sediment. The sample analysis was done at  
27 the Marine Ecology Laboratory, Marine Sciences Department, Hasanuddin University and the Remote Sensing  
28 and Ecology Laboratory Seameo BIOTROP, Bogor.

**Commented [A4]:** We erased this phrase as we didn't need it because we already mentioned it before in million metric tons.

**Commented [A5]:** Providing a brief explanation on how remote sensing data are used to identify coastal-marine debris would be appropriate prior to mentioning objective of the study.

**Commented [A6R5]:** we have added an explanation of the remote sensing methodology

**Commented [A7]:** Brief explanation of each sampling site's characteristics and why it were selected should be provided in this section.

**Commented [A8R7]:** We add sampling site's character and the reason why we selected the location

**Commented [A9]:** 1.Referring the map in the above text body is not helping the reader(s) in understanding the characteristics of three sampling sites.

2.It is more appropriate to label the blue area as 'water bodies' rather than 'river' as the sea is also present.

3.Please change the background of lower right map to blue to match two other maps.

4.Pay attention to the color intensity of the symbol in the legend and what was draw on the map as they are different.

**Commented [A10R9]:** we already make a revision on the map and answering all the questions regarding the map.



Figure 1. Makassar Coastal Water; Study area and sampling station

The spectral identification of plastic debris in the beach refers to the method used by Murphy et al. (2018) and its development with the implementation stages as follows:

a) *Sample collection*: sample collection was conducted in the beach of the coast of Makassar City, at three stations; Station 1 around the Jenneberang River Estuary, Station 2 around Losari Beach and Station 3 around the Tallo River Estuary up to the Paotere port. Furthermore, sorting of the collected sample was held in the Marine Ecology Laboratory, Marine Science Department with 10 plastic debris samples, with different characteristics.

b) *Sample Measurement*: The spectral value of the sample was measured using the Ocean Optics USB 4000 type spectrometer which works on a wavelength 340-1110 nm (nanometer). The spectral retrieval process involves spectrometers, light sources, optical fibers, and computers. One spectroradiometer part is connected to the light source and the other part is connected to the object being measured (Figure 2). The position of the light source does not directly face the sun but forms an angle of approximately 45° and 100 millisecond scanning time (Halma, 2008)



Figure2. Measurement of spectral values of samples.

3) *Recording Reflectance Values* Replay values from samples are recorded using a computer equipped with software **Ocean Optics Spectra Suite 4000**

Data analysis used numeric data processing devices, the measurement data was classified by eliminating error values and cutting off visible and near-infrared light waves. Furthermore, the data was made into graphical form with smoothing graphs and compared with sand's spectral reflectance obtained from data spectral library provided by Hook (2018) and Hewnson (1998).

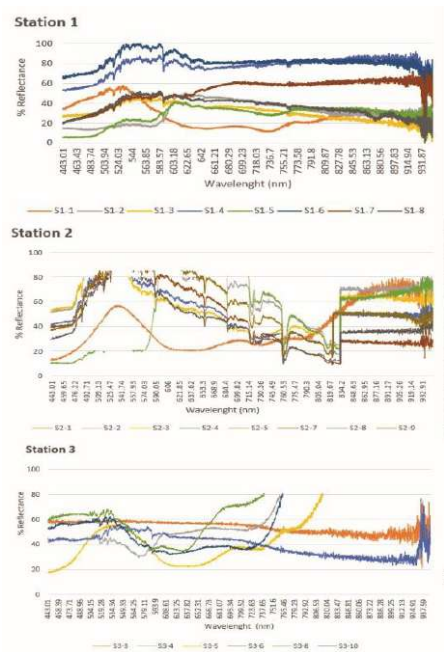
### 3. Result and Discussion

Spectral measurement results of each sample at each station are presented in Figure 3. The spectral reflectance curve of each sample shows the same reflectance pattern on each wavelength spectrum. Figure 3 shows a tendency of an increase in spectral reflectance curves for each station. At station 1 there is an increase in spectral curves at wavelengths of 500-625 nanometers (nm), at station 2 the tendency of the increase of spectral curves occurs at wavelengths of 470-600 nm and at station 3 the tendency of the increase spectral curves happens at wavelengths of 450-570 nm. The graph in Figure 3 shows the difference of the amount of data, this is due to noise that occurred when the recording started so the spectral reflectance curve is smaller than 0%, the value is eventually selected and considered as error data and not employed.

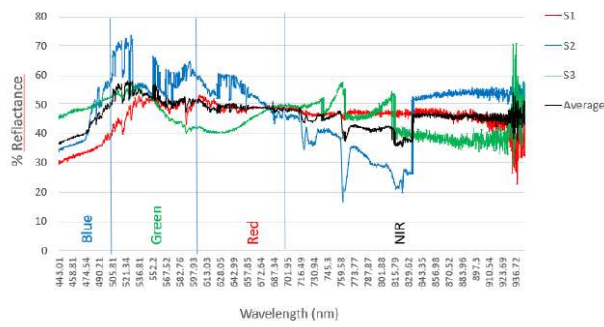
**Commented [A11]:** This is the revision, we added the software name and version.

**Commented [A12]:** Please explain whether the sand or soil's spectral reflectance are also recorded with the equipment or obtained from existing spectral library.

**Commented [A13R12]:** sand's spectral reflectance obtained from data spectral library provided by Hook (2018) and Hewnson (1998).



1  
 2 Figure3. Spectral Reflectance Curve of plastic debris for each sample at all stations.  
 3 The difference in the spectral characteristics of plastic debris at each station is shown in Figure 4. The  
 4 characteristics of each station are obtained from the average spectral reflectance value of each sample at each  
 5 station. The average spectral reflectance value of each station shows the similarity of spectral reflectance  
 6 patterns. The spectral reflectance pattern of each station starts to show an increase in the wavelength of 500 nm  
 7 (blue wavelength) and decreases at a wavelength of 700 nm (red wavelength).



8  
 9 Figure4. Comparison of Spectral Reflectance Curves for each station with average reflectance and divisions  
 10 based on wavelength.

1 Figure 3 denotes the difference in spectral reflectance curves between each sample with the same pattern  
2 tendency. The difference in spectral reflectance curves of each object is influenced by several factors;  
3 characteristics of object or sample, the amount of light penetration received by objects (Murphy et al., 2018).  
4 Plastics found at the study site have different chemical compositions which will give different reflectance, plastic  
5 debris consists of several types; polyethylene (PE), poly-propylene (PP), polyvinylchloride (PVC), poly-amide  
6 (nylon) and polystyrene (PS) (Andrady, 2015). Different chemical compositions resulted in different spectral  
7 reflectance values as well (Imhof et al., 2017). Another factor is because the found samples have been degraded  
8 and have weathered naturally or partially fragmented into microplastic (GESAMP, 2015; Shah et al., 2008;  
9 Thevenon F., 2014). In different time and weather conditions, the sunlight's penetration that reaches to the  
10 earth's surface also varies, the number of wavelengths that reach the earth's surface or the object is affected by  
11 the amount of scattering and absorption of particles in the atmosphere (Lillesand et al., 2015; Murphy et al.,  
12 2018).

13 The tendency of reflectance pattern of each sample at every station (Figure 3) is almost the same, this is due to  
14 similarity of the main chemical component of the plastic (Andrady, 2015). In several hyperspectral studies with  
15 different objects and similar main components, have similar spectral patterns, such as vegetation (Huete, 1988),  
16 coral reefs (Hochberg et al., 2003), soil (Lillesand et al., 2015) and others.

17 The spectral reflectance pattern of plastic debris found in the beach at all observation stations (Figure 4) shows  
18 various spectral values with optimum spectral reflectance values at 500 - 700 nm. Based on wavelengths division,  
19 that range is at the visible wavelength (400 - 700 nm). In detail, the visible wavelength is divided into 3  
20 wavelengths; Blue (400 - 500 nm), Green (500 - 600 nm) and Red (600 - 700 nm). One factor that might cause  
21 differences in the spectral characteristics of each station is the presence of macroalgae that began to grow in  
22 various samples, will automatically influence the spectral reflection of each object at each station (Diaz and  
23 Rosenberg, 1995).

24 The analysis of variance on the data of all stations showed no differences in the spectral characteristics of each  
25 station ( $p > 0.05$ ) therefore the spectral values of each station were averaged and compiled with the spectral  
26 reflectance of mud sand (Hook, 2018), sand, and calcareous sand (Hewson, 1998) as in Figure 5

27

Commented [A14]: We changed the sentence before and provide with a new sentence

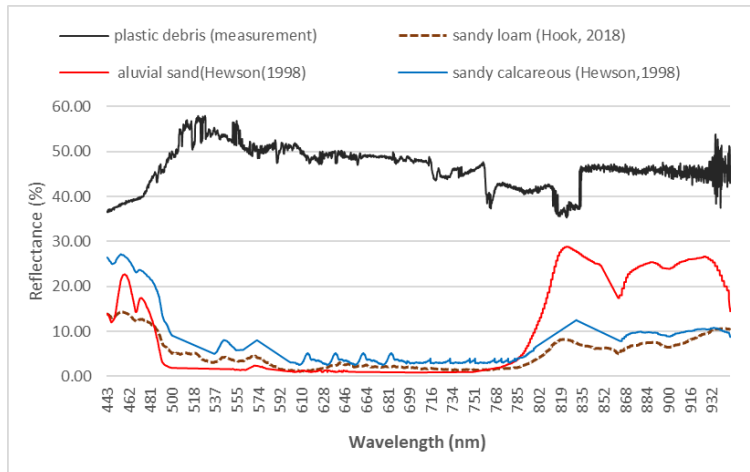


Figure 5. Comparison of the average value of plastic reflectance with sand reflectance

The results of our study indicate that identification of plastic debris in the supralittoral region at the condition of muddy sand, sand and calcareous sand substrates is possible by using wavelengths of 500 - 785 nm or in blue and green visible wavelengths.

Wavelengths of 500-785 nm would be the optimum wavelength are used to distinguish between plastic waste and substrates, this will facilitate identification of plastic debris objects in coastal areas. The use of multispectral classification techniques by utilizing spectral values of objects can be done in a broad scale mapping (Jensen, 2004). Including the utilization of the spectral curve from plastic waste, a multispectral classification can also be carried out for mapping the distribution of plastic debris. But in its implementation the identification of plastic debris objects can only be done: 1) in the locations of accumulated plastic debris, and it is less likely to be used to detect the distribution of small amount or scattered plastic debris, 2) to detect plastic debris on the surface of the substrates. Another obstacle to the introduction of plastic debris is related to spatial resolution, the lower the resolution, the lower the recognition of objects (Moy et al., 2018).

The difference in the spectral value of an object, including plastic debris, will be a reference in the remote sensing method, especially in multispectral classification. Our result of plastic debris spectral curve could be a reference for plastic debris mapping in coastal area. The mapping of plastic debris distribution with the remote sensing method will be a solution in effectively mapping the plastic debris.

#### 4. Conclusion

This study aims to examine the spectral characteristics of plastic debris in the coastal area (beach) of Makassar City with different type of substrates namely sandy, calcareous and muddy substrates. Our results showed spectral characteristics of plastic debris were not different between stations, therefore the substrates where plastic debris found were not affecting the spectral reflection curve of plastic debris.

**Commented [A15]:** These are new paragraphs that we hope can explain better

**Commented [A16]:** Conclusion should not only contain summary of what was written, but should correlate or promote the study relevancy with nowadays problems and/or the study continuity (e.g. as potential source of remote-sensing based debris identification).

**Commented [A17R16]:** we have revised it

1 Optimum value for identification of plastic debris in the coastal area is 500-785 nm (green and red wavelengths).  
2 This value will be a reference in the remote sensing method, especially multispectral classification in mapping  
3 plastic debris found in coastal areas, and will be one solution to effectively mapping plastic debris.

#### 5 Acknowledgement

6 This research was done with research funding from the Competency-Based Research Scheme (Penelitian  
7 Berbasis Kompetensi) with Contract Number L 1715 / UN4.21 / PL.00.00 / 2018. This research, in addition, was  
8 also carried out with participation of Widodo, Researcher in the Laboratory of Remote Sensing and Ecology,  
9 SEAMEO Biotrop, also Sunarto and Muhammad Ilham from the Faculty of Marine and Fisheries, Hasanuddin  
10 University.

#### 12 References

- 13 Andrady, A. L. (2015). Persistence of plastic litter in the oceans. In M. In: Bergmann, Gutow, L., Klages, M (Ed.),  
14 *Marine Anthropogenic Litter* (pp. 57-22): Springer International Publishing AG Switzerland.
- 15 Aoyama, T. (2014). *Monitoring of marine debris in the sea of Japan using multi-spectral satellite images* Paper  
16 presented at the SPIE Asia-Pacific Remote Sensing.
- 17 Diaz R.J. & Rosenberg R., 1995. Marine benthic hypoxia: A review of its ecological effects and the behavioural  
18 responses of benthic macrofauna. *Oceanography and Marine Biology – An Annual Review*, 33: 245-  
19 303.
- 20 Driedger, H. Durr, K. Mitchel, J. Flannery, E. Brancazi, & Cappelen, P. V. (2013). *Plastic Debris; Remote sensing  
21 and characterization*. Canada: University of Waterloo.
- 22 GESAMP. (2015). *Sources, fate and effects of microplastics in the marine environment: Part two of a global  
23 assessment* (P. J. K. a. C. M. Rochman Ed.). 4 Albert Embankment, London SE1 7SR:  
24 INTERNATIONAL MARITIME ORGANIZATION.
- 25 Halma, C. (2008). USB4000 Fiber Optic Spectrometer: Instalation and Operation Manual. Retrieved from  
26 [www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf](http://www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf)
- 27 Hewson, R. D. (1998). An investigation of mineralogical and textural effects on thermal infrared energy  
28 interactions with an arid environment. Unpublished PhD thesis. School of Applied Geology, University  
29 of NSW, Sydney. pp.
- 30 Hochberg, E. J., Atkinson, M. J., & Andréfouët, S. (2003). Spectral reflectance of coral reef bottom-types  
31 worldwide and implications for coral reef remote sensing. *Remote Sensing of Environment*, 85(2), 159-  
32 173. doi:[https://doi.org/10.1016/S0034-4257\(02\)00201-8](https://doi.org/10.1016/S0034-4257(02)00201-8)
- 33 Hook, S. J. (2018). ECOSTRESS Spectral Library - Version 1.0 — ECOSTRESS Speclib. Retrieved from  
34 <https://speclib.jpl.nasa.gov/library/ecospeclibinteractive>
- 35 Horig, B., Kühn, F., Oschütz, F., & Lehmann, F. (2001). HyMap hyperspectral remote sensing to detect  
36 hydrocarbons. *International Journal of Remote Sensing*, 22(8), 1413-1422.  
37 doi:10.1080/01431160120909
- 38 Huete, A. R. (1988). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, 25(3), 295-309.  
39 doi:[https://doi.org/10.1016/0034-4257\(88\)90106-X](https://doi.org/10.1016/0034-4257(88)90106-X)
- 40 Imhof, H. K., Sigl, R., Brauer, E., Feyl, S., Giesemann, P., Klink, S., Leupolz, K., Loder, M.G.J., Löschel, L.A.,  
41 Missun, Jan Muszynski, S., Ramsperger, A.F. R. M., Schrank, I., Speck, S., Steibl, S., Trotter, B., Winter,  
42 L., Laforsch, C. (2017). Spatial and temporal variation of macro-, meso- and microplastic abundance on  
43 a remote coral island of the Maldives, Indian Ocean. *Marine Pollution Bulletin*, 116(1), 340-347.  
44 doi:<https://doi.org/10.1016/j.marpolbul.2017.01.010>
- 45 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., Law, K. L. (2015).  
46 Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771. doi:10.1126/science.1260352
- 47 Jensen, J.R. (2004) *Introductory Digital Image Processing: A Remote Sensing Perspective*. 3rd Edition, Prentice-  
48 Hall, Inc., New York, 316.

- 1 Lillesand, Ralph W. Kiefer , & Chipman, J. (2015). *Remote Sensing and Image Interpretation*: John Wiley and  
2 Sons.
- 3 Mace, T. H. (2012). At-sea detection of marine debris: Overview of technologies, processes, issues, and options.  
4 *Marine Pollution Bulletin*, 65(1), 23-27. doi:<https://doi.org/10.1016/j.marpolbul.2011.08.042>
- 5 Maulana, F. (2016). *Identifikasi sampah laut di kawasan wisata pantai Kota Makassar*. (Skripsi), Universitas  
6 Hasanuddin, Makassar.
- 7 Moy, K., Neilson, B., Chung, A., Meadows, A., Castrence, M., Ambagis, S., & Davidson, K. (2018). Mapping  
8 coastal marine debris using aerial imagery and spatial analysis. *Marine Pollution Bulletin*, 132, 52-59.  
9 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.045>
- 10 Murphy, L. G., Peters, S., van Sebille, E., James, N. A., & Gibb, S. (2018). Concept for a hyperspectral remote  
11 sensing algorithm for floating marine macro plastics. *Marine Pollution Bulletin*, 126, 255-262.  
12 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.011>
- 13 NOAA. (2015). *Turning The Tide On Trash. A Learning Guide On Marine Debris*: NOAA PIFSC CRED.
- 14 Pichel, W. G., Churnside, J. H., Veenstra, T. S., Foley, D. G., Friedman, K. S., Brainard, R. E., Nicoll, J.B., Zheng,  
15 Q., Clemente-Colón, P. (2007). Marine debris collects within the North Pacific Subtropical  
16 Convergence Zone. *Marine Pollution Bulletin*, 54(8), 1207-1211.  
17 doi:<https://doi.org/10.1016/j.marpolbul.2007.04.010>
- 18 Shah, A. A., Hasan, F., Hameed, A., & Ahmed, S. (2008). Biological degradation of plastics: A comprehensive  
19 review. *Biotechnology Advances*, 26(3), 246-265. doi:<https://doi.org/10.1016/j.biotechadv.2007.12.005>
- 20 Thevenon F., C. C., Sousa J. (2014). *Plastic Debris in the Ocean. The Characterization of Marine Plastics and their*  
21 *Environmental Impacts. Situation Analysis Report*. Gland, Switzerland: IUCN
- 22 Van Cauwenberghe, L., Claessens, M., Vandegehuchte, M. B., Mees, J., & Janssen, C. R. (2013). Assessment of  
23 marine debris on the Belgian Continental Shelf. *Marine Pollution Bulletin*, 73(1), 161-169.  
24 doi:<https://doi.org/10.1016/j.marpolbul.2013.05.026>
- 25 Veenstra, T. S., & Churnside, J. H. (2012). Airborne sensors for detecting large marine debris at sea. *Marine*  
26 *Pollution Bulletin*, 65(1), 63-68. doi:<https://doi.org/10.1016/j.marpolbul.2010.11.018>

# Spectral Characteristics of Plastic Debris in the Beach: Case Study of Makassar Coastal Area

**Commented [A1]:** Editor Decision: Revision Required: 2019-03-13 11:39 AM

**Abstract** Plastic debris becomes a global problem that threatens the coastal ecosystems, and the supralittoral area (beach) turns to be a place for plastic debris to accumulate. Data from the United Nation (UN) states that Indonesia is the second plastic debris contributor in world waters. This study aimed to examine the spectral characteristics of plastic debris accumulated in the beach. The data was collected from the coast of Makassar at 3 different stations: Jenneberang River estuary, Losari Beach and Tallo River estuary. The spectral sample was measured using a 4000 A spectroradiometer that works on a wavelength spectrum 340 - 1040 nm. The results showed that the optimum value for identification of plastic debris in the coastal area is 500-785 nm (green and red wavelengths). This value will be a reference in the remote sensing method, especially multispectral classification in mapping plastic debris found in coastal areas, and will be one solution to effectively mapping plastic debris.

**Commented [A2]:** Ed : The last sentence of the abstract is confusing. Please revise

**Aut :** This sentence has been revised and added one sentence to complete the meaning.

**Key words:** plastic debris, wavelength, spectral

**Abstrak** Sampah plastik menjadi masalah global yang mengancam kondisi ekosistem pesisir, dan daerah supralittoral (pantai) menjadi tempat penumpukan sampah plastik. Data United Nation (UN) menyebutkan bahwa Indonesia menjadi penyumbang sampah plastik nomor dua di perairan dunia. Penelitian ini bertujuan untuk mengkaji karakteristik spektral dari sampah plastik yang terakumulasi di daerah pantai. Data dikoleksi dari pesisir pantai Makassar pada 3 stasiun yang berbeda yaitu di muara Sungai Jenneberang, Pantai Losari dan Muara Sungai Tallo. Spektral sampel diukur dengan menggunakan spektrometri 4000 A yang bekerja pada spektrum panjang gelombang 340 - 1040 nm. Hasil penelitian Nilai Optimum untuk indentifikasi sampah plastik pada daerah pantai adalah 500-785 nm (Panjang gelombang hijau dan merah). Nilai ini akan menjadi referensi dalam metode penginderaan jauh khususnya klasifikasi multispectral dalam memetakan sampah plastik yang terdapat di wilayah pesisir, dan akan menjadi salah satu solusi metode pemetaan sampah plastik yang efektif.

**Kata kunci :** Sampah plastik, Panjang Gelombang, spektral

## 1. Introduction

Marine debris is now a global problem that has affected all water bodies, especially the water surface in coastal areas. Its influence visibly shows towards the economy, ecology, public health, and environmental aesthetics.

Marine debris pollution is no longer a regional problem but has scaled up into a global or international problem.

Marine debris, especially plastic in waters, has transformed into agents that potentially bring toxic chemicals, such as PCBs and heavy metals to human. Whilst microplastics, fragmented from larger plastic debris, that are largely invisible to humans, can also accumulate in the food chain (Driedger et al., 2013).

Some time ago, it was estimated that around 10% of debris has been discharged into the waters (Van Cauwenberghe et al., 2013) Generally, marine debris with various forms (such as plastic, metal, wood, clothing,

1 etc.) accumulates in coastal areas (NOAA, 2015). The main sources of debris in the waters are from recreational  
2 activities, wind or storm, illegal dumping, sewage treatment plants, and fishing industry (Driedger et al., 2013).  
3 In 2010, it was predicted that around 4.8 to 12.7 million metric tons of plastic debris had entered the ocean, from  
4 192 countries and Indonesia is the second contributor to the sea debris after China. According to Jambeck et al.  
5 (2015) Indonesia contributed plastic debris to the sea by 1.29 million tons/year after China by 3.53 million  
6 tons/year in 2010. With regards to this condition, plastic debris pollution will add to a very large environmental  
7 and socio-economic problems in Indonesian waters (Driedger et al., 2013).  
8 Marine debris, especially plastic debris in the waters, due to hydro-oceanographic influences were stranded and  
9 accumulated in the beach including in the coastal city of Makassar (Maulana, 2016). Identification of marine  
10 debris has been carried out using traditional survey methods (Driedger et al., 2013) including in South Sulawesi  
11 (Maulana, 2016). Another alternative that might be used is to employ the remote sensing method. The  
12 identification of objects using this method is generally based on the spectral characteristics of the object, each  
13 different material will give a different spectral curve, including plastic debris will give a different reflection curve  
14 to the surrounding object (Driedger et al., 2013; Hörig et al., 2001; Pichel et al., 2007). This second alternative  
15 enables relatively cheaper cost and faster time. The study of remote sensing of plastic debris in coastal areas was  
16 still experimental. However, several researchers have tried to monitor marine debris in various parts of the world  
17 (Aoyama, 2014; Jambeck et al., 2015; Mace, 2012; Veenstra & Churnside, 2012). This study aimed to examine  
18 spectral characteristics of the plastic debris in the beach and will be used as a reference for identifying plastic debris  
19 in coastal areas using satellite imagery.

20

## 21 **2. The Methods**

22 This research was carried out in coastal areas, especially in the beach of Makassar City, South Sulawesi Province,  
23 at three stations with adequately different characteristics (Figure 1.). All stations were connected to the water ways  
24 that comes from the city of Makassar that would potentially bring marine debris to the sea: Station 1, estuary of  
25 Jeneberang River, represented the water influenced by Jeneberang River with substrate type of alluvial sand; station  
26 2, Losari Beach, represented the water influenced by the city small canals disemboque along Losari Beach with  
27 sandy calcareous type sediment; and station 3, estuary of Tallo River, which represented the water influenced by  
28 Paotere Canal and Tallo River with sandy loam type of sediment. The sample analysis was done at the Marine  
29 Ecology Laboratory, Marine Sciences Department, Hasanuddin University and the Remote Sensing and Ecology  
30 Laboratory Seameo BIOTROP, Bogor.

31



Figure 1. Makassar Coastal Water; Study area and sampling station

The spectral identification of plastic debris in the beach refers to the method used by Murphy et al. (2018) and its development with the implementation stages as follows:

a) *Sample collection*: sample collection was conducted in the beach of the coast of Makassar City, at three stations; Station 1 around the Jenneberang River Estuary, Station 2 around Losari Beach and Station 3 around the Tallo River Estuary up to the Paotere port. Furthermore, sorting of the collected sample was held in the Marine Ecology Laboratory, Marine Science Department with 10 plastic debris samples, with different characteristics.

b) *Sample Measurement*: The spectral value of the sample was measured using the Ocean Optics USB 4000 type spectrometer which works on a wavelength 340-1110 nm (nanometer). The spectral retrieval process involves spectrometers, light sources, optical fibers, and computers. One spectroradiometer part is connected to the light source and the other part is connected to the object being measured (Figure 2). The position of the light source does not directly face the sun but forms an angle of approximately 45° and 100 millisecond scanning time (Halma, 2008)



Figure2. Measurement of spectral values of samples.

1  
2  
3 c) **Recording Reflectance Values** Replay values from samples are recorded using a computer equipped with  
4 software Ocean Optics Spectra Suite 4000. The spectroradiometer used has a wavelength range of 300-1040 nm  
5 with spectrometer components including 3648 linear silicon CCD Array elements, solar sources in the field,  
6 optical fibers with a diameter of 400  $\mu\text{m}$  and a length of 2 meters, and a computer. Before measurement, a  
7 calibration was taken with dark spectral technique and a reference. The dark spectral technique is a data spectral  
8 retrieval without light and samples, and a reference technique is taking spectral data using a reference from diffuse  
9 reflectance standard model WS-1, Ocean Optics USA.

10 At the time of measurement, one optic fiber section is connected to the light source and the spectrometer, other  
11 optic fiber parts are connected to the sample. Spectral reflectance of the plastic debris is measured twice, with  
12 integration time of 100 ms and resulting in 50 scans for each measurement, after which the spectral measurement  
13 were averaged

14 Data analysis used numeric data processing devices, the measurement data was classified by eliminating error  
15 values and cutting off visible and near-infrared light waves. Furthermore, the data was made into graphical form  
16 with smoothing graphs and compared with sand's spectral reflectance obtained from data spectral library provided  
17 by Hook (2018) and Hewnson (1998).

### 19 3. Result and Discussion

20 Spectral measurement results of each sample at each station are presented in Figure 3. The spectral reflectance  
21 curve of each sample shows the same reflectance pattern on each wavelength spectrum. Figure 3 shows a tendency  
22 of an increase in spectral reflectance curves for each station. At station 1 there is an increase in spectral curves at  
23 wavelengths of 500-625 nanometers (nm), at station 2 the tendency of the increase of spectral curves occurs at  
24 wavelengths of 470-600 nm and at station 3 the tendency of the increase spectral curves happens at wavelengths  
25 of 450-570 nm. The graph in Figure 3 shows the difference of the amount of data, this is due to noise that occurred  
26 when the recording started so the spectral reflectance curve is smaller than 0%, the value is eventually selected and  
27 considered as error data and not employed. The measurement of plastic debris spectral reflectance used a radiation  
28 source directly from the sun, which has a high wavelength ( $> 800 \text{ nm}$ ). According to Jensen (2004), the higher the  
29 wavelength spectrum, the weaker the energy reflected, which could cause a lot of noise as depicted in figure 3 and  
30 4

**Commented [A3]:** Ed : Explain the detail of spectrometer setting. For example, integration time, boxcar width, etc

-Aut : the spectrometer setting method has been added.

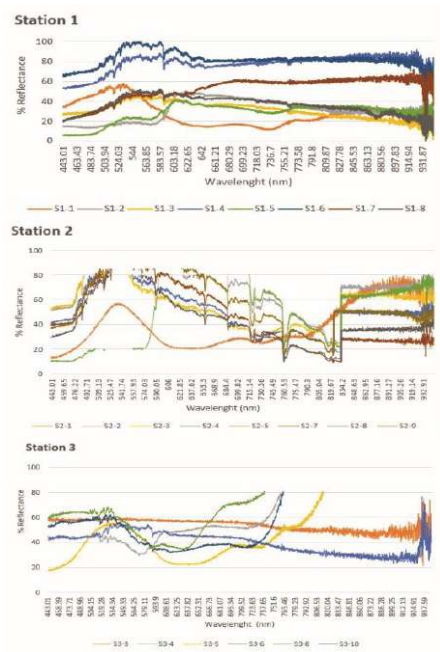
**Commented [A4]:** Ed : Why did you have to compare with sand and soil reflectance

Aut ; in order to ensure plastic debris spectral reflectance on the sand substrate, it is required to compare the substrate spectral with the object on it (plastic debris).

**Commented [A5]:** Ed : In most figures, the reflectance beyond 800 nm have a lot of noise. Can you explain why?

Aut : These sentences are the explanation of the occurrence of noise at a wavelength of  $> 800 \text{ nm}$

1



2

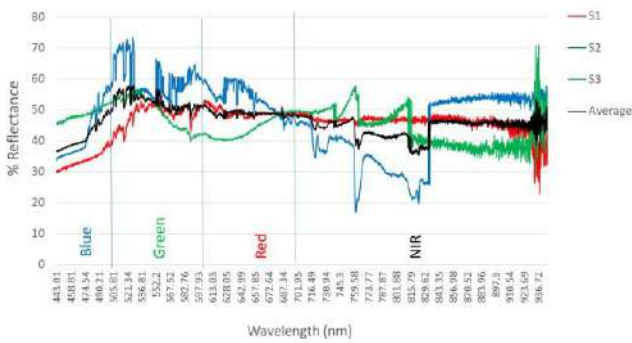
3

Figure3. Spectral Reflectance Curve of plastic debris for each sample at all stations.

4

The difference in the spectral characteristics of plastic debris at each station is shown in Figure 4. The characteristics of each station are obtained from the average spectral reflectance value of each sample at each station. The average spectral reflectance value of each station shows the similarity of spectral reflectance patterns. The spectral reflectance pattern of each station starts to show an increase in the wavelength of 500 nm (blue wavelength) and decreases at a wavelength of 800 nm (red wavelength).

8



9

10

Figure 4. Comparison of Spectral Reflectance Curves for each station with average reflectance and divisions based on wavelength.

11

Commented [A6]: Ed : Typo in y-axis of Figure 4

Aut : The Graph in Figure 4 has been corrected

1 Figure 3 denotes the difference in spectral reflectance curves between each sample with the same pattern tendency.  
2 The difference in spectral reflectance curves of each object is influenced by several factors; characteristics of object  
3 or sample, the amount of light penetration received by objects (Murphy et al., 2018). Plastics found at the study  
4 site have different chemical compositions which will give different reflectance, plastic debris consists of several  
5 types; polyethylene (PE), poly-propylene (PP), polyvinylchloride (PVC), poly-amide (nylon) and polystyrene (PS)  
6 (Andrady, 2015). Different chemical compositions resulted in different spectral reflectance values as well (Imhof  
7 et al., 2017). Another factor is because the found samples have been degraded and have weathered naturally or  
8 partially fragmented into microplastic (GESAMP, 2015; Shah et al., 2008; Thevenon F., 2014). In different time  
9 and weather conditions, the sunlight's penetration that reaches to the earth's surface also varies, the number of  
10 wavelengths that reach the earth's surface or the object is affected by the amount of scattering and absorption of  
11 particles in the atmosphere (Lillesand et al., 2015; Murphy et al., 2018).

12 The tendency of reflectance pattern of each sample at every station (Figure 3) is almost the same, this is due to  
13 similarity of the main chemical component of the plastic (Andrady, 2015). In several hyperspectral studies with  
14 different objects and similar main components, have similar spectral patterns, such as vegetation (Huete, 1988),  
15 coral reefs (Hochberg et al., 2003), soil (Lillesand et al., 2015) and others.

16 The spectral reflectance pattern of plastic debris found in the beach at all observation stations (Figure 4) shows  
17 various spectral values with optimum spectral reflectance values at 500 - 700 nm. Based on wavelengths division,  
18 that range is at the visible wavelength (400 - 700 nm). In detail, the visible wavelength is divided into 3 wavelengths;  
19 Blue (400 - 500 nm), Green (500 - 600 nm) and Red (600 - 700 nm). One factor that might cause differences in  
20 the spectral characteristics of each station is the presence of macroalgae that began to grow in various samples,  
21 will automatically influence the spectral reflection of each object at each station (Diaz and Rosenberg, 1995).

22 The analysis of variance on the data of all stations showed no differences in the spectral characteristics of each  
23 station ( $p > 0.05$ ) therefore the spectral values of each station were averaged and compiled with the spectral  
24 reflectance of mud sand (Hook, 2018), sand, and calcareous sand (Hewson, 1998) as in Figure 5

25

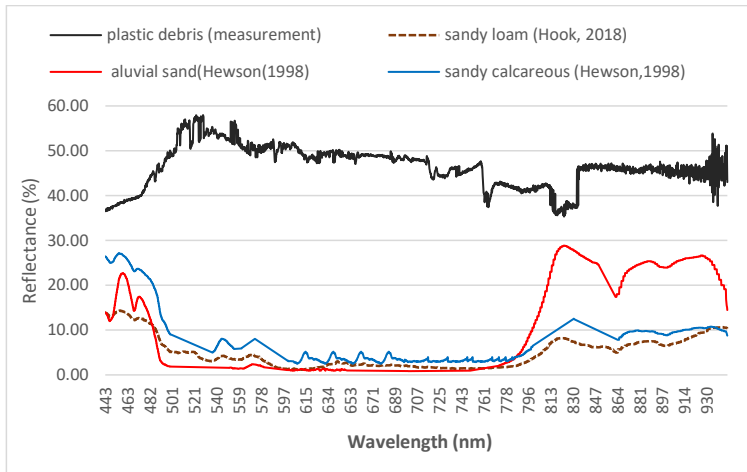


Figure 5. Comparison of the average value of plastic reflectance with sand reflectance (Hewson (1998) and Hook (2018) retrieved from <https://speclib.jpl.nasa.gov/library>)

Based on the reflectance curve depicted in Figure 5, it shows the difference in the reflection curve between plastic debris and the three types of sand substrates is highest at the wavelength range of 500-785 nm, therefore those were the best range (optimal range). Determination of the wavelength optimal range is by comparing the spectral of plastic debris with the spectral of where a substrate was found, in this case is a sand. The greater the range or the difference between the reflectance plastic debris and other objects, the easier the object identification is and the optimum wavelength can be determined. The results of our study indicate that identification of plastic debris in the supralittoral region at the condition of muddy sand, sand and calcareous sand substrates is optimum by using wavelengths of 500 - 785 nm or in blue and green visible wavelengths.

The use of multispectral classification techniques by utilizing spectral values of objects can be done in a broad scale mapping (Jensen, 2004). Including the utilization of the spectral curve from plastic waste, a multispectral classification can also be carried out for mapping the distribution of plastic debris. But in its implementation the identification of plastic debris objects can only be done: 1) in the locations of accumulated plastic debris, and it is less likely to be used to detect the distribution of small amount or scattered plastic debris, 2) to detect plastic debris on the surface of the substrates. Another obstacle to the identification of plastic debris is related to spatial resolution, the lower the resolution, the lower the recognition of objects (Moy et al., 2018).

The difference in the spectral value of an object, including plastic debris, will be a reference in the remote sensing method, especially in multispectral classification. Our result of plastic debris spectral curve could be a reference for plastic debris mapping in coastal area. The mapping of plastic debris distribution with the remote sensing method will be a solution in effectively mapping the plastic debris.

**Commented [A7]:** Ed : In Figure 5, the curve for sand objects did not seem correct? are you sure it is the correct sand reflectance

Aut : The sand reflectances: alluvial sand, sandy loam, and sandy calcareous, were secunder data obtained from Spectral Library type soil by <https://speclib.jpl.nasa.gov/library>

**Commented [A8]:** Ed : Why did you decide 500-785 nm is the best range??

Aut : This sentence has been added one sentence to reason question

**Commented [A9]:** Ed; Explain in more clearly how did you determine the optimum range for separating plastic debris from other objects

Aut : This sentence has been added one sentence to reason question

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25

#### 1 4. Conclusion

2 This study aims to examine the spectral characteristics of plastic debris in the coastal area (beach) of Makassar  
3 City with different type of substrates namely sandy, calcareous and muddy substrates. Our results showed spectral  
4 characteristics of plastic debris were not different between stations, therefore the substrates where plastic debris  
5 found were not affecting the spectral reflection curve of plastic debris.

6 Optimum value for identification of plastic debris in the coastal area is 500-785 nm (green and red wavelengths).  
7 This value will be a reference in the remote sensing method, especially multispectral classification in mapping  
8 plastic debris found in coastal areas, and will be one solution to effectively mapping plastic debris.

9

#### 10 Acknowledgement

11 This research was done with research funding from the Competency-Based Research Scheme (Penelitian Berbasis  
12 Kompetensi) with Contract Number L 1715 / UN4.21 / PL.00.00 / 2018. This research, in addition, was also carried  
13 out with participation of Widodo, Researcher in the Laboratory of Remote Sensing and Ecology, SEAMEO  
14 Biotrop, also Sunarto and Muhammad Ilham from the Faculty of Marine and Fisheries, Hasanuddin University.

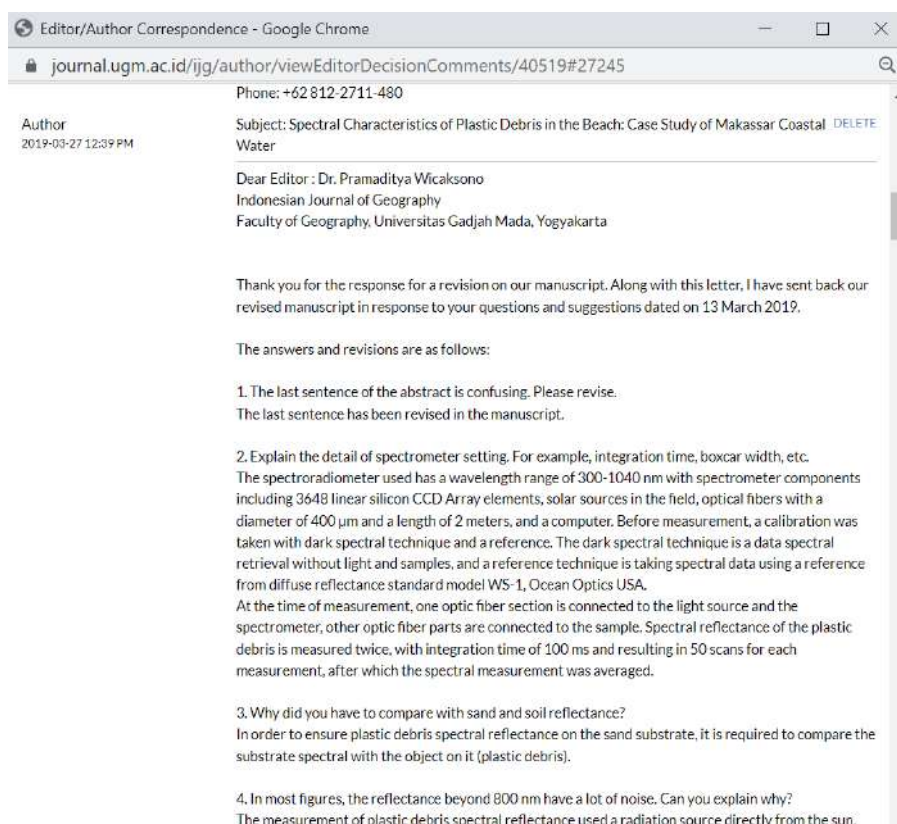
15

#### 16 References

- 17 Andrady, A. L. (2015). Persistence of plastic litter in the oceans. In M. In: Bergmann, Gutow, L., Klages, M (Ed.),  
18 *Marine Anthropogenic Litter* (pp. 57-22): Springer International Publishing AG Switzerland.
- 19 Aoyama, T. (2014). *Monitoring of marine debris in the sea of Japan using multi-spectral satellite images* Paper  
20 presented at the SPIE Asia-Pacific Remote Sensing.
- 21 Diaz R.J. & Rosenberg R., 1995. Marine benthic hypoxia: A review of its ecological effects and the behavioural  
22 responses of benthic macrofauna. *Oceanography and Marine Biology – An Annual Review*, 33: 245-303.
- 23 Driedger, H. Durr, K. Mitchel, J. Flannery, E. Brancazi, & Cappelen, P. V. (2013). *Plastic Debris; Remote sensing  
24 and characterization*. Canada: University of Waterloo.
- 25 GESAMP. (2015). *Sources, fate and effects of microplastics in the marine environment: Part two of a global  
26 assessment* (P. J. K. a. C. M. Rochman Ed.). 4 Albert Embankment, London SE1 7SR: INTERNATIONAL  
27 MARITIME ORRGANIZATION.
- 28 Halma, C. (2008). USB4000 Fiber Optic Spectrometer: Instalation and Operation Manual. Retrieved from  
29 [www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf](http://www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf)
- 30 Hewson, R. D. (1998). An investigation of mineralogical and textual effects on thermal infrared energy interactions  
31 with an arid environment. Unpublished PhD thesis. School of Applied Geology, University of NSW,  
32 Sydney. pp. retrieved from <https://speclib.jpl.nasa.gov/library/>
- 33 Hochberg, E. J., Atkinson, M. J., & Andréfouët, S. (2003). Spectral reflectance of coral reef bottom-types worldwide  
34 and implications for coral reef remote sensing. *Remote Sensing of Environment*, 85(2), 159-173.  
35 doi:[https://doi.org/10.1016/S0034-4257\(02\)00201-8](https://doi.org/10.1016/S0034-4257(02)00201-8)
- 36 Hook, S. J. (2018). ECOSTRESS Spectral Library - Version 1.0 — ECOSTRESS Speclib. Retrieved from  
37 <https://speclib.jpl.nasa.gov/library/>
- 38 Hörig, B., Kühn, F., Oschütz, F., & Lehmann, F. (2001). HyMap hyperspectral remote sensing to detect  
39 hydrocarbons. *International Journal of Remote Sensing*, 22(8), 1413-1422. doi:10.1080/01431160120909
- 40 Huete, A. R. (1988). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, 25(3), 295-309.  
41 doi:[https://doi.org/10.1016/0034-4257\(88\)90106-X](https://doi.org/10.1016/0034-4257(88)90106-X)
- 42 Imhof, H. K., Sigl, R., Brauer, E., Feyl, S., Giesemann, P., Klink, S., Leupolz, K., Loder, M.G.J., Löschel, L.A., Missun,  
43 Jan Muszynski, S., Ramsperger, A.F. R. M., Schrank, I., Speck, S., Steibl, S., Trotter, B., Winter, I.,  
44 Laforsch, C. (2017). Spatial and temporal variation of macro-, meso- and microplastic abundance on a  
45 remote coral island of the Maldives, Indian Ocean. *Marine Pollution Bulletin*, 116(1), 340-347.  
46 doi:<https://doi.org/10.1016/j.marpolbul.2017.01.010>

- 1 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., Law, K. L. (2015).  
2 Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771. doi:10.1126/science.1260352
- 3 Jensen, J.R. (2004) Introductory Digital Image Processing: A Remote Sensing Perspective. 3rd Edition, Prentice-  
4 Hall, Inc., New York, 316.
- 5 Lillesand, Ralph W. Kiefer, & Chipman, J. (2015). *Remote Sensing and Image Interpretation*: John Wiley and Sons.
- 6 Mace, T. H. (2012). At-sea detection of marine debris: Overview of technologies, processes, issues, and options.  
7 *Marine Pollution Bulletin*, 65(1), 23-27. doi:<https://doi.org/10.1016/j.marpolbul.2011.08.042>
- 8 Maulana, F. (2016). *Identifikasi sampah laut di kawasan wisata pantai Kota Makassar*. (Skripsi), Universitas  
9 Hasanuddin, Makassar.
- 10 Moy, K., Neilson, B., Chung, A., Meadows, A., Castrence, M., Ambagis, S., & Davidson, K. (2018). Mapping coastal  
11 marine debris using aerial imagery and spatial analysis. *Marine Pollution Bulletin*, 132, 52-59.  
12 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.045>
- 13 Murphy, L. G., Peters, S., van Sebille, E., James, N. A., & Gibb, S. (2018). Concept for a hyperspectral remote sensing  
14 algorithm for floating marine macro plastics. *Marine Pollution Bulletin*, 126, 255-262.  
15 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.011>
- 16 NOAA. (2015). *Turning The Tide On Trash. A Learning Guide On Marine Debris*. NOAA PIFSC CRED.
- 17 Pichel, W. G., Churnside, J. H., Veenstra, T. S., Foley, D. G., Friedman, K. S., Brainard, R. E., Nicoll, J.B., Zheng, Q.,  
18 Clemente-Colón, P. (2007). Marine debris collects within the North Pacific Subtropical Convergence  
19 Zone. *Marine Pollution Bulletin*, 54(8), 1207-1211. doi:<https://doi.org/10.1016/j.marpolbul.2007.04.010>
- 20 Shah, A. A., Hasan, F., Hameed, A., & Ahmed, S. (2008). Biological degradation of plastics: A comprehensive review.  
21 *Biotechnology Advances*, 26(3), 246-265. doi:<https://doi.org/10.1016/j.biotechadv.2007.12.005>
- 22 Thevenon F., C. C., Sousa J. (2014). *Plastic Debris in the Ocean. The Characterization of Marine Plastics and their*  
23 *Environmental Impacts. Situation Analysis Report*. Gland, Switzerland: IUCN
- 24 Van Cauwenberghe, L., Claessens, M., Vandegehuchte, M. B., Mees, J., & Janssen, C. R. (2013). Assessment of  
25 marine debris on the Belgian Continental Shelf. *Marine Pollution Bulletin*, 73(1), 161-169.  
26 doi:<https://doi.org/10.1016/j.marpolbul.2013.05.026>
- 27 Veenstra, T. S., & Churnside, J. H. (2012). Airborne sensors for detecting large marine debris at sea. *Marine*  
28 *Pollution Bulletin*, 65(1), 63-68. doi:<https://doi.org/10.1016/j.marpolbul.2010.11.018>

## Jawaban Korespondensi dari Penulis Sebagai Tanggapan atas saran perbaikan 03-01-2019



Editor/Author Correspondence - Google Chrome

journal.ugm.ac.id/ijg/author/viewEditorDecisionComments/40519#27245

Phone: +62 812-2711-480

Author  
2019-03-27 12:39 PM

Subject: Spectral Characteristics of Plastic Debris in the Beach: Case Study of Makassar Coastal Water [DELETE](#)

Dear Editor : Dr. Pramaditya Wicaksono  
Indonesian Journal of Geography  
Faculty of Geography, Universitas Gadjah Mada, Yogyakarta

Thank you for the response for a revision on our manuscript. Along with this letter, I have sent back our revised manuscript in response to your questions and suggestions dated on 13 March 2019.

The answers and revisions are as follows:

1. The last sentence of the abstract is confusing. Please revise.  
The last sentence has been revised in the manuscript.
2. Explain the detail of spectrometer setting. For example, integration time, boxcar width, etc.  
The spectroradiometer used has a wavelength range of 300-1040 nm with spectrometer components including 3648 linear silicon CCD Array elements, solar sources in the field, optical fibers with a diameter of 400  $\mu$ m and a length of 2 meters, and a computer. Before measurement, a calibration was taken with dark spectral technique and a reference. The dark spectral technique is a data spectral retrieval without light and samples, and a reference technique is taking spectral data using a reference from diffuse reflectance standard model WS-1, Ocean Optics USA.  
At the time of measurement, one optic fiber section is connected to the light source and the spectrometer, other optic fiber parts are connected to the sample. Spectral reflectance of the plastic debris is measured twice, with integration time of 100 ms and resulting in 50 scans for each measurement, after which the spectral measurement was averaged.
3. Why did you have to compare with sand and soil reflectance?  
In order to ensure plastic debris spectral reflectance on the sand substrate, it is required to compare the substrate spectral with the object on it (plastic debris).
4. In most figures, the reflectance beyond 800 nm have a lot of noise. Can you explain why?  
The measurement of plastic debris spectral reflectance used a radiation source directly from the sun,

### Selengkapnya Sebagai Berikut

Author [DELETE](#)  
2019-03-27 12:39 PM Subject: Spectral Characteristics of Plastic Debris in the Beach:  
Case Study of Makassar Coastal Water  
Dear Editor : Dr. Pramaditya Wicaksono  
Indonesian Journal of Geography  
Faculty of Geography, Universitas Gadjah Mada, Yogyakarta

Thank you for the response for a revision on our manuscript. Along

with this letter, I have sent back our revised manuscript in response to your questions and suggestions dated on 13 March 2019.

The answers and revisions are as follows:

1. The last sentence of the abstract is confusing. Please revise.  
The last sentence has been revised in the manuscript.

2. Explain the detail of spectrometer setting. For example, integration time, boxcar width, etc.  
The spectroradiometer used has a wavelength range of 300-1040 nm with spectrometer components including 3648 linear silicon CCD Array elements, solar sources in the field, optical fibers with a diameter of 400  $\mu\text{m}$  and a length of 2 meters, and a computer. Before measurement, a calibration was taken with dark spectral technique and a reference. The dark spectral technique is a data spectral retrieval without light and samples, and a reference technique is taking spectral data using a reference from diffuse reflectance standard model WS-1, Ocean Optics USA. At the time of measurement, one optic fiber section is connected to the light source and the spectrometer, other optic fiber parts are connected to the sample. Spectral reflectance of the plastic debris is measured twice, with integration time of 100 ms and resulting in 50 scans for each measurement, after which the spectral measurement was averaged.

3. Why did you have to compare with sand and soil reflectance?  
In order to ensure plastic debris spectral reflectance on the sand substrate, it is required to compare the substrate spectral with the object on it (plastic debris).

4. In most figures, the reflectance beyond 800 nm have a lot of noise. Can you explain why?  
The measurement of plastic debris spectral reflectance used a radiation source directly from the sun, which has a high wavelength (> 800 nm). According to Jensen (2004) that the higher the wavelength spectrum, the weaker the energy reflected, which could cause a lot of noise.

5. Typo in y-axis of Figure 4  
The Graph in Figure 4 has been corrected

6. Explain in more clearly how did you determine the optimum range for separating plastic debris from other objects  
Determination of the wavelength optimal range is by comparing

the spectral of plastic debris with the spectral of where a substrate was found, in this case is a sand. The greater the range or the difference between the reflectance plastic debris and other objects, the easier the object identification is and the optimum wavelength can be determined.

7. Why did you decide 500-785 nm is the best range??

Based on the reflectance curve depicted in Figure 5, it shows the difference in the reflection curve between plastic debris and the three types of sand substrates is highest at the wavelength range of 500-785 nm, therefore those were the best range.

8. In Figure 5, the curve for sand objects did not seem correct? are you sure it is the correct sand reflectance?

The sand reflectances: alluvial sand, sandy loam, and sandy calcareous, were secunder data obtained from Spectral Library type soil by <https://speclib.jpl.nasa.gov/library>

With regards,  
Ahmad Faizal

## **Hasil Revisi 2 atas perbaikan Artikel**

[40519-119685-2-ED.DOCX](#) 2019-03-27

# Korespondensi ke 3

Via OJS 28 Maret 2019

Editor/Author Correspondence - Google Chrome

journal.ugm.ac.id/ijg/author/viewEditorDecisionComments/40519#27245

Editor  
2019-03-28 05:36 PM

Subject: [IJG] Editor Decision: Resubmit manuscript DELETE

Dear Mr. Ahmad Faizal,

After reading your revised version. I found a fatal mistake of your analysis. The spectral library to use as a reference from <https://speclib.jpl.nasa.gov/library/ecoviewplot> is mistakenly adapted in your research.

The wavelength in the speclib is micrometers, meanwhile, your measurement is nanometers, hence incomparable. See attached file.

Therefore, all your method, result, analysis, and conclusion should be rewritten. It is because of your result, analysis, and conclusion mainly based on the comparison with the spectra from speclib that you incorrectly adapted. This is why I mentioned in the previous email that your spectra of sand etc. are incorrect.

Also, I want complete information whether you measured the integration time, dark and white reference, boxcar setting and spectra averaging during your spectra measurement as these significantly affect your measurement. Also, the noise that I asked you has not been properly answered.

I give you another chance to resubmit your manuscript after major revision based on these comments as well as previous comments. Please carefully respond to reviewer's comments when resubmitting your manuscript, and please clearly indicate the changes that you made (or highlight them).

I hope this decision does not discourage you to submit your paper to our journal in the future. Thank you.

Best wishes,  
Dr. Pramaditya Wicaksono  
ID SCOPUS: 54279699900, Faculty of Geography Universitas Gadjah Mada, Yogyakarta  
Phone +6281391179917  
Fax +62274569595  
[prama.wicaksono@geo.ugm.ac.id](mailto:prama.wicaksono@geo.ugm.ac.id)

Section Editor  
Indonesian Journal of Geography  
Faculty of Geography Universitas Gadjah Mada, Yogyakarta

# Tanggapan atas pesan tsb

29-03-2019

Editor/Author Correspondence - Google Chrome

journal.ugm.ac.id/ijg/author/viewEditorDecisionComments/40519#27245

Author  
2019-03-29 02:22 PM

Subject: Spectral Characteristics of Plastic Debris in the Beach: Case Study of Makassar Coastal Water [DELETE](#)

---

Dear Dr. Pramaditya Wicaksono,

Thank you for your fast response on our revisions. Before we revise the paper further, we would like to discuss about the data in spacelib that we used as a reference. The spacelib uses data in micrometer, and since our data was measured in nano meter, for convenience to compare with most publications which used wavelength in nano meter, so we choose to convert data in spacelib to nano meter. Since this conversion is widely used, so we think is acceptable to do it. However, if you think we must follow the spacelib unit wavelength in micro meter, we will revise all the manuscript regarding the unit.

Best regards,

Ahmad Faizal

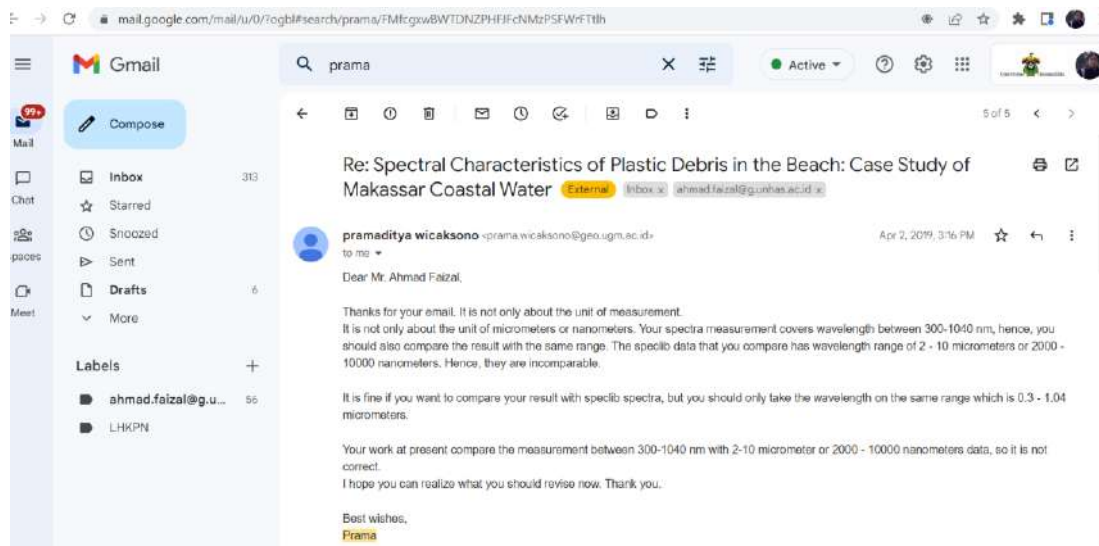
---

Chief Editor  
Indonesian Journal of Geography  
<http://jurnal.ugm.ac.id/index.php/ijg>  
0024-9521 (print), 2354-9114 (online)  
Phone: +62 812-2711-480

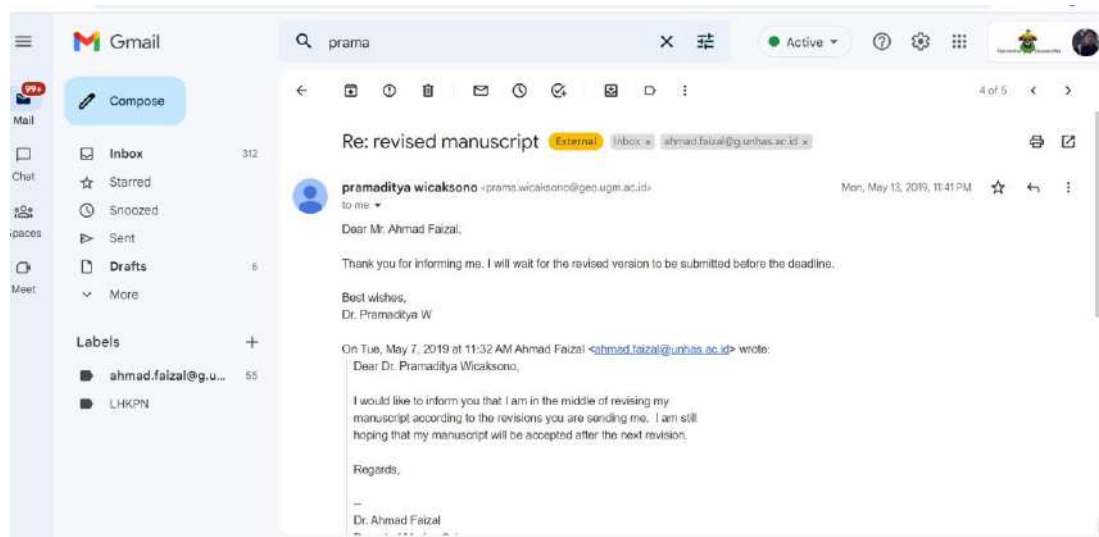
Author  
2019-03-29 02:22 PM

Subject: Spectral Characteristics of Plastic Debris in the Beach: Case Study of Makassar Coastal [DELETE](#)

## Karena ada masalah pada OJS maka Korespondensi ke 4 Via email

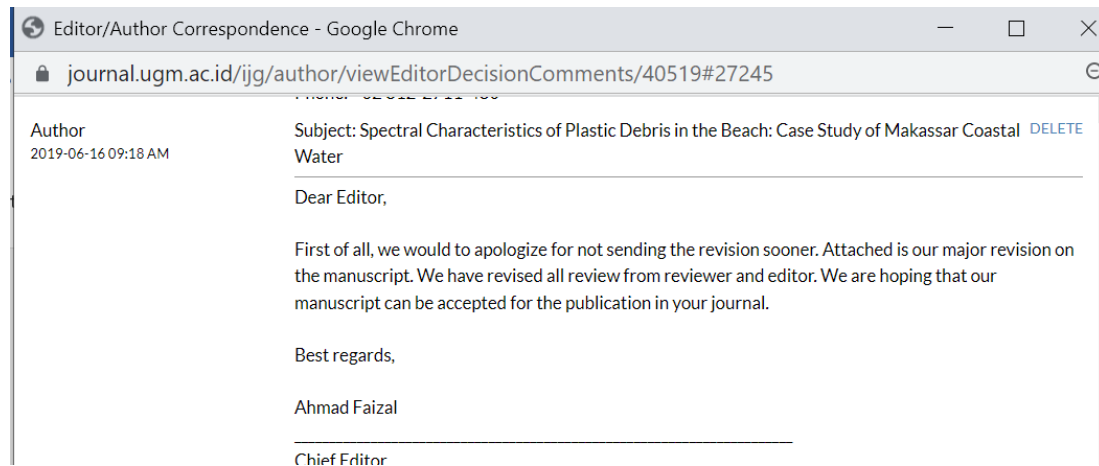


## Korespondensi ke 5 via email



# Korespondensi ke 6 Via OJS

16-06-2019



Berikut kami Lampirkan perbaikan  
Artikel Revisi ke 3

[40519-119685-3-ED.DOCX](#)

2019-06-16

# 1 Spectral Characteristics of Plastic Debris in the Beach: Case Study of Makassar Coastal Area

3  
4 **Abstract** Plastic debris becomes a global problem that threatens the coastal ecosystems, and the supralittoral area (beach) turns to be a place for plastic debris to accumulate. Data from the United Nation (UN) states that Indonesia is the second plastic debris contributor in world waters. This study aimed to examine the spectral characteristics of plastic debris accumulated in the beach. The data was collected from the coast of Makassar at 3 different stations: Jenneberang River estuary, Losari Beach and Tallo River estuary. The spectral sample was measured using a 4000 A spectroradiometer that works on a wavelength spectrum 340 - 1040 nm. The results showed that the optimum value for plastic debris identification in the coastal area at low tide (dry sand) is 443-760 nm and at high tide (wet sand) is 443-950 nm. This value will be a reference in the remote sensing method, especially multispectral classification in mapping plastic debris found in coastal areas, and will be one solution to effectively mapping plastic debris.

13 **Key words:** plastic debris, wavelength, spectral

14 **Abstrak** Sampah plastik menjadi masalah global yang mengancam kondisi ekosistem pesisir, dan daerah supralittoral (pantai) menjadi tempat penumpukan sampah plastik. Data United Nation (UN) menyebutkan bahwa Indonesia menjadi penyumbang sampah plastik nomor dua di perairan dunia. Penelitian ini bertujuan untuk mengkaji karakteristik spektral dari sampah plastik yang terakumulasi di daerah pantai. Data dikoleksi dari pesisir pantai Makassar pada 3 stasiun yang berbeda yaitu di muara Sungai Jenneberang, Pantai Losari dan Muara Sungai Tallo. Spektral sampel diukur dengan menggunakan spektrometri 4000 A yang bekerja pada spektrum panjang gelombang 340 - 1040 nm. Hasil penelitian menunjukkan nilai optimal untuk identifikasi sampah plastik di wilayah pantai pada kondisi pasir kering-surut adalah 443-760 nm dan pada kondisi pasir basah-pasang adalah 443-950 nm. Nilai ini akan menjadi referensi dalam metode penginderaan jauh khususnya klasifikasi multispectral dalam memetakan sampah plastik yang terdapat di wilayah pesisir, dan akan menjadi salah satu solusi metode pemetaan sampah plastik yang efektif.

24 **Kata kunci :** Sampah plastik, Panjang Gelombang, spektral

## 1. Introduction

26 Marine debris is now a global problem that has affected all water bodies, especially the water surface in coastal areas. Its influence visibly shows towards the economy, ecology, public health, and environmental aesthetics. Marine debris pollution is no longer a regional problem but has scaled up into a global or international problem. Marine debris, especially plastic in waters, has transformed into agents that potentially bring toxic chemicals, such as PCBs and heavy metals to human. Whilst microplastics, fragmented from larger plastic debris, that are largely invisible to humans, can also accumulate in the food chain (Driedger et al., 2013).

32 Some time ago, it was estimated that around 10% of debris has been discharged into the waters (Van Cauwenberghe et al., 2013) Generally, marine debris with various forms (such as plastic, metal, wood, clothing, etc.) accumulates in coastal areas (NOAA, 2015). The main sources of debris in the waters are from recreational activities, wind or storm, illegal dumping, sewage treatment plants, and fishing industry (Driedger et al., 2013).

Formatted: Highlight

Commented [A1]: Ed : The last sentence of the abstract is confusing. Please revise

Aut : This sentence has been revised and added one sentence to complete the meaning.

Deleted: This value will be a reference in the remote sensing method, especially multispectral classification in mapping plastic debris found in coastal areas, and will be one solution to effectively mapping plastic debris.

Nilai optimal untuk identifikasi sampah plastik di wilayah pantai pada kondisi pasir kering-surut adalah 443-760 nm dan pada kondisi pasir basah-pasang adalah 443-950 nm.

¶  
¶  
¶

Deleted: ¶

Formatted: Highlight

Deleted: ¶

Nilai Optimum untuk indentifikasi sampah plastik pada daerah pantai adalah 500-785 nm (Panjang gelombang hijau dan merah).

Deleted: ¶

Nilai optimal untuk identifikasi sampah plastik di wilayah pantai pada kondisi pasir kering-surut adalah 443-760 nm dan pada kondisi pasir basah-pasang adalah 443-950 nm.

¶  
¶

Deleted: ¶

Commented [A2]: Fd: Apparently, plastic debris in the sea are lethal to wildlife and fisheries. Mentioning this issues prior to explaining the cycle until it reaches human would be more appropriate. ( Reviewer)

Aut : We already revised this sentence into the more appropriate one. In the first sentence what we mean is plastic debris can bring toxic chemical and in the second sentence we meant that fragmented plastic debris can also accumulated through food chain. So, it could have double impacts.

1 In 2010, it was predicted that around 4.8 to 12.7 million metric tons of plastic debris had entered the ocean, from  
 2 192 countries and Indonesia is the second contributor to the sea debris after China. According to Jambeck et al.  
 3 (2015) Indonesia contributed plastic debris to the sea by 1.29 million tons/year after China by 3.53 million  
 4 tons/year in 2010. With regards to this condition, plastic debris pollution will add to a very large environmental  
 5 and socio-economic problems in Indonesian waters (Driedger et al., 2013).  
 6 Marine debris, especially plastic debris in the waters, due to hydro-oceanographic influences were stranded and  
 7 accumulated in the beach including in the coastal city of Makassar (Maulana, 2016). Identification of marine  
 8 debris has been carried out using traditional survey methods (Driedger et al., 2013) including in South Sulawesi  
 9 (Maulana, 2016). Another alternative that might be used is to employ the remote sensing method. The  
 10 identification of objects using this method is generally based on the spectral characteristics of the object, each  
 11 different material will give a different spectral curve, including plastic debris will give a different reflection curve  
 12 to the surrounding object (Driedger et al., 2013; Hörig et al., 2001; Pichel et al., 2007). This second alternative  
 13 enables relatively cheaper cost and faster time. The study of remote sensing of plastic debris in coastal areas was  
 14 still experimental. However, several researchers have tried to monitor marine debris in various parts of the world  
 15 (Aoyama, 2014; Jambeck et al., 2015; Mace, 2012; Veenstra & Churnside, 2012). This study aimed to examine  
 16 spectral characteristics of the plastic debris in the beach and will be used as a reference for identifying plastic debris  
 17 in coastal areas using satellite imagery.

19 **2. The Methods**

20 This research was carried out in coastal areas, especially in the beach of Makassar City, South Sulawesi Province,  
 21 at three stations with adequately different characteristics (Figure 1.). All stations were connected to the water ways  
 22 that comes from the city of Makassar that would potentially bring marine debris to the sea: Station 1, estuary of  
 23 Jeneberang River, represented exposure area and the water influenced by Jeneberang River; station 2, Losari Beach,  
 24 represented shelter area and the water influenced by the city small canals disemboque along Losari Beach; and  
 25 station 3, estuary of Tallo River, which represented semi enclosed area and the water influenced by Paotere Canal  
 26 and Tallo River.

28 The sample analysis was done at the Marine Ecology Laboratory, Marine Sciences Department, Hasanuddin  
 29 University and the Remote Sensing and Ecology Laboratory Seameo BIOTROP, Bogor.

**Commented [A3]:** FD : Please consider to change the measurement unit into ton  
 Aut : This sentence has been revised unit in ton

**Commented [A4]:** Fd : Providing a brief explanation on how remote sensing data are used to identify coastal-marine debris would be appropriate prior to mentioning objective of the study.  
 Aut : we have added an explanation of the remote sensing methodology

**Commented [A5]:** Fd : Brief explanation of each sampling site's characteristics and why it were selected should be provided in this section  
 Aut : We add sampling site's character and the reason why we selected the location

**Formatted:** Highlight

**Moved (insertion) [1]**

**Deleted:** dengan tipe sampah plastik yang baru terakumulasi.

**Deleted:** with dengan tipe sampah palstik yang sudah lama

**Deleted:** with tipe sampah .....

**Deleted:** ¶

**Deleted:** Station 1, estuary of Jeneberang River, represented the water influenced by Jeneberang River with substrate type of alluvial sand; station 2, Losari Beach, represented the water influenced by the city small canals disemboque along Losari Beach with sandy calcareous type sediment; and station 3, estuary of Tallo River, which represented the water influenced by Paotere Canal and Tallo River with sandy loam type of sediment.

**Moved up [1]:** Station 1, estuary of Jeneberang River, represented the water influenced by Jeneberang River dengan tipe sampah plastik yang baru terakumulasi. station 2, Losari Beach, represented the water influenced by the city small canals disemboque along Losari Beach with dengan tipe sampah palstik yang sudah lama and station 3, estuary of Tallo River, which represented the water influenced by Paotere Canal and Tallo River with tipe sampah .....

**Formatted:** Not Highlight



Figure 1. Makassar Coastal Water; Study area and sampling station

The spectral identification of plastic debris in the beach refers to the method used by Murphy et al. (2018) and its development with the implementation stages as follows:

a) *Sample collection*: sample collection was conducted in the beach of the coast of Makassar City, at three stations; Station 1 around the Jenneberang River Estuary, Station 2 around Losari Beach and Station 3 around the Tallo River Estuary up to the Paotere port. Furthermore, sorting of the collected sample was held in the Marine Ecology Laboratory, Marine Science Department with 10 plastic debris samples, with different characteristics.

b) *Sample Measurement*: The spectral value of the sample was measured using the Ocean Optics USB 4000 type spectrometer which works on a wavelength 340-1110 nm (nanometer). The spectral retrieval process involves spectrometers, light sources, optical fibers, and computers. One spectroradiometer part is connected to the light source and the other part is connected to the object being measured. The position of the light source does not directly face the sun but forms an angle of approximately 45° and 100 millisecond scanning time (Halma, 2008)

c) *Spectra Collection*: Replay values from samples are recorded using a computer equipped with software Ocean Optics Spectra Suite USB-4000. The spectroradiometer used has a wavelength range of 350-1040 nm with spectrometer components including 3648 linear silicon CCD Array elements, solar sources in the field, optical fibers with a diameter of 400 μm and a length of 2 meters, and a computer. The measurement steps are as follows:  
 1. Dark Calibration, a calibration was taken with dark spectral technique and a reference. The dark spectral technique is a data spectral retrieval without light and samples, and a reference technique is taking spectral data using a reference from diffuse reflectance standard model WS-1, Ocean Optics USA.

**Commented [A6]:** 1.Referring the map in the above text body is not helping the reader(s) in understanding the characteristics of three sampling sites.

2.It is more appropriate to label the blue area as 'water bodies' rather than 'river' as the sea is also present.

3.Please change the background of lower right map to blue to match two other maps.

4.Pay attention to the color intensity of the symbol in the legend and what was draw on the map as they are different.

**Aut :** The map has been revised

**Formatted:** Highlight

**Commented [A7]:** Ed : Explain the detail of spectrometer setting. For example, integration time, boxcar width, etc

**Aut :** the spectrometer setting method has been added.

**Formatted:** Highlight

**Formatted:** Highlight

**Formatted:** Font color: Auto

**Deleted:** Dengan tahapan pengukuran sebagai berikut

1 Reference Calibration/Light Calibration: Reference calibration is carried out by allowing light to reach an  
 2 equilibrium (takes 30 minutes), making sure all cuvettes are clean of dust or dirt and are functioning  
 3 normally. The integration time is optimized to reach ~ 80%. The reference data obtained is stored as a  
 4 reference for sample measurements.

5 - Setting Boxcar. The boxcar settings are adjusted to a value that is approximately the same as the pixel  
 6 resolution of the spectrometer, the spatial resolution of the tool is 8  $\mu\text{m} \times 200 \mu\text{m}$ .

7 - Spectral and Integration time measurement: At the time of measurement, one optic fiber section is  
 8 connected to the light source and the spectrometer, other optic fiber parts are connected to the sample.  
 9 Spectral reflectance of the plastic debris is measured twice, with integration time of 100 ms and resulting  
 10 in 50 scans for each measurement, after which the spectral measurement were averaged

11

12 d. Data analysis used numeric data processing devices, the measurement data was classified by eliminating error  
 13 values and cutting off visible and near-infrared light waves. Furthermore, the data was made into graphical form  
 14 with smoothing graphs, and were statistically analysed using One-Way Analysis of Varians to evaluate differences  
 15 of spectral reflectance curves among stations. The spectral reflectance curves were then compared to spectral  
 16 reflectance of beach sand during dry conditions (occurring during low tide or beach sand which is not affected by  
 17 tidal-range) and beach sand during wet conditions (occurs during high tide or beach sand which is still affected  
 18 by tidal rides) by Nolet et al., 2014.

19

20 **3. Result and Discussion**

21 Spectral measurement results of each sample at each station are presented in Figure 2. The spectral reflectance  
 22 curve of each sample shows the same reflectance pattern on each wavelength spectrum. Figure 2 shows a tendency  
 23 of an increase in spectral reflectance curves for each station. At station 1 there is an increase in spectral curves at  
 24 wavelengths of 500-625 nanometers (nm), at station 2 the tendency of the increase of spectral curves occurs at  
 25 wavelengths of 470-600 nm and at station 3 the tendency of the increase spectral curves happens at wavelengths  
 26 of 450-570 nm. The graph in Figure 2 shows the difference of the amount of data, this is due to noise that occurred  
 27 when the recording started so the spectral reflectance curve is smaller than 0%, the value is eventually selected and  
 28 considered as error data and not employed. The measurement of plastic debris spectral reflectance using a  
 29 radiation source directly from the sun, which has a high wavelength (> 800 nm), was found to have a lot of noise  
 30 that appears most likely caused by low primary light intensity at the time of measurement. According to Michael  
 31 and Stefan (2000) and Dennis et al., (2004), noises occur at spectral reflectance recording are due to poor primary  
 32 light intensity from sun and so noise comes up and enters. They also stated that the noise is further enhanced as a  
 33 result of high sample attenuation and making the transmitted light intensity is very poor and thus gets noisy.

34

35

**Deleted:** ¶

**Formatted:** Font: (Default) Minion Pro, 10 pt, Complex Script  
 Font: Courier New, 10 pt, Highlight

**Deleted:** <#>Kalibrasi referensi dilakukan dengan membiarkan cahaya mencapai kesetimbangan (dibutuhkan waktu selama 30 menit), pastikan semua semua kuvet bersih dari debu atau kotoran dan berfungsi normal. Waktu integrasi sikyal dioptimalkan hingga mencapai ~80%. Data referensi yang didapatkan disimpan untuk menjadi referensi pada pengukuran sampel. ¶

**Deleted:** <#>

**Formatted:** Font: Minion Pro, , Highlight

**Deleted:** <#>Pengaturan boxcar disesuaikan dengan nilai yang kira-kira sama dengan resolusi piksel spektrometer, resolusi spasial alat adalah 8  $\mu\text{m} \times 200 \mu\text{m}$ . ¶

**Deleted:** <#>Pengukuran Spektral dan Integrasi waktu pengukuran ;

**Deleted:** ¶

**Deleted:**

**Deleted:** analisis variasi untuk uji beda nyata kurva pantulan spectral antar stasiun

**Deleted:**

**Formatted:** Font: Minion Pro, Highlight

**Deleted:** and compared with sand's spectral reflectance obtained from data spectral library provided by Hook (2018) and Hewson (1998).. ¶  
 dikomparasi dengan pantulan spectral pasir pantai pada saat kondisi kering (terjadi pada saat surut atau pasir pantai yang tidak terpengaruh tidal-range) dan pasir pantai pada saat kondisi basah (terjadi pada saat pasang atau pasir pantai yang masih terpengaruh tidal-range) by Nolet et al, 2014. ¶

**Commented [A9]:** Ed. : In most figures, the reflectance beyond 800 nm have a lot of noise. Can you explain why?  
 Aut : These sentences are the explanation of the occurrence of noise at a wavelength of > 800 nm

**Deleted:** The measurement of plastic debris spectral reflectance used a radiation source directly from the sun, which has a high wavelength (> 800 nm). According to Jensen (2004), the higher the wavelength spectrum, the weaker the energy reflected, which could cause a lot of noise as depicted in figure 2 and 3. ¶

**Deleted:** ed

**Formatted:** Highlight

**Formatted:** Font: 10 pt, Complex Script Font: Times New Roman, 10 pt, English (United States), Highlight

**Formatted:** Font: (Default) Minion Pro, 10 pt, Complex Script Font: Times New Roman, 10 pt, English (United States), Highlight

**Deleted:** accure

**Formatted:**

**Formatted:** Font: (Default) Minion Pro, 10 pt, Complex Script Font: Times New Roman, 10 pt, English (United States)

**Formatted:** Font: (Default) Minion Pro, Complex Script Font: Times New Roman

**Deleted:** ditemukan banyak noise yang muncul kemungkinan besar disebabkan oleh rendahnya intensitas cahaya primer pada saat ¶

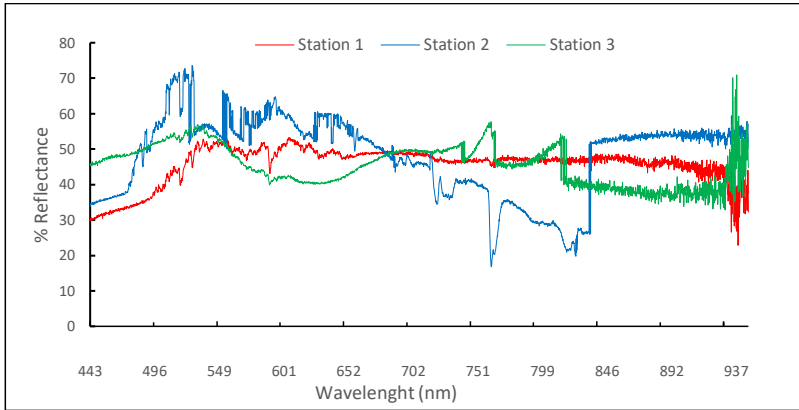


Figure 2. Spectral Reflectance Curve of plastic debris for each sample at all stations.

The difference in the spectral characteristics of plastic debris at each station is shown in Figure 2. The characteristics of each station are obtained from the average spectral reflectance value of each sample at each station. The average spectral reflectance value of each station shows the similarity of spectral reflectance patterns. The spectral reflectance pattern of each station starts to show an increase in the wavelength of 500 nm (blue wavelength) and decreases at a wavelength of 800 nm (red wavelength).

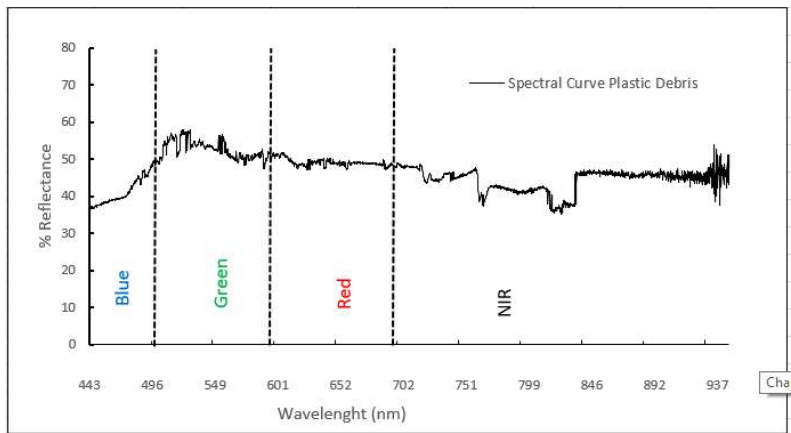


Figure 3. Comparison of spectral curve plastic debris with divisions based on wavelength.

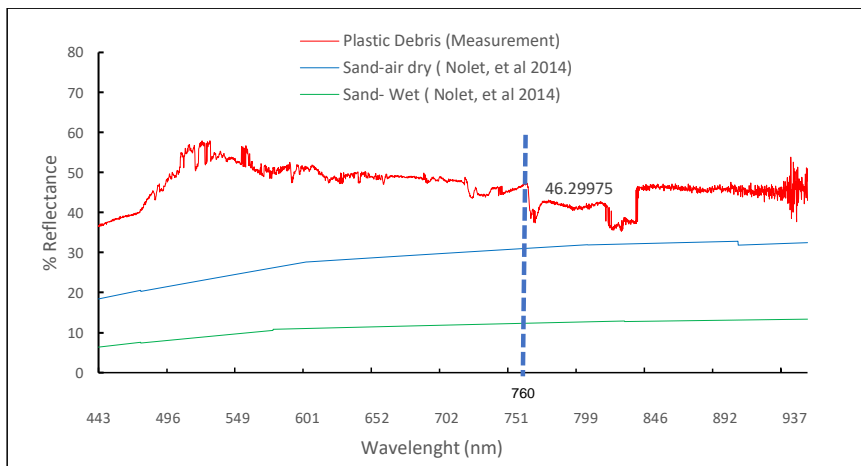
Figure 2 denotes the difference in spectral reflectance curves between each sample with the same pattern tendency. The difference in spectral reflectance curves of each object is influenced by several factors; characteristics of object or sample, the amount of light penetration received by objects (Murphy et al., 2018). Plastics found at the study site have different chemical compositions which will give different reflectance, plastic debris consists of several types; polyethylene (PE), poly-propylene (PP), polyvinylchloride (PVC), poly-amide (nylon) and polystyrene (PS)

Commented [A10]: Ed : Typo in y-axis of Figure 4

Aut : The Graph in Figure 4 has been corrected

1 (Andrady, 2015). Different chemical compositions resulted in different spectral reflectance values as well (Imhof  
 2 et al., 2017). Another factor is because the found samples have been degraded and have weathered naturally or  
 3 partially fragmented into microplastic (GESAMP, 2015; Shah et al., 2008; Thevenon F., 2014). In different time  
 4 and weather conditions, the sunlight's penetration that reaches to the earth's surface also varies, the number of  
 5 wavelengths that reach the earth's surface or the object is affected by the amount of scattering and absorption of  
 6 particles in the atmosphere (Lillesand et al., 2015; Murphy et al., 2018).  
 7 The tendency of reflectance pattern of each sample at every station (Figure 2) is almost the same, this is due to  
 8 similarity of the main chemical component of the plastic (Andrady, 2015). In several hyperspectral studies with  
 9 different objects and similar main components, have similar spectral patterns, such as vegetation (Huete, 1988),  
 10 coral reefs (Hochberg et al., 2003), soil (Lillesand et al., 2015) and others.  
 11 The spectral reflectance pattern of plastic debris found in the beach at all observation stations (Figure 3) shows  
 12 various spectral values with optimum spectral reflectance values at 500 - 700 nm. Based on wavelengths division,  
 13 that range is at the visible wavelength (400 - 700 nm). In detail, the visible wavelength is divided into 3 wavelengths;  
 14 Blue (400 - 500 nm), Green (500 - 600 nm) and Red (600 - 700 nm). One factor that might cause differences in  
 15 the spectral characteristics of each station is the presence of macroalgae that began to grow in various samples,  
 16 will automatically influence the spectral reflection of each object at each station (Diaz and Rosenberg, 1995).  
 17 The analysis of variance on the data of all stations showed no differences in the spectral characteristics of each  
 18 station ( $p > 0.05$ ) therefore the spectral values of each station were averaged and compiled with the spectral  
 19 [reflectance curves from sand beach at two conditions of volumetric moisture content of 32% \(wet or saturation\)](#)  
 20 [and 0.01% \(air-dry\) \(Nolet et al., 2014\) as in Figure 4](#).

21



22

23 **Figure 4.** Comparison of the average value of plastic reflectance with sand reflectance [by Nolet, et al :2014](#)

**Deleted:** saturation

**Deleted:** reflectance of mud sand (Hook, 2018), sand, and calcareous sand (Hewson, 1998) as in Figure 4  
 Curve reflectance dari pasir pantai pada dua kondisi yaitu volumetric moisture content 32% (saturation) and 0.01% (air-dry by Nolet et al. 2014) as in Figure 4

**Commented [A11]:** Ed : In Figure 4, the curve for sand objects did not seem correct? are you sure it is the correct sand reflectance

**Aut ;** has been corrected

1 The reflectance graph in Figure 4 shows there is a difference in reflectance curves between plastic debris and sand  
2 both in dry air conditions (air-dry) and in conditions of wet sand (saturation). The wavelength range of 443-760  
3 nm is the best wavelength for identification of plastic debris in the condition of air-dry beach, in the case of wet  
4 beach sand the overall wavelength range of 443-950 nm is optimal for use. If it is connected with a range of visible  
5 light waves, the results show that in dry beach sand conditions, identification of plastic debris can be carried out  
6 at blue, green and red wavelengths and in wet sand conditions it can use all visible and near infrared waves.

8 The use of multispectral classification techniques by utilizing spectral values of objects can be done in a broad  
9 scale mapping (Jensen, 2004). Including the utilization of the spectral curve from plastic waste, a multispectral  
10 classification can also be carried out for mapping the distribution of plastic debris. But in its implementation the  
11 identification of plastic debris objects can only be done: 1) in the locations of accumulated plastic debris, and it is  
12 less likely to be used to detect the distribution of small amount or scattered plastic debris, 2) to detect plastic debris  
13 on the surface of the substrates. Another obstacle to the identification of plastic debris is related to spatial  
14 resolution, the lower the resolution, the lower the recognition of objects (Moy et al., 2018).

16 The difference in the spectral value of an object, including plastic debris, will be a reference in the remote sensing  
17 method, especially in multispectral classification. Our result of plastic debris spectral curve could be a reference  
18 for plastic debris mapping in coastal area. The mapping of plastic debris distribution with the remote sensing  
19 method will be a solution in effectively mapping the plastic debris.

#### 22 4. Conclusion

23 This study aims to examine the spectral characteristics of plastic debris in the coastal area (beach) of Makassar  
24 City with different type of exposure. Our results showed spectral characteristics of plastic debris were not different  
25 between stations, therefore the substrates where plastic debris found were not affecting the spectral reflection  
26 curve of plastic debris. The optimal value for identification of plastic debris in the coastal beach under conditions  
27 of dry sand-low tide is 443-760 nm and in the condition of wet sand-high tide is 443-950 nm. This value will be a  
28 reference in the remote sensing method, especially multispectral classification in mapping plastic debris found in  
29 coastal areas, and will be one solution to effectively mapping plastic debris.

#### 31 Acknowledgement

32 This research was done with research funding from the Competency-Based Research Scheme (Penelitian Berbasis  
33 Kompetensi) with Contract Number L 1715 / UN4.21 / PL.00.00 / 2018. This research, in addition, was also carried  
34 out with participation of Widodo, Researcher in the Laboratory of Remote Sensing and Ecology, SEAMEO  
35 Biotrop, also Sunarto and Muhammad Ilham from the Faculty of Marine and Fisheries, Hasanuddin University.

**Formatted:** Font: (Default) Minion Pro, Complex Script Font: Times New Roman, , Highlight

**Deleted:** Berdasarkan grafik reflektansi yang pada Gambar 4 menunjukkan adanya perbedaan kurva reflektansi antara sampah plastik dengan pasir baik pada kondisi pasir kering (air-dry) maupun pada kondisi pasir yang basah (saturation). Rentang panjang gelombang 443-760 nm adalah Panjang gelombang yang terbaik untuk identifikasi sampah plastik pada kondisi pasir pantai yang kering (air-dry), pada kondisi pasir pantai basah maka keseluruhan rentang panjang gelombang yakni 443-950 nm optimal untuk dimanfaatkan. Jika dihubungkan dengan range gelombang cahaya tampak maka hasil penelitian menunjukkan bahwa pada kondisi pasir pantai yang kering maka identifikasi sampah plastik dapat dilakukan pada Panjang gelombang biru, hijau dan merah dan pada kondisi pasir yang basah maka dapat menggunakan keseluruhan gelombang cahaya tampak dan inframerah dekat.

**Deleted:** of substrates namely sandy, calcareous and muddy substrates.

**Formatted:** Highlight

**Deleted:** Dengan karakteristik pantai yang berbeda yaitu.....

**Formatted:** Font: (Default) Minion Pro, Complex Script Font: Times New Roman, Highlight

**Deleted:** Optimum value for identification of plastic debris in the coastal area is 500-785 nm (green and red wavelengths).

**Formatted:** Highlight

**Commented [A12]:** Conclusion should not only contain summary of what was written, but should correlate or promote the study relevancy with nowadays problems and/or the study continuity (e.g. as potential source of remote-sensing based debris identification).

**Aut :** Has been revised

**Deleted:** Nilai optimal untuk identifikasi sampah plastik di wilayah pantai pada kondisi pasir kering-surut adalah 443-760 nm dan pada kondisi pasir basah-pasang adalah 443-950 nm.

1   **References**

2   Andrady, A. L. (2015). Persistence of plastic litter in the oceans. In M. In: Bergmann, Gutow, L., Klages, M (Ed.),  
3    *Marine Anthropogenic Litter* (pp. 57-22): Springer International Publishing AG Switzerland.

4   Aoyama, T. (2014). *Monitoring of marine debris in the sea of Japan using multi-spectral satellite images* Paper  
5    presented at the SPIE Asia-Pacific Remote Sensing.

6   Dennis F. Flanigan, Alan C. Samuels, and Avishai Ben-David 2004 . Noise assessment of a Fourier transform  
7    infrared spectroradiometer subject to the stability of a conventional laboratory blackbody source," *Appl.*  
8    *Opt.* 43, 2767-2776 .

9

10   Diaz R.J. & Rosenberg R., 1995. Marine benthic hypoxia: A review of its ecological effects and the behavioural  
11    responses of benthic macrofauna. *Oceanography and Marine Biology – An Annual Review*, 33: 245-303.

12   Driedger, H. Durr, K. Mitchel, J. Flannery, E. Brancazi, & Cappelen, P. V. (2013). *Plastic Debris; Remote sensing*  
13    *and characterization*. Canada: University of Waterloo.

14   GESAMP. (2015). *Sources, fate and effects of microplastics in the marine environment: Part two of a global*  
15    *assessment* (P. J. K. a. C. M. Rochman Ed.). 4 Albert Embankment, London SE1 7SR: INTERNATIONAL  
16    MARITIME ORRGANIZATION.

17   Halma, C. (2008). *USB4000 Fiber Optic Spectrometer: Instalation and Operation Manual*. Retrieved from  
18    [www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf](http://www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf)

19

20   Hochberg, E. J., Atkinson, M. J., & Andréfouët, S. (2003). Spectral reflectance of coral reef bottom-types worldwide  
21    and implications for coral reef remote sensing. *Remote Sensing of Environment*, 85(2), 159-173.  
22    doi:[https://doi.org/10.1016/S0034-4257\(02\)00201-8](https://doi.org/10.1016/S0034-4257(02)00201-8)

23

24   Hörig, B., Kühn, F., Oshütz, F., & Lehmann, F. (2001). HyMap hyperspectral remote sensing to detect  
25    hydrocarbons. *International Journal of Remote Sensing*, 22(8), 1413-1422. doi:10.1080/01431160120909

26   Huete, A. R. (1988). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, 25(3), 295-309.  
27    doi:[https://doi.org/10.1016/0034-4257\(88\)90106-X](https://doi.org/10.1016/0034-4257(88)90106-X)

28   Imhof, H. K., Sigl, R., Brauer, E., Feyl, S., Giesemann, P., Klink, S., Leupolz, K., Loder, M.G.J., Löschel, L.A., Missun,  
29    Jan Muszynski, S., Ramsperger, A.F. R. M., Schrank, I., Speck, S., Steibl, S., Trotter, B., Winter, I.,  
30    Laforsch, C. (2017). Spatial and temporal variation of macro-, meso- and microplastic abundance on a  
31    remote coral island of the Maldives, Indian Ocean. *Marine Pollution Bulletin*, 116(1), 340-347.  
32    doi:<https://doi.org/10.1016/j.marpolbul.2017.01.010>

33   Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., Law, K. L. (2015).  
34    Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771. doi:10.1126/science.1260352

35   Jensen, J.R. (2004) *Introductory Digital Image Processing: A Remote Sensing Perspective*. 3rd Edition, Prentice-  
36    Hall, Inc., New York, 316.

37   Lillesand, Ralph W. Kiefer , & Chipman, J. (2015). *Remote Sensing and Image Interpretation*: John Wiley and Sons.

38   Mace, T. H. (2012). At-sea detection of marine debris: Overview of technologies, processes, issues, and options.  
39    *Marine Pollution Bulletin*, 65(1), 23-27. doi:<https://doi.org/10.1016/j.marpolbul.2011.08.042>

40   Maulana, F. (2016). *Identifikasi sampah laut di kawasan wisata pantai Kota Makassar*. (Skripsi), Universitas  
41    Hasanuddin, Makassar.

42   Michael E. Schaepman and Stefan Dangel 2000. *Solid laboratory calibration of a nonimaging spectroradiometer*,  
43    *Appl. Opt.* 39, 3754-3764.

44   Moy, K., Neilson, B., Chung, A., Meadows, A., Castrence, M., Ambagis, S., & Davidson, K. (2018). Mapping coastal  
45    marine debris using aerial imagery and spatial analysis. *Marine Pollution Bulletin*, 132, 52-59.  
46    doi:<https://doi.org/10.1016/j.marpolbul.2017.11.045>

47   Murphy, L. G., Peters, S., van Sebille, E., James, N. A., & Gibb, S. (2018). Concept for a hyperspectral remote sensing  
48    algorithm for floating marine macro plastics. *Marine Pollution Bulletin*, 126, 255-262.  
49    doi:<https://doi.org/10.1016/j.marpolbul.2017.11.011>

50   NOAA. (2015). *Turning The Tide On Trash. A Learning Guide On Marine Debris*. NOAA PIFSC CRED.

51

52   Nolet C, Poortinga A, Roosjen P, Bartholomeus H, Ruessink G (2014) Measuring and Modeling the Effect of Surface  
53    Moisture on the Spectral Reflectance of Coastal Beach Sand. *PLOS ONE* 9(11): e112151.  
54    <https://doi.org/10.1371/journal.pone.0112151>

Field Code Changed

Field Code Changed

Field Code Changed

**Deleted:** Hook, S. J. (2018). ECOSTRESS Spectral Library -  
Version 1.0 — ECOSTRESS Speclib. Retrieved from  
<https://speclib.jpl.nasa.gov/library/>

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

1 Pichel, W. G., Churnside, J. H., Veenstra, T. S., Foley, D. G., Friedman, K. S., Brainard, R. E., Nicoll, J.B., Zheng, Q.,  
2 Clemente-Colón, P. (2007). Marine debris collects within the North Pacific Subtropical Convergence  
3 Zone. *Marine Pollution Bulletin*, 54(8), 1207-1211. doi:<https://doi.org/10.1016/j.marpolbul.2007.04.010>  
4 Shah, A. A., Hasan, F., Hameed, A., & Ahmed, S. (2008). Biological degradation of plastics: A comprehensive review.  
5 *Biotechnology Advances*, 26(3), 246-265. doi:<https://doi.org/10.1016/j.biotechadv.2007.12.005>  
6 Thevenon F., C. C., Sousa J. (2014). *Plastic Debris in the Ocean. The Characterization of Marine Plastics and their*  
7 *Environmental Impacts. Situation Analysis Report*. Gland, Switzerland: IUCN  
8 Van Cauwenberghe, L., Claessens, M., Vandegehuchte, M. B., Mees, J., & Janssen, C. R. (2013). Assessment of  
9 marine debris on the Belgian Continental Shelf. *Marine Pollution Bulletin*, 73(1), 161-169.  
10 doi:<https://doi.org/10.1016/j.marpolbul.2013.05.026>  
11 Veenstra, T. S., & Churnside, J. H. (2012). Airborne sensors for detecting large marine debris at sea. *Marine*  
12 *Pollution Bulletin*, 65(1), 63-68. doi:<https://doi.org/10.1016/j.marpolbul.2010.11.018>

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

# Korepondensi ke 7

08-08-2019

Editor/Author Correspondence - Google Chrome

journal.ugm.ac.id/ijg/author/viewEditorDecisionComments/40519#27245

<http://jurnal.ugm.ac.id/index.php/ijg>  
0024-9521 (print),2354-9114 (online)  
Phone: +62 812-2711-480

Editor  
2019-08-08 10:19 AM

Subject: [IJG] Editor Decision: Minor Revision Required DELETE

Dear Mr. Ahmad Faizal,

Thank you for submitting your revised manuscript. In general, I'm happy with the improvement. However, there are still some corrections need to be done.

1. Format your manuscript and reference following the journal guideline
2. See attached file for the additional comments.

Once again, thank you for submitting your manuscript to the Indonesian Journal of Geography and I look forward to receiving your revision no later than 30 days from now. If you failed to meet the deadline, we may have to consider your paper rejected.

Best wishes,  
Dr. Pramaditya Wicaksono  
ID SCOPUS: 54279699900, Faculty of Geography Universitas Gadjah Mada, Yogyakarta  
Phone +6281391179917  
Fax +62274569595  
prama.wicaksono@geo.ugm.ac.id  
Section Editor  
Indonesian Journal of Geography  
Faculty of Geography, Universitas Gadjah Mada, Yogyakarta

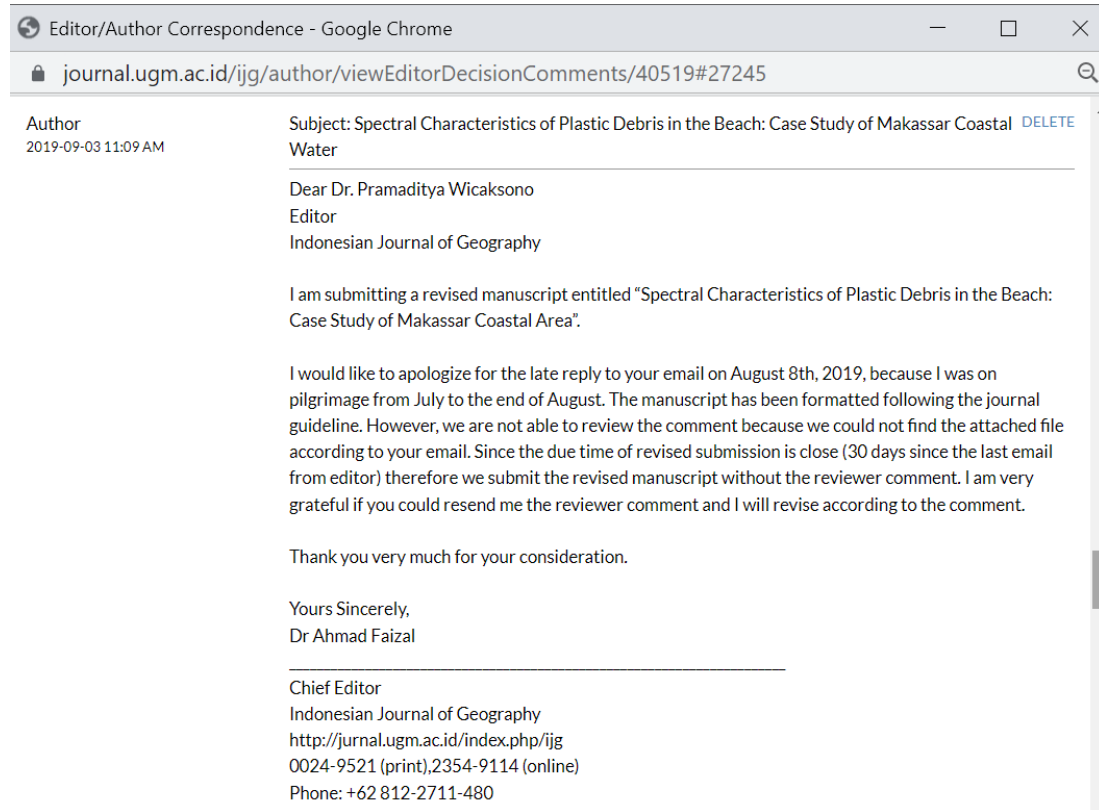
---

Chief Editor  
Indonesian Journal of Geography  
<http://jurnal.ugm.ac.id/index.php/ijg>  
0024-9521 (print),2354-9114 (online)  
Phone: +62 812-2711-480

## Perbaikan atas revisi sebelumnya

### Korespondensi ke 8

03-09-2019



The screenshot shows a web browser window with the title "Editor/Author Correspondence - Google Chrome". The address bar contains the URL "journal.ugm.ac.id/ijg/author/viewEditorDecisionComments/40519#27245". The email content is as follows:

Author  
2019-09-03 11:09 AM

Subject: Spectral Characteristics of Plastic Debris in the Beach: Case Study of Makassar Coastal Water [DELETE](#)

---

Dear Dr. Pramaditya Wicaksono  
Editor  
Indonesian Journal of Geography

I am submitting a revised manuscript entitled "Spectral Characteristics of Plastic Debris in the Beach: Case Study of Makassar Coastal Area".

I would like to apologize for the late reply to your email on August 8th, 2019, because I was on pilgrimage from July to the end of August. The manuscript has been formatted following the journal guideline. However, we are not able to review the comment because we could not find the attached file according to your email. Since the due time of revised submission is close (30 days since the last email from editor) therefore we submit the revised manuscript without the reviewer comment. I am very grateful if you could resend me the reviewer comment and I will revise according to the comment.

Thank you very much for your consideration.

Yours Sincerely,  
Dr Ahmad Faizal

---

Chief Editor  
Indonesian Journal of Geography  
<http://jurnal.ugm.ac.id/index.php/ijg>  
0024-9521 (print), 2354-9114 (online)  
Phone: +62 812-2711-480

## Lampiran File Perbaikan

40519-119685-4-ED

03-09-2019

# 1 Spectral Characteristics of Plastic Debris in the Beach: Case Study 2 of Makassar Coastal Area

3

4 **Ahmad Faizal, Shinta Werorilangi, Wasir Samad**

5 Departement Ilmu Kelautan, Universitas Hasanuddin, Indonesia

6 [ahmad.faizal@unhas.ac.id](mailto:ahmad.faizal@unhas.ac.id)

7

8 **Abstract** *Plastic debris becomes a global problem that threatens the coastal ecosystems, and the supralittoral area (beach) turns*  
9 *to be a place for plastic debris to accumulate. Data from the United Nations (UN) states that Indonesia is the second plastic*  
10 *debris contributor in world waters. This study aimed to examine the spectral characteristics of plastic debris accumulated on*  
11 *the beach. The data was collected from the coast of Makassar at 3 different stations: Jenneberang river estuary, Losari Beach*  
12 *and Tallo River estuary. The spectral sample was measured using a 4000 A spectroradiometer that works on a wavelength*  
13 *spectrum 340 - 1040 nm. The results showed that the optimum value for plastic debris identification in the coastal area at low*  
14 *tide (dry sand) is 443-760 nm and at high tide (wet sand) is 443-950 nm. This value will be a reference in the remote sensing*  
15 *method, especially multispectral classification in mapping plastic debris found in coastal areas, and will be one solution to*  
16 *effectively mapping plastic debris.*

17

18 **Keywords:** plastic debris, wavelength, spectral

19

20 **Abstrak** *Sampah plastik menjadi masalah global yang mengancam kondisi ekosistem pesisir, dan daerah supralittoral (pantai)*  
21 *menjadi tempat penumpukan sampah plastik. Data United Nation (UN) menyebutkan bahwa Indonesia menjadi penyumbang*  
22 *sampah plastik nomer dua di perairan dunia. Penelitian ini bertujuan untuk mengkaji karakteristik spektral dari sampah*  
23 *plastik yang terakumulasi di daerah pantai. Data dikoleksi dari pesisir pantai makassar pada 3 stasiun yang berbeda yaitu di*  
24 *muara Sungai Jenneberang, Pantai Losari dan Muara Sungai Tallo. Spektral sampel diukur dengan menggunakan*  
25 *spektroradiometer 4000 A yang bekerja pada spektrum panjang gelombang 340 – 1040 nm. Hasil penelitian menunjukkan nilai*  
26 *optimal untuk identifikasi sampah plastic di wilayah pantai pada kondisi pasir kering\_surut adalah 443-760 nm dan pada*  
27 *kondisi pasir basah-pasang adalah 443-950 nm. Nilai ini akan menjadi referensi dalam metode penginderaan jauh khususnya*  
28 *klasifikasi multispectral dalam memetakan sampah plasik yang terdapat di wilayah pesisir, dan akan menjadi salah satu solusi*  
29 *metode pemetaan sampah plastik yang efektif.*

30

31 **Kata kunci :** Sampah plastik, Panjang Gelombang, spektral

## 32 **1. Introduction**

33 Marine debris is now a global problem that has affected all water bodies, especially the water surface in coastal  
34 areas. Its influence visibly shows towards the economy, ecology, public health, and environmental aesthetics.  
35 Marine debris pollution is no longer a regional problem but has scaled up into a global or international problem.  
36 Marine debris, especially plastic in waters, has transformed into agents that potentially bring toxic chemicals, such  
37 as PCBs and heavy metals to humans. Whilst microplastics, fragmented from larger plastic debris, that are largely  
38 invisible to humans, can also accumulate in the food chain (Driedger et al., 2013).

1 Some time ago, it was estimated that around 10% of debris has been discharged into the waters (Van  
2 Cauwenberghe et al., 2013) Generally, marine debris with various forms (such as plastic, metal, wood, clothing,  
3 etc.) accumulates in coastal areas (NOAA, 2015). The main sources of debris in the waters are from recreational  
4 activities, wind or storm, illegal dumping, sewage treatment plants, and fishing industry (Driedger et al., 2013).  
5 In 2010, it was predicted that around 4.8 to 12.7 million metric tons of plastic debris had entered the ocean, from  
6 192 countries and Indonesia is the second contributor to the sea debris after China. According to Jambeck et al.  
7 (2015), Indonesia contributed plastic debris to the sea by 1.29 million tons/year after China by 3.53 million  
8 tons/year in 2010. With regards to this condition, plastic debris pollution will add to a very large environmental  
9 and socio-economic problems in Indonesian waters (Driedger et al., 2013).  
10 Marine debris, especially plastic debris in the waters, due to hydro-oceanographic influences were stranded and  
11 accumulated in the beach including in the coastal city of Makassar (Maulana, 2016). Identification of marine  
12 debris has been carried out using traditional survey methods (Driedger et al., 2013) including in South Sulawesi  
13 (Maulana, 2016). Another alternative that might be used is to employ the remote sensing method. The  
14 identification of objects using this method is generally based on the spectral characteristics of the object, each  
15 different material will give a different spectral curve, including plastic debris will give a different reflection curve  
16 to the surrounding object (Driedger et al., 2013; Hörig et al., 2001; Pichel et al., 2007). This second alternative  
17 enables relatively cheaper cost and faster time. The study of remote sensing of plastic debris in coastal areas was  
18 still experimental. However, several researchers have tried to monitor marine debris in various parts of the world  
19 (Aoyama, 2014; Jambeck et al., 2015; Mace, 2012; Veenstra & Churnside, 2012). This study aimed to examine  
20 spectral characteristics of the plastic debris on the beach and will be used as a reference for identifying plastic  
21 debris in coastal areas using satellite imagery.

22

## 23 **2. The Methods**

24 This research was carried out in coastal areas, especially in the beach of Makassar City, South Sulawesi Province,  
25 at three stations with adequately different characteristics (Figure 1.). All stations were connected to the waterways  
26 that come from the city of Makassar that would potentially bring marine debris to the sea: Station 1, estuary of  
27 Jeneberang River, represented exposure area and the water influenced by Jeneberang River; station 2, Losari Beach,  
28 represented shelter area and the water influenced by the city small canals disembogues along Losari Beach; and  
29 station 3, estuary of Tallo River, which represented semi-enclosed area and the water influenced by Paotere Canal  
30 and Tallo River.

31 The sample analysis was done at the Marine Ecology Laboratory, Marine Sciences Department, Hasanuddin  
32 University and the Remote Sensing and Ecology Laboratory Seameo BIOTROP, Bogor.

33

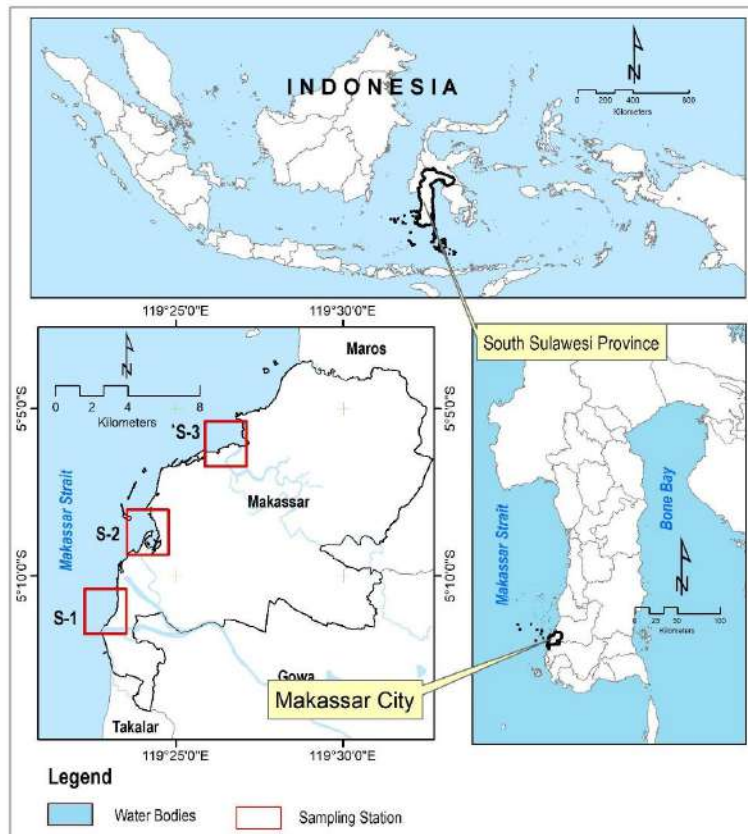


Figure 1. Makassar Coastal Water; Study area and sampling station

The spectral identification of plastic debris in the beach refers to the method used by Murphy et al. (2018) and its development with the implementation stages as follows:

a) *Sample collection*: sample collection was conducted on the beach of the coast of Makassar City, at three stations; Station 1 around the Jenneberang River Estuary, Station 2 around Losari Beach and Station 3 around the Tallo River Estuary up to the Paotere port. Furthermore, sorting of the collected sample was held in the Marine Ecology Laboratory, Marine Science Department with 10 plastic debris samples, with different characteristics.

b) *Sample Measurement*: The spectral value of the sample was measured using the Ocean Optics USB 4000 type spectrometer which works on a wavelength 340-1110 nm (nanometer). The spectral retrieval process involves spectrometers, light sources, optical fibers, and computers. One spectroradiometer part is connected to the light source and the other part is connected to the object being measured. The position of the light source does not directly face the sun but forms an angle of approximately 45° and 100 millisecond scanning time (Halma, 2008)

c) *Spectra Collection* Replay values from samples are recorded using a computer equipped with software Ocean Optics Spectra Suite USB-4000. The spectroradiometer used has a wavelength range of 350-1040 nm with spectrometer components including 3648 linear silicon CCD Array elements, solar sources in the field, optical fibers with a diameter of 400 μm and a length of 2 meters, and a computer. The measurement steps are as follows:

- Dark Calibration, a calibration was taken with dark spectral technique and a reference. The dark spectral technique is a data spectral retrieval without light and samples, and a reference technique is taking spectral data using a reference from diffuse reflectance standard model WS-1, Ocean Optics USA.
- Reference Calibration/Light Calibration: Reference calibration is carried out by allowing light to reach an equilibrium (takes 30 minutes), making sure all cuvettes are clean of dust or dirt and are functioning

1 normally. The integration time is optimized to reach ~ 80%. The reference data obtained is stored as a  
2 reference for sample measurements.

3 - Setting Boxcar: The boxcar settings are adjusted to a value that is approximately the same as the pixel  
4 resolution of the spectrometer, the spatial resolution of the tool is 8  $\mu\text{m}$  x 200  $\mu\text{m}$ .

5 - Spectral and Integration time measurement: At the time of measurement, one optic fiber section is  
6 connected to the light source and the spectrometer, other optic fiber parts are connected to the sample.  
7 Spectral reflectance of the plastic debris is measured twice, with an integration time of 100 ms and resulting  
8 in 50 scans for each measurement, after which the spectral measurement was averaged

9 d. *Data analysis* used numeric data processing devices, the measurement data was classified by eliminating error  
10 values and cutting off visible and near-infrared light waves. Furthermore, the data was made into graphical form  
11 with smoothing graphs and were statistically analyzed using One-Way Analysis of Variance to evaluate differences  
12 of spectral reflectance curves among stations. The spectral reflectance curves were then compared to spectral  
13 reflectance of beach sand during dry conditions (occurring during low tide or beach sand which is not affected by  
14 tidal-range) and beach sand during wet conditions (occurs during high tide or beach sand which is still affected  
15 by tidal rides) by Nolet et al., 2014.

### 17 3. Result and Discussion

18 The spectral measurement results of each sample at each station are presented in Figure 2. The spectral reflectance  
19 curve of each sample shows the same reflectance pattern on each wavelength spectrum. Figure 2 shows a tendency  
20 of an increase in spectral reflectance curves for each station. At station 1 there is an increase in spectral curves at  
21 wavelengths of 500-625 nanometers (nm), at station 2 the tendency of the increase of spectral curves occurs at  
22 wavelengths of 470-600 nm and at station 3 the tendency of the increase spectral curves happen at wavelengths of  
23 450-570 nm. The graph in Figure 2 shows the difference in the amount of data, this is due to noise that occurred  
24 when the recording started so the spectral reflectance curve is smaller than 0%, the value is eventually selected and  
25 considered as error data and not employed. The measurement of plastic debris spectral reflectance using radiation  
26 sourced directly from the sun, which has a high wavelength (> 800 nm), was found to have a lot of noise that  
27 appears most likely caused by low primary light intensity at the time of measurement. According to Michael and  
28 Stefan (2000) and Dennis et al., (2004), noises occur at spectral reflectance recordings are due to poor primary  
29 light intensity from sun and so noise comes up and enters. They also stated that the noise is further enhanced as a  
30 result of high sample attenuation and making the transmitted light intensity is very poor and thus gets noisy.

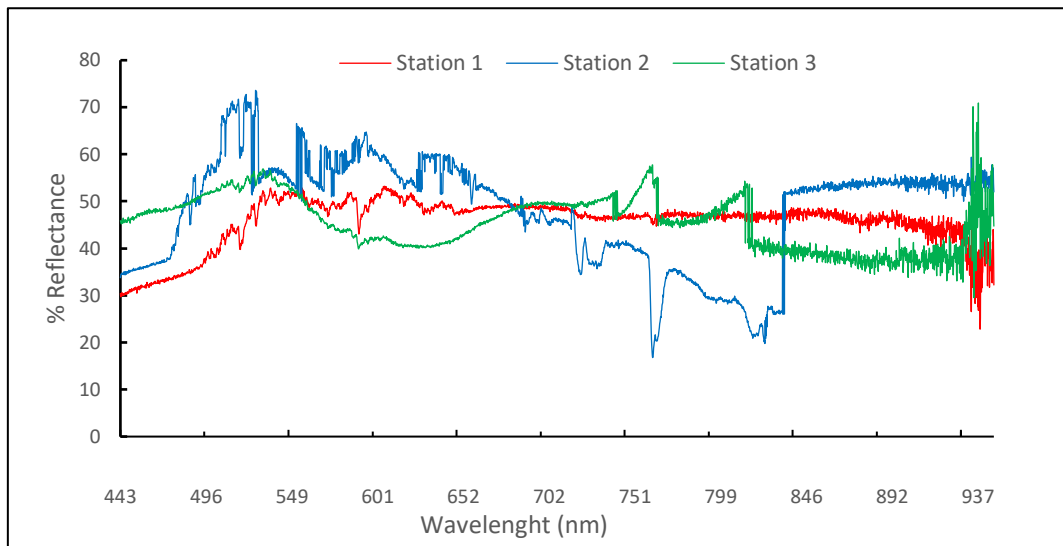


Figure2. Spectral Reflectance Curve of plastic debris for each sample at all stations.

The difference in the spectral characteristics of plastic debris at each station is shown in Figure 2. The characteristics of each station are obtained from the average spectral reflectance value of each sample at each station. The average spectral reflectance value of each station shows the similarity of spectral reflectance patterns. The spectral reflectance pattern of each station starts to show an increase in the wavelength of 500 nm (blue wavelength) and decreases at a wavelength of 800 nm (red wavelength).

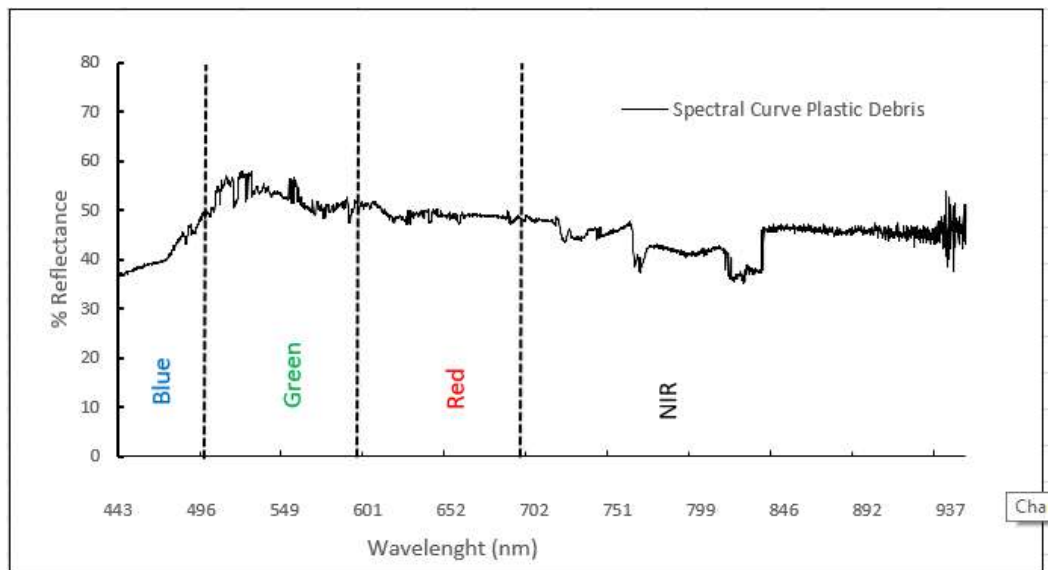
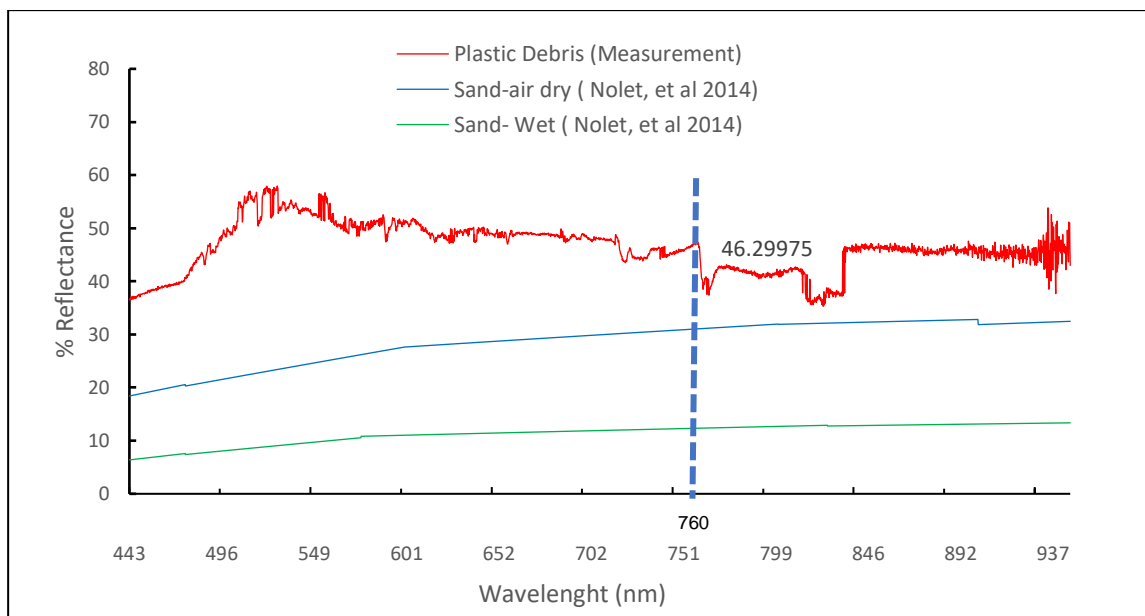


Figure 3. Comparison of spectral curve plastic debris with divisions based on wavelength.

Figure 2 denotes the difference in spectral reflectance curves between each sample with the same pattern tendency. The difference in spectral reflectance curves of each object is influenced by several factors; characteristics of object or sample, the amount of light penetration received by objects (Murphy et al., 2018). Plastics found at the study site have different chemical compositions which will give different reflectance, plastic debris consists of several types; polyethylene (PE), polypropylene (PP), polyvinylchloride (PVC), polyamide (nylon) and polystyrene (PS) (Andrady, 2015). Different chemical compositions resulted in different spectral reflectance values as well (Imhof

1 et al., 2017). Another factor is because the found samples have been degraded and have weathered naturally or  
 2 partially fragmented into microplastic (GESAMP, 2015; Shah et al., 2008; Thevenon et al., 2014). In different time  
 3 and weather conditions, the sunlight's penetration that reaches to the earth's surface also varies, the number of  
 4 wavelengths that reach the earth's surface or the object is affected by the amount of scattering and absorption of  
 5 particles in the atmosphere (Lillesand et al., 2015; Murphy et al., 2018).  
 6 The tendency of reflectance pattern of each sample at every station (Figure 2) is almost the same, this is due to the  
 7 similarity of the main chemical component of the plastic (Andrady, 2015). In several hyperspectral studies with  
 8 different objects and similar main components, have similar spectral patterns, such as vegetation (Huete, 1988),  
 9 coral reefs (Hochberg et al., 2003), soil (Lillesand et al., 2015) and others.  
 10 The spectral reflectance pattern of plastic debris found on the beach at all observation stations (Figure 3) shows  
 11 various spectral values with optimum spectral reflectance values at 500 - 700 nm. Based on wavelengths division,  
 12 that range is at the visible wavelength (400 - 700 nm). In detail, the visible wavelength is divided into 3 wavelengths;  
 13 Blue (400 - 500 nm), Green (500 - 600 nm) and Red (600 - 700 nm). One factor that might cause differences in  
 14 the spectral characteristics of each station is the presence of macroalgae that began to grow in various samples,  
 15 will automatically influence the spectral reflection of each object at each station (Diaz and Rosenberg, 1995).  
 16 The analysis of variance on the data of all stations showed no differences in the spectral characteristics of each  
 17 station ( $p > 0.05$ ) therefore the spectral values of each station were averaged and compiled with the spectral  
 18 reflectance curves from sand beach at two conditions of volumetric moisture content of 32% (wet or saturation)  
 19 and 0.01% (air-dry) (Nolet et al., 2014) as in Figure 4  
 20



21  
 22 Figure 4. Comparison of the average value of plastic reflectance with sand reflectance by Nolet, et al., (2014)  
 23 The reflectance graph in Figure 4 shows there is a difference in reflectance curves between plastic debris and sand  
 24 both in dry air conditions (air-dry) and in conditions of wet sand (saturation). The wavelength range of 443-760  
 25 nm is the best wavelength for identification of plastic debris in the condition of the air-dry beach, in the case of  
 26 wet beach sand the overall wavelength range of 443-950 nm is optimal for use. If it is connected with a range of

1 visible light waves, the results show that in dry beach sand conditions, identification of plastic debris can be carried  
2 out at blue, green and red wavelengths and in wet sand conditions it can use all visible and near-infrared waves.

3  
4 The use of multispectral classification techniques by utilizing spectral values of objects can be done in a broad  
5 scale mapping (Jensen, 2004). Including the utilization of the spectral curve from plastic waste, a multispectral  
6 classification can also be carried out for mapping the distribution of plastic debris. But in its implementation the  
7 identification of plastic debris objects can only be done: 1) in the locations of accumulated plastic debris, and it is  
8 less likely to be used to detect the distribution of a small amount of scattered plastic debris, 2) to detect plastic  
9 debris on the surface of the substrates. Another obstacle to the identification of plastic debris is related to spatial  
10 resolution, the lower the resolution, the lower the recognition of objects (Moy et al., 2018).

11 The difference in the spectral value of an object, including plastic debris, will be a reference in the remote sensing  
12 method, especially in multispectral classification. Our result of plastic debris spectral curve could be a reference  
13 for plastic debris mapping in a coastal area. The mapping of plastic debris distribution with the remote sensing  
14 method will be a solution in effectively mapping the plastic debris.

#### 16 4. Conclusion

17 This study aims to examine the spectral characteristics of plastic debris in the coastal area (beach) of Makassar  
18 City with a different type of exposure. Our results showed spectral characteristics of plastic debris were not  
19 different between stations, therefore the substrates where plastic debris found were not affecting the spectral  
20 reflection curve of plastic debris. The optimal value for identification of plastic debris in the coastal beach under  
21 conditions of dry sand-low tide is 443-760 nm and in the condition of wet sand-high tide is 443-950 nm. This  
22 value will be a reference in the remote sensing method, especially multispectral classification in mapping plastic  
23 debris found in coastal areas, and will be one solution to effectively mapping plastic debris.

#### 25 Acknowledgment

26 This research was done with research funding from the Competency-Based Research Scheme (Penelitian Berbasis  
27 Kompetensi) with Contract Number L 1715 / UN4.21 / PL.00.00 / 2018. This research, in addition, was also carried  
28 out with the participation of Widodo, Researcher in the Laboratory of Remote Sensing and Ecology, SEAMEO  
29 Biotrop, also Sunarto and Muhammad Ilham from the Faculty of Marine and Fisheries, Hasanuddin University.

#### 31 References

- 32 Andrady, A. L. (2015). Persistence of plastic litter in the oceans. In M. In: Bergmann, Gutow, L., Klages, M (Ed.),  
33 *Marine Anthropogenic Litter* (pp. 57-22): Springer International Publishing AG Switzerland.
- 34 Aoyama, T. (2014). *Monitoring of marine debris in the sea of Japan using multi-spectral satellite images* Paper  
35 presented at the SPIE Asia-Pacific Remote Sensing.
- 36 Driedger, H. Durr, K. Mitchel, J. Flannery, E. Brancazi, & P. V. Cappelen. (2013). *Plastic Debris; Remote sensing*  
37 *and characterization*. Canada: University of Waterloo.
- 38 GESAMP. (2015). *Sources, fate and effects of microplastics in the marine environment: Part two of a global*  
39 *assessment* (P. J. K. a. C. M. Rochman Ed.). 4 Albert Embankment, London SE1 7SR: INTERNATIONAL  
40 MARITIME ORRGANIZATION.

- 1 Halma, C. (2008). USB4000 Fiber Optic Spectrometer: Instalation and Operation Manual. Retrieved from  
2 [www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf](http://www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf)
- 3 Hochberg, E. J., M. J. Atkinson, & S. Andréfouët. (2003). Spectral reflectance of coral reef bottom-types worldwide  
4 and implications for coral reef remote sensing. *Remote Sensing of Environment*, 85(2), 159-173.  
5 doi:[https://doi.org/10.1016/S0034-4257\(02\)00201-8](https://doi.org/10.1016/S0034-4257(02)00201-8)
- 6 Hörig, B., F. Kühn, F. Oschütz, & F. Lehmann. (2001). HyMap hyperspectral remote sensing to detect  
7 hydrocarbons. *International Journal of Remote Sensing*, 22(8), 1413-1422. doi:10.1080/01431160120909
- 8 Huete, A. R. (1988). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, 25(3), 295-309.  
9 doi:[https://doi.org/10.1016/0034-4257\(88\)90106-X](https://doi.org/10.1016/0034-4257(88)90106-X)
- 10 Imhof, H. K., R. Sigl, E. Brauer, S. Feyl, P. Giesemann, S. Klink, K. Leupolz, M. G. J. Löder, L. A. Löschel, J. Missun,  
11 S. Muszynski, A. F. R. M. Ramsperger, I. Schrank, S. Speck, S. Steibl, B. Trotter, I. Winter, & C. Laforsch.  
12 (2017). Spatial and temporal variation of macro-, meso- and microplastic abundance on a remote coral  
13 island of the Maldives, Indian Ocean. *Marine Pollution Bulletin*, 116(1), 340-347.  
14 doi:<https://doi.org/10.1016/j.marpolbul.2017.01.010>
- 15 Jambeck, J. R., R. Geyer, C. Wilcox, T. R. Siegler, M. Perryman, A. Andrady, R. Narayan, & K. L. Law. (2015).  
16 Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771. doi:10.1126/science.1260352
- 17 Lillesand, Ralph W. Kiefer, & J. Chipman. (2015). *Remote Sensing and Image Interpretation*: John Wiley and  
18 Sons.
- 19 Mace, T. H. (2012). At-sea detection of marine debris: Overview of technologies, processes, issues, and options.  
20 *Marine Pollution Bulletin*, 65(1), 23-27. doi:<https://doi.org/10.1016/j.marpolbul.2011.08.042>
- 21 Maulana, F. (2016). *Identifikasi sampah laut di kawasan wisata pantai Kota Makassar*. (Skripsi), Universitas  
22 Hasanuddin, Makassar.
- 23 Moy, K., B. Neilson, A. Chung, A. Meadows, M. Castrence, S. Ambagis, & K. Davidson. (2018). Mapping coastal  
24 marine debris using aerial imagery and spatial analysis. *Marine Pollution Bulletin*, 132, 52-59.  
25 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.045>
- 26 Murphy, L. G., S. Peters, E. van Sebille, N. A. James, & S. Gibb. (2018). Concept for a hyperspectral remote sensing  
27 algorithm for floating marine macro plastics. *Marine Pollution Bulletin*, 126, 255-262.  
28 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.011>
- 29 NOAA. (2015). *Turning The Tide On Trash. A Learning Guide On Marine Debris*: NOAA PIFSC CRED.
- 30 Pichel, W. G., J. H. Churnside, T. S. Veenstra, D. G. Foley, K. S. Friedman, R. E. Brainard, J. B. Nicoll, Q. Zheng,  
31 & P. Clemente-Colón. (2007). Marine debris collects within the North Pacific Subtropical Convergence  
32 Zone. *Marine Pollution Bulletin*, 54(8), 1207-1211. doi:<https://doi.org/10.1016/j.marpolbul.2007.04.010>
- 33 Shah, A. A., F. Hasan, A. Hameed, & S. Ahmed. (2008). Biological degradation of plastics: A comprehensive  
34 review. *Biotechnology Advances*, 26(3), 246-265. doi:<https://doi.org/10.1016/j.biotechadv.2007.12.005>
- 35 Thevenon, F., C. Carroll, & J. Sousa. (2014). *Plastic Debris in the Ocean. The Characterization of Marine Plastics  
36 and their Environmental Impacts. Situation Analysis Report*. Gland, Switzerland: IUCN
- 37 Van Cauwenberghe, L., M. Claessens, M. B. Vandegheuchte, J. Mees, & C. R. Janssen. (2013). Assessment of  
38 marine debris on the Belgian Continental Shelf. *Marine Pollution Bulletin*, 73(1), 161-169.  
39 doi:<https://doi.org/10.1016/j.marpolbul.2013.05.026>
- 40 Veenstra, T. S., & J. H. Churnside. (2012). Airborne sensors for detecting large marine debris at sea. *Marine  
41 Pollution Bulletin*, 65(1), 63-68. doi:<https://doi.org/10.1016/j.marpolbul.2010.11.018>
- 42

# Korespondensi ke 9

## 14-10-2019

Editor/Author Correspondence - Google Chrome

journal.ugm.ac.id/ijg/author/viewEditorDecisionComments/40519#27245

Editor  
2019-10-14 09:52 PM

Subject: [IJG] Editor Decision: Minor Revision Required DELETE

Dear Dr. Ahmad Faizal,

After considering reviewer's comments (see the attachment in your OJS account), We have reached the decision to Accept your manuscript with minor revision regarding your submission to Indonesian Journal of Geography, "Spectral Characteristics of Plastic Debris in the Beach: Case Study of Makassar Coastal Water".

Attached is the reviewer's comments that should be sent previously. We apologize for this inconvenience.

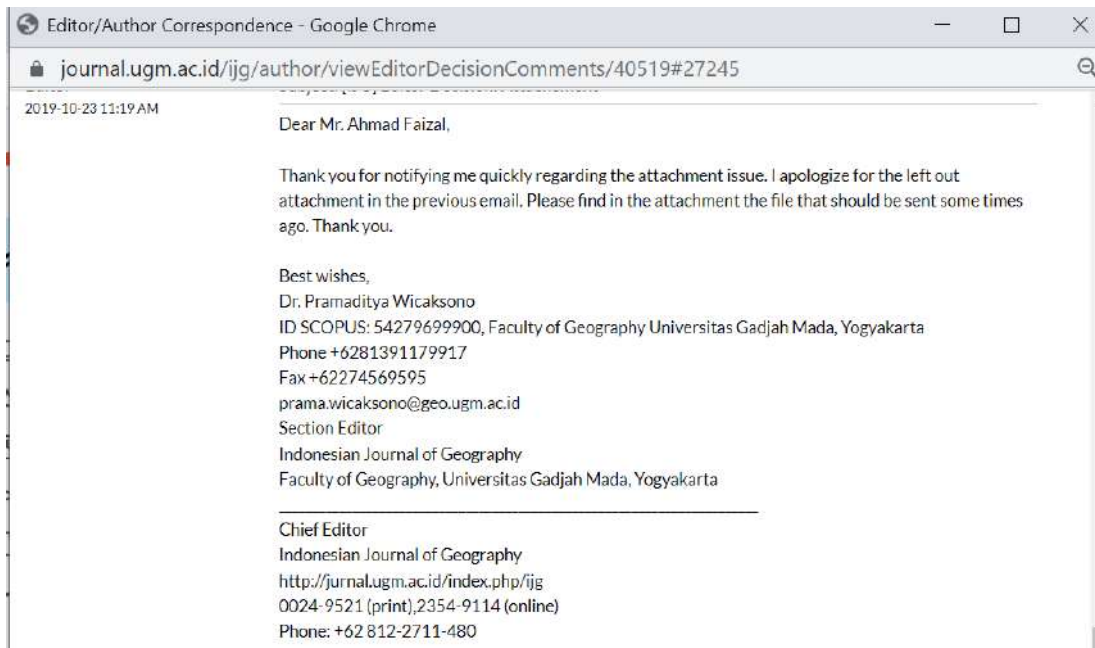
Once again, thank you for submitting your manuscript to the Indonesian Journal of Geography and I look forward to receiving your revision no later than 15 days from now. If you failed to meet the deadline, we may have to consider your paper rejected.

NB: Please use the follow the guideline in the attached template for your revision.

Best wishes,  
Dr. Pramaditya Wicaksono  
ID SCOPUS: 54279699900, Faculty of Geography Universitas Gadjah Mada, Yogyakarta  
Phone +6281391179917  
Fax +62274569595  
prama.wicaksono@geo.ugm.ac.id  
Section Editor  
Indonesian Journal of Geography  
Faculty of Geography, Universitas Gadjah Mada, Yogyakarta

---

Chief Editor  
Indonesian Journal of Geography  
<http://jurnal.ugm.ac.id/index.php/ijg>  
0024-9521 (print),2354-9114 (online)  
Phone: +62 812-2711-480



## Lampiran Saran Reviewer



# 1 Spectral Characteristics of Plastic Debris in the Beach: Case Study 2 of Makassar Coastal Area

3  
4 **Abstract** Plastic debris becomes a global problem that threatens the coastal ecosystems, and the supralittoral area (beach)  
5 turns to be a place for plastic debris to accumulate. Data from the United Nation (UN) states that Indonesia is the second  
6 plastic debris contributor in world waters. This study aimed to examine the spectral characteristics of plastic debris  
7 accumulated in the beach. The data was collected from the coast of Makassar at 3 different stations: Jenneberang River estuary,  
8 Losari Beach and Tallo River estuary. The spectral sample was measured using a 4000 A spectroradiometer that works on a  
9 wavelength spectrum 340 - 1040 nm. **The results showed that the optimum value for plastic debris identification in the coastal**  
10 **area at low tide (dry sand) is 443-760 nm and at high tide (wet sand) is 443-950 nm. This value will be a reference in the remote**  
11 **sensing method, especially multispectral classification in mapping plastic debris found in coastal areas, and will be one solution**  
12 **to effectively mapping plastic debris.**

13 **Key words:** plastic debris, wavelength, spectral

14 **Abstrak** Sampah plastik menjadi masalah global yang mengancam kondisi ekosistem pesisir, dan daerah supralittoral (pantai)  
15 menjadi tempat penumpukan sampah plastik. Data United Nation (UN) menyebutkan bahwa Indonesia menjadi penyumbang  
16 sampah plastik nomer dua di perairan dunia. Penelitian ini bertujuan untuk mengkaji karakteristik spektral dari sampah  
17 plastik yang terakumulasi di daerah pantai. Data dikoleksi dari pesisir pantai makassar pada 3 stasiun yang berbeda yaitu di  
18 muara Sungai Jenneberang, Pantai Losari dan Muara Sungai Tallo. Spektral sampel diukur dengan menggunakan  
19 spektorradiometer 4000 A yang bekerja pada spektrum panjang gelombang 340 - 1040 nm. **Hasil penelitian menunjukkan nilai**  
20 **optimal untuk identifikasi sampah plastic di wilayah pantai pada kondisi pasir kering\_surut adalah 443-760 nm dan pada**  
21 **kondisi pasir basah-pasang adalah 443-950 nm. Nilai ini akan menjadi referensi dalam metode penginderaan jauh khususnya**  
22 **klasifikasi multispectral dalam memetakan sampah plastik yang terdapat di wilayah pesisir, dan akan menjadi salah satu solusi**  
23 **metode pemetaan sampah plastik yang efektif.**

24 **Kata kunci :** Sampah plastik, Panjang Gelombang, spektral

## 25 1. Introduction

26 Marine debris is now a global problem that has affected all water bodies, especially the water surface in coastal  
27 areas. Its influence visibly shows towards the economy, ecology, public health, and environmental aesthetics.  
28 Marine debris pollution is no longer a regional problem but has scaled up into a global or international problem.  
29 Marine debris, especially plastic in waters, has transformed into agents that potentially bring toxic chemicals, such  
30 as PCBs and heavy metals to human. **Whilst microplastics, fragmented from larger plastic debris, that are largely**  
31 **invisible to humans, can also accumulate in the food chain** (Driedger et al., 2013).

32 Some time ago, it was estimated that around 10% of debris has been discharged into the waters (Van  
33 Cauwenberghe et al., 2013) Generally, marine debris with various forms (such as plastic, metal, wood, clothing,  
34 etc.) accumulates in coastal areas (NOAA, 2015). The main sources of debris in the waters are from recreational  
35 activities, wind or storm, illegal dumping, sewage treatment plants, and fishing industry (Driedger et al., 2013).

1 In 2010, it was predicted that around 4.8 to 12.7 million metric tons of plastic debris had entered the ocean, from  
2 192 countries and Indonesia is the second contributor to the sea debris after China. According to Jambeck et al.  
3 (2015) Indonesia contributed plastic debris to the sea by 1.29 million tons/year after China by 3.53 million  
4 tons/year in 2010. With regards to this condition, plastic debris pollution will add to a very large environmental  
5 and socio-economic problems in Indonesian waters (Driedger et al., 2013).  
6 Marine debris, especially plastic debris in the waters, due to hydro-oceanographic influences were stranded and  
7 accumulated in the beach including in the coastal city of Makassar (Maulana, 2016). Identification of marine  
8 debris has been carried out using traditional survey methods (Driedger et al., 2013) including in South Sulawesi  
9 (Maulana, 2016). Another alternative that might be used is to employ the remote sensing method. The  
10 identification of objects using this method is generally based on the spectral characteristics of the object, each  
11 different material will give a different spectral curve, including plastic debris will give a different reflection curve  
12 to the surrounding object (Driedger et al., 2013; Hörig et al., 2001; Pichel et al., 2007). This second alternative  
13 enables relatively cheaper cost and faster time. The study of remote sensing of plastic debris in coastal areas was  
14 still experimental. However, several researchers have tried to monitor marine debris in various parts of the world  
15 (Aoyama, 2014; Jambeck et al., 2015; Mace, 2012; Veenstra & Churnside, 2012). This study aimed to examine  
16 spectral characteristics of the plastic debris in the beach and will be used as a reference for identifying plastic debris  
17 in coastal areas using satellite imagery.

18

## 19 2. The Methods

20 This research was carried out in coastal areas, especially in the beach of Makassar City, South Sulawesi Province,  
21 at three stations with adequately different characteristics (Figure 1.). All stations were connected to the water ways  
22 that comes from the city of Makassar that would potentially bring marine debris to the sea: Station 1, estuary of  
23 Jeneberang River, represented exposure area and the water influenced by Jeneberang River; station 2, Losari Beach,  
24 represented shelter area and the water influenced by the city small canals disemboque along Losari Beach; and  
25 station 3, estuary of Tallo River, which represented semi enclosed area and the water influenced by Paotere Canal  
26 and Tallo River.

27

28 The sample analysis was done at the Marine Ecology Laboratory, Marine Sciences Department, Hasanuddin  
29 University and the Remote Sensing and Ecology Laboratory Seameo BIOTROP, Bogor.

30



Figure 1. Makassar Coastal Water; Study area and sampling station

The spectral identification of plastic debris in the beach refers to the method used by Murphy et al. (2018) and its development with the implementation stages as follows:

a) *Sample collection*: sample collection was conducted in the beach of the coast of Makassar City, at three stations; Station 1 around the Jenneberang River Estuary, Station 2 around Losari Beach and Station 3 around the Tallo River Estuary up to the Paotere port. Furthermore, sorting of the collected sample was held in the Marine Ecology Laboratory, Marine Science Department with 10 plastic debris samples, with different characteristics.

b) *Sample Measurement*: The spectral value of the sample was measured using the Ocean Optics USB 4000 type spectrometer which works on a wavelength 340-1110 nm (nanometer). The spectral retrieval process involves spectrometers, light sources, optical fibers, and computers. One spectroradiometer part is connected to the light source and the other part is connected to the object being measured. The position of the light source does not directly face the sun but forms an angle of approximately 45° and 100 millisecond scanning time (Halma, 2008)

c) *Spectra Collection* Replay values from samples are recorded using a computer equipped with software Ocean Optics Spectra Suite USB-4000. The spectroradiometer used has a wavelength range of 350-1040 nm with spectrometer components including 3648 linear silicon CCD Array elements, solar sources in the field, optical fibers with a diameter of 400 μm and a length of 2 meters, and a computer. The measurement steps are as follows:

- Dark Calibration, a calibration was taken with dark spectral technique and a reference. The dark spectral technique is a data spectral retrieval without light and samples, and a reference technique is taking spectral data using a reference from diffuse reflectance standard model WS-1, Ocean Optics USA.

**Commented [A1]:** What is replay values?  
**Commented [A2]:** It is different from the previous text, which is 340-1100 nm

1 - Reference Calibration/Light Calibration: Reference calibration is carried out by allowing light to reach an  
2 equilibrium (takes 30 minutes), making sure all cuvettes are clean of dust or dirt and are functioning  
3 normally. The integration time is optimized to reach ~ 80%. The reference data obtained is stored as a  
4 reference for sample measurements.

5 - Setting Boxcar: The boxcar settings are adjusted to a value that is approximately the same as the pixel  
6 resolution of the spectrometer, the spatial resolution of the tool is  $8 \mu\text{m} \times 200 \mu\text{m}$ .

7 - Spectral and Integration time measurement: At the time of measurement, one optic fiber section is  
8 connected to the light source and the spectrometer, other optic fiber parts are connected to the sample.  
9 Spectral reflectance of the plastic debris is measured twice, with integration time of 100 ms and resulting  
10 in 50 scans for each measurement, after which the spectral measurement were averaged

11  
12 d. *Data analysis* used numeric data processing devices, the measurement data was classified by eliminating error  
13 values and cutting off visible and near-infrared light waves. Furthermore, the data was made into graphical form  
14 with smoothing graphs, and were statistically analysed using One-Way Analysis of Variance to evaluate differences  
15 of spectral reflectance curves among stations. The spectral reflectance curves were then compared to spectral  
16 reflectance of beach sand during dry conditions (occurring during low tide or beach sand which is not affected by  
17 tidal-range) and beach sand during wet conditions (occurs during high tide or beach sand which is still affected  
18 by tidal rides) by Nolet et al., 2014.

### 20 3. Result and Discussion

21 Spectral measurement results of each sample at each station are presented in Figure 2. The spectral reflectance  
22 curve of each sample shows the same reflectance pattern on each wavelength spectrum. Figure 2 shows a tendency  
23 of an increase in spectral reflectance curves for each station. At station 1 there is an increase in spectral curves at  
24 wavelengths of 500-625 nanometers (nm), at station 2 the tendency of the increase of spectral curves occurs at  
25 wavelengths of 470-600 nm and at station 3 the tendency of the increase spectral curves happens at wavelengths  
26 of 450-570 nm. The graph in Figure 2 shows the difference of the amount of data, this is due to noise that occurred  
27 when the recording started so the spectral reflectance curve is smaller than 0%, the value is eventually selected and  
28 considered as error data and not employed. The measurement of plastic debris spectral reflectance using a  
29 radiation source directly from the sun, which has a high wavelength ( $> 800 \text{ nm}$ ), was found to have a lot of noise  
30 that appears most likely caused by low primary light intensity at the time of measurement. According to Michael  
31 and Stefan (2000) and Dennis et al., (2004), noises occur at spectral reflectance recording are due to poor primary  
32 light intensity from sun and so noise comes up and enters. They also stated that the noise is further enhanced as a  
33 result of high sample attenuation and making the transmitted light intensity is very poor and thus gets noisy.

Commented [A3]: Is the explanation on boxcar setting is correct? Because boxcar setting does not correlate with spatial resolution but with spectral resolution and precision

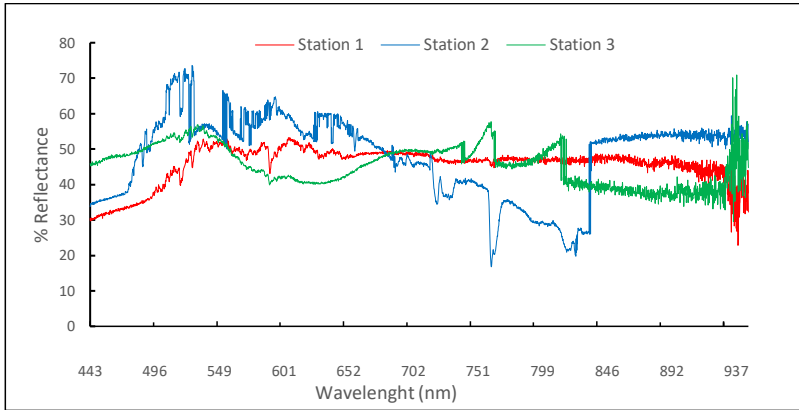


Figure 2. Spectral Reflectance Curve of plastic debris for each sample at all stations.

The difference in the spectral characteristics of plastic debris at each station is shown in Figure 2. The characteristics of each station are obtained from the average spectral reflectance value of each sample at each station. The average spectral reflectance value of each station shows the similarity of spectral reflectance patterns. The spectral reflectance pattern of each station starts to show an increase in the wavelength of 500 nm (blue wavelength) and decreases at a wavelength of 800 nm (red wavelength).

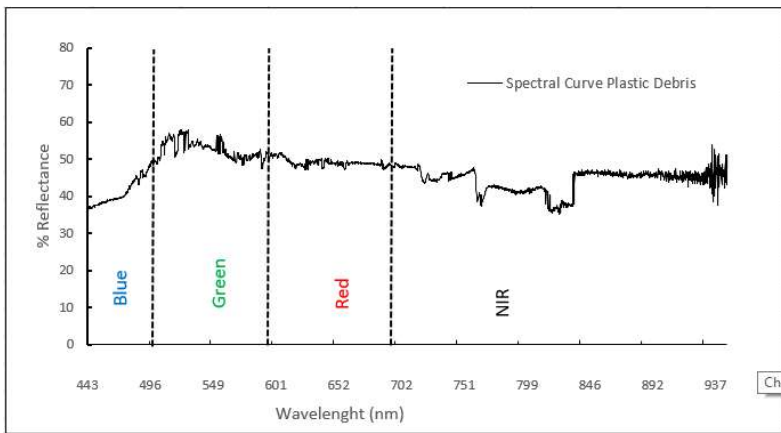


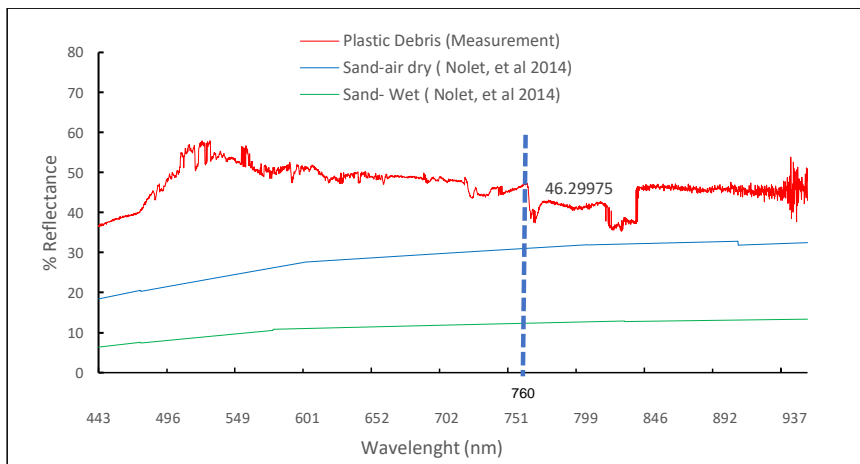
Figure 3. Comparison of spectral curve plastic debris with divisions based on wavelength.

Figure 2 denotes the difference in spectral reflectance curves between each sample with the same pattern tendency. The difference in spectral reflectance curves of each object is influenced by several factors; characteristics of object or sample, the amount of light penetration received by objects (Murphy et al., 2018). Plastics found at the study site have different chemical compositions which will give different reflectance, plastic debris consists of several types; polyethylene (PE), poly-propylene (PP), polyvinylchloride (PVC), poly-amide (nylon) and polystyrene (PS)

Commented [A4]: Is this the average from all measurement from all stations?

1 (Andrady, 2015). Different chemical compositions resulted in different spectral reflectance values as well (Imhof  
 2 et al., 2017). Another factor is because the found samples have been degraded and have weathered naturally or  
 3 partially fragmented into microplastic (GESAMP, 2015; Shah et al., 2008; Thevenon F., 2014). In different time  
 4 and weather conditions, the sunlight's penetration that reaches to the earth's surface also varies, the number of  
 5 wavelengths that reach the earth's surface or the object is affected by the amount of scattering and absorption of  
 6 particles in the atmosphere (Lillesand et al., 2015; Murphy et al., 2018).  
 7 The tendency of reflectance pattern of each sample at every station (Figure 2) is almost the same, this is due to  
 8 similarity of the main chemical component of the plastic (Andrady, 2015). In several hyperspectral studies with  
 9 different objects and similar main components, have similar spectral patterns, such as vegetation (Huete, 1988),  
 10 coral reefs (Hochberg et al., 2003), soil (Lillesand et al., 2015) and others.  
 11 The spectral reflectance pattern of plastic debris found in the beach at all observation stations (Figure 3) shows  
 12 various spectral values with optimum spectral reflectance values at 500 - 700 nm. Based on wavelengths division,  
 13 that range is at the visible wavelength (400 - 700 nm). In detail, the visible wavelength is divided into 3 wavelengths;  
 14 Blue (400 - 500 nm), Green (500 - 600 nm) and Red (600 - 700 nm). One factor that might cause differences in  
 15 the spectral characteristics of each station is the presence of macroalgae that began to grow in various samples,  
 16 will automatically influence the spectral reflection of each object at each station (Diaz and Rosenberg, 1995).  
 17 The analysis of variance on the data of all stations showed no differences in the spectral characteristics of each  
 18 station ( $p > 0.05$ ) therefore the spectral values of each station were averaged and compiled with the spectral  
 19 reflectance curves from sand beach at two conditions of volumetric moisture content of 32% (wet or saturation)  
 20 and 0.01% (air-dry) (Nolet et al., 2014) as in Figure 4

21



22

23 **Figure 4. Comparison of the average value of plastic reflectance with sand reflectance by Nolet, et al :2014**

24 **The reflectance graph in Figure 4 shows there is a difference in reflectance curves between plastic debris and sand**  
 25 **both in dry air conditions (air-dry) and in conditions of wet sand (saturation). The wavelength range of 443-760**

1 nm is the best wavelength for identification of plastic debris in the condition of air-dry beach, in the case of wet  
2 beach sand the overall wavelength range of 443-950 nm is optimal for use. If it is connected with a range of visible  
3 light waves, the results show that in dry beach sand conditions, identification of plastic debris can be carried out  
4 at blue, green and red wavelengths and in wet sand conditions it can use all visible and near infrared waves.

5  
6 The use of multispectral classification techniques by utilizing spectral values of objects can be done in a broad  
7 scale mapping (Jensen, 2004). Including the utilization of the spectral curve from plastic waste, a multispectral  
8 classification can also be carried out for mapping the distribution of plastic debris. But in its implementation the  
9 identification of plastic debris objects can only be done: 1) in the locations of accumulated plastic debris, and it is  
10 less likely to be used to detect the distribution of small amount or scattered plastic debris, 2) to detect plastic debris  
11 on the surface of the substrates. Another obstacle to the identification of plastic debris is related to spatial  
12 resolution, the lower the resolution, the lower the recognition of objects (Moy et al., 2018).

13  
14 The difference in the spectral value of an object, including plastic debris, will be a reference in the remote sensing  
15 method, especially in multispectral classification. Our result of plastic debris spectral curve could be a reference  
16 for plastic debris mapping in coastal area. The mapping of plastic debris distribution with the remote sensing  
17 method will be a solution in effectively mapping the plastic debris.

#### 18 19 20 4. Conclusion

21 This study aims to examine the spectral characteristics of plastic debris in the coastal area (beach) of Makassar  
22 City with different type of exposure. Our results showed spectral characteristics of plastic debris were not different  
23 between stations, therefore the substrates where plastic debris found were not affecting the spectral reflection  
24 curve of plastic debris. The optimal value for identification of plastic debris in the coastal beach under conditions  
25 of dry sand-low tide is 443-760 nm and in the condition of wet sand-high tide is 443-950 nm. This value will be a  
26 reference in the remote sensing method, especially multispectral classification in mapping plastic debris found in  
27 coastal areas, and will be one solution to effectively mapping plastic debris.

#### 28 29 Acknowledgement

30 This research was done with research funding from the Competency-Based Research Scheme (Penelitian Berbasis  
31 Kompetensi) with Contract Number L 1715 / UN4.21 / PL.00.00 / 2018. This research, in addition, was also carried  
32 out with participation of Widodo, Researcher in the Laboratory of Remote Sensing and Ecology, SEAMEO  
33 Biotrop, also Sunarto and Muhammad Ilham from the Faculty of Marine and Fisheries, Hasanuddin University.

#### 34 35 References

36 Andrady, A. L. (2015). Persistence of plastic litter in the oceans. In M. In: Bergmann, Gutow, L., Klages, M (Ed.),  
37 *Marine Anthropogenic Litter* (pp. 57-22): Springer International Publishing AG Switzerland.

1 Aoyama, T. (2014). *Monitoring of marine debris in the sea of Japan using multi-spectral satellite images* Paper  
2 presented at the SPIE Asia-Pacific Remote Sensing.

3 Dennis F. Flanigan, Alan C. Samuels, and Avishai Ben-David 2004 . Noise assessment of a Fourier transform  
4 infrared spectroradiometer subject to the stability of a conventional laboratory blackbody source," *Appl.*  
5 *Opt.* 43, 2767-2776 .

6

7 Diaz R.J. & Rosenberg R., 1995. Marine benthic hypoxia: A review of its ecological effects and the behavioural  
8 responses of benthic macrofauna. *Oceanography and Marine Biology – An Annual Review*, 33: 245-303.

9 Driedger, H. Durr, K. Mitchel, J. Flannery, E. Brancazi, & Cappelen, P. V. (2013). *Plastic Debris; Remote sensing*  
10 *and characterization*. Canada: University of Waterloo.

11 GESAMP. (2015). *Sources, fate and effects of microplastics in the marine environment: Part two of a global*  
12 *assessment* (P. J. K. a. C. M. Rochman Ed.). 4 Albert Embankment, London SE1 7SR: INTERNATIONAL  
13 MARITIME ORRGANIZATION.

14 Halma, C. (2008). USB4000 Fiber Optic Spectrometer: Instalation and Operation Manual. Retrieved from  
15 [www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf](http://www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf)

16

17 Hochberg, E. J., Atkinson, M. J., & Andréfouët, S. (2003). Spectral reflectance of coral reef bottom-types worldwide  
18 and implications for coral reef remote sensing. *Remote Sensing of Environment*, 85(2), 159-173.  
19 doi:[https://doi.org/10.1016/S0034-4257\(02\)00201-8](https://doi.org/10.1016/S0034-4257(02)00201-8)

20

21 Hörig, B., Kühn, F., Oschütz, F., & Lehmann, F. (2001). HyMap hyperspectral remote sensing to detect  
22 hydrocarbons. *International Journal of Remote Sensing*, 22(8), 1413-1422. doi:10.1080/01431160120909

23 Huete, A. R. (1988). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, 25(3), 295-309.  
24 doi:[https://doi.org/10.1016/0034-4257\(88\)90106-X](https://doi.org/10.1016/0034-4257(88)90106-X)

25 Imhof, H. K., Sigl, R., Brauer, E., Feyl, S., Giesemann, P., Klink, S., Leupolz, K., Loder, M.G.J., Löschel, L.A., Missun,  
26 Jan Muszynski, S., Ramsperger, A.F. R. M., Schrank, I., Speck, S., Steibl, S., Trotter, B., Winter, I.,  
27 Laforsch, C. (2017). Spatial and temporal variation of macro-, meso- and microplastic abundance on a  
28 remote coral island of the Maldives, Indian Ocean. *Marine Pollution Bulletin*, 116(1), 340-347.  
29 doi:<https://doi.org/10.1016/j.marpolbul.2017.01.010>

30 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., Law, K. L. (2015).  
31 Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771. doi:10.1126/science.1260352

32 Jensen, J.R. (2004) *Introductory Digital Image Processing: A Remote Sensing Perspective*. 3rd Edition, Prentice-  
33 Hall, Inc., New York, 316.

34 Lillesand, Ralph W. Kiefer, & Chipman, J. (2015). *Remote Sensing and Image Interpretation*: John Wiley and Sons.

35 Mace, T. H. (2012). At-sea detection of marine debris: Overview of technologies, processes, issues, and options.  
36 *Marine Pollution Bulletin*, 65(1), 23-27. doi:<https://doi.org/10.1016/j.marpolbul.2011.08.042>

37 Maulana, F. (2016). *Identifikasi sampah laut di kawasan wisata pantai Kota Makassar*. (Skripsi), Universitas  
38 Hasanuddin, Makassar.

39 Michael E. Schaepman and Stefan Dangel 2000. *Solid laboratory calibration of a nonimaging spectroradiometer*,  
40 *Appl. Opt.* 39, 3754-3764.

41 Moy, K., Neilson, B., Chung, A., Meadows, A., Castrence, M., Ambagis, S., & Davidson, K. (2018). Mapping coastal  
42 marine debris using aerial imagery and spatial analysis. *Marine Pollution Bulletin*, 132, 52-59.  
43 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.045>

44 Murphy, L. G., Peters, S., van Sebille, E., James, N. A., & Gibb, S. (2018). Concept for a hyperspectral remote sensing  
45 algorithm for floating marine macro plastics. *Marine Pollution Bulletin*, 126, 255-262.  
46 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.011>

47 NOAA. (2015). *Turning The Tide On Trash. A Learning Guide On Marine Debris*. NOAA PIFSC CRED.

48

49 Nolet C, Poortinga A, Roosjen P, Bartholomeus H, Ruessink G (2014) Measuring and Modeling the Effect of Surface  
50 Moisture on the Spectral Reflectance of Coastal Beach Sand. *PLOS ONE* 9(11): e112151.  
51 <https://doi.org/10.1371/journal.pone.0112151>

- 1 Pichel, W. G., Churnside, J. H., Veenstra, T. S., Foley, D. G., Friedman, K. S., Brainard, R. E., Nicoll, J.B., Zheng, Q.,  
2 Clemente-Colón, P. (2007). Marine debris collects within the North Pacific Subtropical Convergence  
3 Zone. *Marine Pollution Bulletin*, 54(8), 1207-1211. doi:<https://doi.org/10.1016/j.marpolbul.2007.04.010>  
4 Shah, A. A., Hasan, F., Hameed, A., & Ahmed, S. (2008). Biological degradation of plastics: A comprehensive review.  
5 *Biotechnology Advances*, 26(3), 246-265. doi:<https://doi.org/10.1016/j.biotechadv.2007.12.005>  
6 Thevenon F., C. C., Sousa J. (2014). *Plastic Debris in the Ocean. The Characterization of Marine Plastics and their*  
7 *Environmental Impacts. Situation Analysis Report*. Gland, Switzerland: IUCN  
8 Van Cauwenberghe, L., Claessens, M., Vandegehuchte, M. B., Mees, J., & Janssen, C. R. (2013). Assessment of  
9 marine debris on the Belgian Continental Shelf. *Marine Pollution Bulletin*, 73(1), 161-169.  
10 doi:<https://doi.org/10.1016/j.marpolbul.2013.05.026>  
11 Veenstra, T. S., & Churnside, J. H. (2012). Airborne sensors for detecting large marine debris at sea. *Marine*  
12 *Pollution Bulletin*, 65(1), 63-68. doi:<https://doi.org/10.1016/j.marpolbul.2010.11.018>

# Jawaban Korespondensi ke 9

## 25-10-2019

Editor/Author Correspondence - Google Chrome

journal.ugm.ac.id/ijg/author/viewEditorDecisionComments/40519#27245

Indonesian Journal of Geography  
http://jurnal.ugm.ac.id/index.php/ijg  
0024-9521 (print),2354-9114 (online)  
Phone: +62 812-2711-480

Author  
2019-10-25 10:47 AM

Subject: Spectral Characteristics of Plastic Debris in the Beach: Case Study of Makassar Coastal Water [DELETE](#)

Dr Pramaditya Wicaksono

First of all, thank you for the detailed review of our manuscript. We have revised and answered all the review and questions which we highlighted with yellow. Also, the layout of this manuscript has been revised to follow the IJG template. The reviewer comments and our answers are as follow:

1. What is replay values?  
I am sorry, this is a typo. It is supposed to be "reflectance value" and I already corrected it.
2. It is different from the previous text, which is 340-1100 nm,  
The previous text is incorrect. The correct value is 1040 nm. I already corrected it.
3. Is the explanation on boxcar setting is correct? Because boxcar setting does not correlate with spatial resolution but with spectral resolution and precision  
Has been corrected: Setting Boxcar: The boxcar setting is adjusted to a value is approximately the same as the spectral resolution of the spectrometer. When samples were recorded, the boxcar setting was adjusted to simple boxcar filtering which is a specialized case of Savitzky-Golay filtering where the polynomial order is 0 (Halma, 2008).
4. Is this the average from all measurement from all stations?  
Yes, it is the average value of spectral. I already add the word 'averaged' in the title of Figure 3

Kind regards,

Chief Editor

## Lampiran Perbaikan

[40519-119685-5-ED.DOCX](#)

2019-10-25

# 1 Spectral Characteristics of Plastic Debris in the Beach: Case Study 2 of Makassar Coastal Area

3 Ahmad Faizal, Shinta Werorilangi, Wasir Samad

4 Departement Ilmu Kelautan, Universitas Hasanuddin, Indonesia

5 [ahmad.faizal@unhas.ac.id](mailto:ahmad.faizal@unhas.ac.id)

6

7 **Abstract** Plastic debris becomes a global problem that threatens the coastal ecosystems, and the supralittoral area (beach) turns  
8 to be a place for plastic debris to accumulate. Data from the United Nation (UN) states that Indonesia is the second plastic  
9 debris contributor in world waters. This study aimed to examine the spectral characteristics of plastic debris accumulated in  
10 the beach. The data was collected from the coast of Makassar at 3 different stations: Jenneberang River estuary, Losari Beach  
11 and Tallo River estuary. The spectral sample was measured using a 4000 A spectroradiometer that works on a wavelength  
12 spectrum 340 - 1040 nm. The results showed that the optimum value for plastic debris identification in the coastal area at low  
13 tide (dry sand) is 443-760 nm and at high tide (wet sand) is 443-950 nm. This value will be a reference in the remote sensing  
14 method, especially multispectral classification in mapping plastic debris found in coastal areas, and will be one solution to  
15 effectively mapping plastic debris.

16

17 **Key words:** plastic debris, wavelength, spectral

18

19 **Abstrak** Sampah plastik menjadi masalah global yang mengancam kondisi ekosistem pesisir, dan daerah supralittoral (pantai)  
20 menjadi tempat penumpukan sampah plastik. Data United Nation (UN) menyebutkan bahwa Indonesia menjadi penyumbang  
21 sampah plastik nomer dua di perairan dunia. Penelitian ini bertujuan untuk mengkaji karakteristik spektral dari sampah  
22 plastik yang terakumulasi di daerah pantai. Data dikoleksi dari pesisir pantai makassar pada 3 stasiun yang berbeda yaitu di  
23 muara Sungai Jenneberang, Pantai Losari dan Muara Sungai Tallo. Spektral sampel diukur dengan menggunakan  
24 spektrometri 4000 A yang bekerja pada spektrum panjang gelombang 340 – 1040 nm. Hasil penelitian menunjukkan nilai  
25 optimal untuk identifikasi sampah plastik di wilayah pantai pada kondisi pasir kering surut adalah 443-760 nm dan pada  
26 kondisi pasir basah-pasang adalah 443-950 nm. Nilai ini akan menjadi referensi dalam metode penginderaan jauh khususnya  
27 klasifikasi multispectral dalam memetakan sampah plastik yang terdapat di wilayah pesisir, dan akan menjadi salah satu solusi  
28 metode pemetaan sampah plastik yang efektif.

29

30 **Kata kunci :** Sampah plastik, Panjang Gelombang, spektral

## 31 1. Introduction

32 Marine debris is now a global problem that has affected all water bodies, especially the water surface in coastal  
33 areas. Its influence visibly shows towards the economy, ecology, public health, and environmental aesthetics.  
34 Marine debris pollution is no longer a regional problem but has scaled up into a global or international problem.  
35 Marine debris, especially plastic in waters, has transformed into agents that potentially bring toxic chemicals, such  
36 as PCBs and heavy metals to human. Whilst microplastics, fragmented from larger plastic debris, that are largely  
37 invisible to humans, can also accumulate in the food chain (Driedger et al., 2013).

1 Some time ago, it was estimated that around 10% of debris has been discharged into the waters (Van  
2 Cauwenberghe et al., 2013) Generally, marine debris with various forms (such as plastic, metal, wood, clothing,  
3 etc.) accumulates in coastal areas (NOAA, 2015). The main sources of debris in the waters are from recreational  
4 activities, wind or storm, illegal dumping, sewage treatment plants, and fishing industry (Driedger et al., 2013).  
5 In 2010, it was predicted that around 4.8 to 12.7 million metric tons of plastic debris had entered the ocean, from  
6 192 countries and Indonesia is the second contributor to the sea debris after China. According to Jambeck et al.  
7 (2015) Indonesia contributed plastic debris to the sea by 1.29 million tons/year after China by 3.53 million  
8 tons/year in 2010. With regards to this condition, plastic debris pollution will add to a very large environmental  
9 and socio-economic problems in Indonesian waters (Driedger et al., 2013).  
10 Marine debris, especially plastic debris in the waters, due to hydro-oceanographic influences were stranded and  
11 accumulated in the beach including in the coastal city of Makassar (Maulana, 2016). Identification of marine  
12 debris has been carried out using traditional survey methods (Driedger et al., 2013) including in South Sulawesi  
13 (Maulana, 2016). Another alternative that might be used is to employ the remote sensing method. The  
14 identification of objects using this method is generally based on the spectral characteristics of the object, each  
15 different material will give a different spectral curve, including plastic debris will give a different reflection curve  
16 to the surrounding object (Driedger et al., 2013; Hörig et al., 2001; Pichel et al., 2007). This second alternative  
17 enables relatively cheaper cost and faster time. The study of remote sensing of plastic debris in coastal areas was  
18 still experimental. However, several researchers have tried to monitor marine debris in various parts of the world  
19 (Aoyama, 2014; Jambeck et al., 2015; Mace, 2012; Veenstra & Churnside, 2012). This study aimed to examine  
20 spectral characteristics of the plastic debris in the beach and will be used as a reference for identifying plastic debris  
21 in coastal areas using satellite imagery.

22

## 23 **2. The Methods**

24 This research was carried out in coastal areas, especially in the beach of Makassar City, South Sulawesi Province,  
25 at three stations with adequately different characteristics (Figure 1.). All stations were connected to the water ways  
26 that comes from the city of Makassar that would potentially bring marine debris to the sea: Station 1, estuary of  
27 Jeneberang River, represented exposure area and the water influenced by Jeneberang River; station 2, Losari Beach,  
28 represented shelter area and the water influenced by the city small canals disembogues along Losari Beach; and  
29 station 3, estuary of Tallo River, which represented semi enclosed area and the water influenced by Paotere Canal  
30 and Tallo River.

31 The sample analysis was done at the Marine Ecology Laboratory, Marine Sciences Department, Hasanuddin  
32 University and the Remote Sensing and Ecology Laboratory Seameo BIOTROP, Bogor.

33



Figure 1. Makassar Coastal Water; Study area and sampling station

The spectral identification of plastic debris in the beach refers to the method used by Murphy et al. (2018) and its development with the implementation stages as follows:

a) *Sample collection*: sample collection was conducted in the beach of the coast of Makassar City, at three stations; Station 1 around the Jenneberang River Estuary, Station 2 around Losari Beach and Station 3 around the Tallo River Estuary up to the Paotere port. Furthermore, sorting of the collected sample was held in the Marine Ecology Laboratory, Marine Science Department with 10 plastic debris samples, with different characteristics.

b) *Sample Measurement*: The spectral value of the sample was measured using the Ocean Optics USB 4000 type spectrometer which works on a wavelength 340-1040 nm (nanometer). The spectral retrieval process involves spectrometers, light sources, optical fibers, and computers. One spectroradiometer part is connected to the light source and the other part is connected to the object being measured. The position of the light source does not directly face the sun but forms an angle of approximately 45° and 100 millisecond scanning time (Halma, 2008)

c) *Spectra Collection* : Reflectance values from samples are recorded using a computer equipped with software Ocean Optics Spectra Suite USB-4000. The spectroradiometer used has a wavelength range of 340-1040 nm with spectrometer components including 3648 linear silicon CCD Array elements, solar sources in the field, optical fibers with a diameter of 400 μm and a length of 2 meters, and a computer. The measurement steps are as follows:

- Dark Calibration , a calibration was taken with dark spectral technique and a reference. The dark spectral technique is a data spectral retrieval without light and samples, and a reference technique is taking spectral data using a reference from diffuse reflectance standard model WS-1, Ocean Optics USA.
- Reference Calibration/Light Calibration: Reference calibration is carried out by allowing light to reach an equilibrium (takes 30 minutes), making sure all cuvettes are clean of dust or dirt and are functioning

1 normally. The integration time is optimized to reach ~ 80%. The reference data obtained is stored as a  
2 reference for sample measurements.

3 - **Setting Boxcar:** The boxcar settings is adjusted to a value that is approximately the same as the spectral  
4 resolution of the spectrometer, When samples were recorded, the boxcar setting was adjusted to simple  
5 boxcar filtering which is a specialized case of Savitzky-Golay filtering where the polynomial order is 0  
6 (Halma, 2008).

7 - **Spectral and Integration time measurement:** At the time of measurement, one optic fiber section is  
8 connected to the light source and the spectrometer, other optic fiber parts are connected to the sample.  
9 Spectral reflectance of the plastic debris is measured twice, with integration time of 100 ms and resulting  
10 in 50 scans for each measurement, after which the spectral measurement were averaged

11 d. *Data analysis* used numeric data processing devices, the measurement data was classified by eliminating error  
12 values and cutting off visible and near-infrared light waves. Furthermore, the data was made into graphical form  
13 with smoothing graphs, and were statistically analysed using One-Way Analysis of Varians to evaluate differences  
14 of spectral reflectance curves among stations. The spectral reflectance curves were then compared to spectral  
15 reflectance of beach sand during dry conditions (occurring during low tide or beach sand which is not affected by  
16 tidal-range) and beach sand during wet conditions (occurs during high tide or beach sand which is still affected  
17 by tidal rides) by Nolet et al., 2014.

### 18 19 **3. Result and Discussion**

20 Spectral measurement results of each sample at each station are presented in Figure 2. The spectral reflectance  
21 curve of each sample shows the same reflectance pattern on each wavelength spectrum. Figure 2 shows a tendency  
22 of an increase in spectral reflectance curves for each station. At station 1 there is an increase in spectral curves at  
23 wavelengths of 500-625 nanometers (nm), at station 2 the tendency of the increase of spectral curves occurs at  
24 wavelengths of 470-600 nm and at station 3 the tendency of the increase spectral curves happens at wavelengths  
25 of 450-570 nm. The graph in Figure 2 shows the difference of the amount of data, this is due to noise that occurred  
26 when the recording started so the spectral reflectance curve is smaller than 0%, the value is eventually selected and  
27 considered as error data and not employed. The measurement of plastic debris spectral reflectance using a  
28 radiation source directly from the sun, which has a high wavelength (> 800 nm), was found to have a lot of noise  
29 that appears most likely caused by low primary light intensity at the time of measurement. According to Michael  
30 and Stefan (2000) and Dennis et al., (2004), noises occur at spectral reflectance recording are due to poor primary  
31 light intensity from sun and so noise comes up and enters. They also stated that the noise is further enhanced as a  
32 result of high sample attenuation and making the transmitted light intensity is very poor and thus gets noisy.

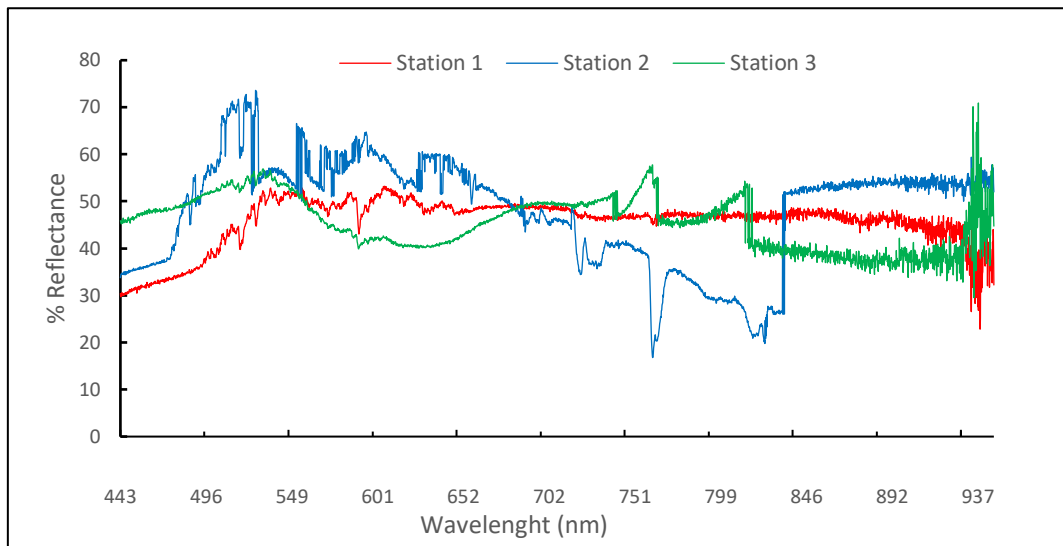


Figure 2. Spectral Reflectance Curve of plastic debris for each sample at all stations.

The difference in the spectral characteristics of plastic debris at each station is shown in Figure 2. The characteristics of each station are obtained from the average spectral reflectance value of each sample at each station. The average spectral reflectance value of each station shows the similarity of spectral reflectance patterns. The spectral reflectance pattern of each station starts to show an increase in the wavelength of 500 nm (blue wavelength) and decreases at a wavelength of 800 nm (red wavelength).

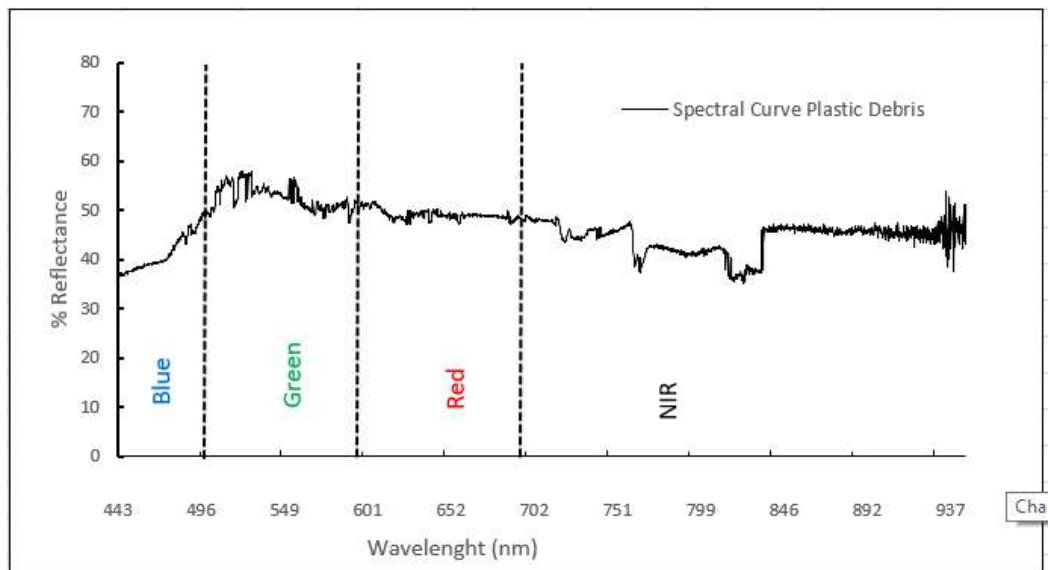


Figure 3. Comparisons of averaged spectral curve plastic debris with divisions based on wavelength.

Figure 2 denotes the difference in spectral reflectance curves between each sample with the same pattern tendency. The difference in spectral reflectance curves of each object is influenced by several factors; characteristics of object or sample, the amount of light penetration received by objects (Murphy et al., 2018). Plastics found at the study site have different chemical compositions which will give different reflectance, plastic debris consists of several types; polyethylene (PE), poly-propylene (PP), polyvinylchloride (PVC), poly-amide (nylon) and polystyrene (PS) (Andrady, 2015). Different chemical compositions resulted in different spectral reflectance values as well (Imhof et al., 2017). Another factor is because the found samples have been degraded and have weathered naturally or

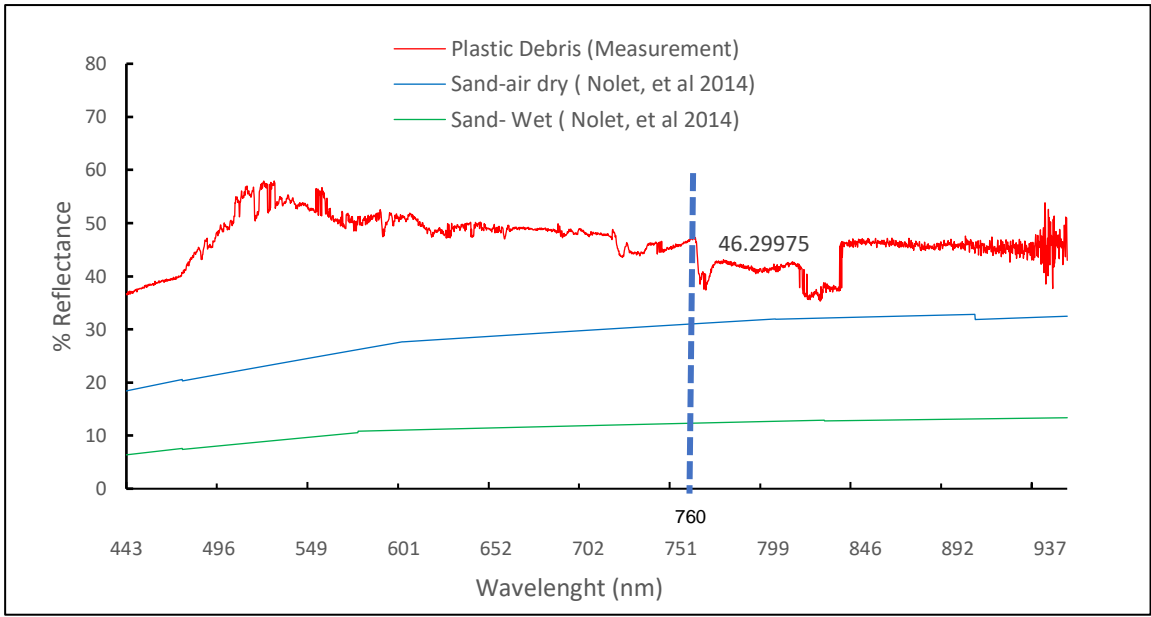
1 partially fragmented into microplastic (GESAMP, 2015; Shah et al., 2008; Thevenon F., 2014). In different time  
2 and weather conditions, the sunlight's penetration that reaches to the earth's surface also varies, the number of  
3 wavelengths that reach the earth's surface or the object is affected by the amount of scattering and absorption of  
4 particles in the atmosphere (Lillesand et al., 2015; Murphy et al., 2018).

5 The tendency of reflectance pattern of each sample at every station (Figure 2) is almost the same, this is due to  
6 similarity of the main chemical component of the plastic (Andrady, 2015). In several hyperspectral studies with  
7 different objects and similar main components, have similar spectral patterns, such as vegetation (Huete, 1988),  
8 coral reefs (Hochberg et al., 2003), soil (Lillesand et al., 2015) and others.

9 The spectral reflectance pattern of plastic debris found in the beach at all observation stations (Figure 3) shows  
10 various spectral values with optimum spectral reflectance values at 500 - 700 nm. Based on wavelengths division,  
11 that range is at the visible wavelength (400 - 700 nm). In detail, the visible wavelength is divided into 3 wavelengths;  
12 Blue (400 - 500 nm), Green (500 - 600 nm) and Red (600 - 700 nm). One factor that might cause differences in  
13 the spectral characteristics of each station is the presence of macroalgae that began to grow in various samples,  
14 will automatically influence the spectral reflection of each object at each station (Diaz and Rosenberg, 1995).

15 The analysis of variance on the data of all stations showed no differences in the spectral characteristics of each  
16 station ( $p > 0.05$ ) therefore the spectral values of each station were averaged and compiled with the spectral  
17 reflectance curves from sand beach at two conditions of volumetric moisture content of 32% (wet or saturation)  
18 and 0.01% (air-dry) (Nolet et al., 2014) as in Figure 4

19



20

21 Figure 4. Comparison of the average value of plastic reflectance with sand reflectance by Nolet, et al :2014

22 The reflectance graph in Figure 4 shows there is a difference in reflectance curves between plastic debris and sand  
23 both in dry air conditions (air-dry) and in conditions of wet sand (saturation). The wavelength range of 443-760  
24 nm is the best wavelength for identification of plastic debris in the condition of air-dry beach, in the case of wet  
25 beach sand the overall wavelength range of 443-950 nm is optimal for use. If it is connected with a range of visible

1 light waves, the results show that in dry beach sand conditions, identification of plastic debris can be carried out  
2 at blue, green and red wavelengths and in wet sand conditions it can use all visible and near infrared waves.  
3 The use of multispectral classification techniques by utilizing spectral values of objects can be done in a broad  
4 scale mapping (Jensen, 2004). Including the utilization of the spectral curve from plastic waste, a multispectral  
5 classification can also be carried out for mapping the distribution of plastic debris. But in its implementation the  
6 identification of plastic debris objects can only be done: 1) in the locations of accumulated plastic debris, and it is  
7 less likely to be used to detect the distribution of small amount or scattered plastic debris, 2) to detect plastic debris  
8 on the surface of the substrates. Another obstacle to the identification of plastic debris is related to spatial  
9 resolution, the lower the resolution, the lower the recognition of objects (Moy et al., 2018).  
10 The difference in the spectral value of an object, including plastic debris, will be a reference in the remote sensing  
11 method, especially in multispectral classification. Our result of plastic debris spectral curve could be a reference  
12 for plastic debris mapping in coastal area. The mapping of plastic debris distribution with the remote sensing  
13 method will be a solution in effectively mapping the plastic debris.

#### 14 15 **4. Conclusion**

16 This study aims to examine the spectral characteristics of plastic debris in the coastal area (beach) of Makassar  
17 City with different type of exposure. Our results showed spectral characteristics of plastic debris were not different  
18 between stations, therefore the substrates where plastic debris found were not affecting the spectral reflection  
19 curve of plastic debris. The optimal value for identification of plastic debris in the coastal beach under conditions  
20 of dry sand-low tide is 443-760 nm and in the condition of wet sand-high tide is 443-950 nm. This value will be a  
21 reference in the remote sensing method, especially multispectral classification in mapping plastic debris found in  
22 coastal areas, and will be one solution to effectively mapping plastic debris.

#### 23 24 **Acknowledgement**

25 This research was done with research funding from the Competency-Based Research Scheme (Penelitian Berbasis  
26 Kompetensi) with Contract Number L 1715 / UN4.21 / PL.00.00 / 2018. This research, in addition, was also carried  
27 out with participation of Widodo, Researcher in the Laboratory of Remote Sensing and Ecology, SEAMEO  
28 Biotrop, also Sunarto and Muhammad Ilham from the Faculty of Marine and Fisheries, Hasanuddin University.

#### 29 30 **References**

- 31 Andrady, A. L. (2015). Persistence of plastic litter in the oceans. In M. In: Bergmann, Gutow, L., Klages, M (Ed.),  
32 *Marine Anthropogenic Litter* (pp. 57-22): Springer International Publishing AG Switzerland.
- 33 Aoyama, T. (2014). *Monitoring of marine debris in the sea of Japan using multi-spectral satellite images* Paper  
34 presented at the SPIE Asia-Pacific Remote Sensing.
- 35 Dennis F. Flanigan, Alan C. Samuels, and Avishai Ben-David 2004 . Noise assessment of a Fourier transform  
36 infrared spectroradiometer subject to the stability of a conventional laboratory blackbody source," *Appl.*  
37 *Opt.* 43, 2767-2776 .
- 38 Diaz R.J. & Rosenberg R., 1995. Marine benthic hypoxia: A review of its ecological effects and the behavioural  
39 responses of benthic macrofauna. *Oceanography and Marine Biology – An Annual Review*, 33: 245-303.
- 40 Driedger, H. Durr, K. Mitchel, J. Flannery, E. Brancazi, & Cappelen, P. V. (2013). *Plastic Debris; Remote sensing*  
41 *and characterization*. Canada: University of Waterloo.

- 1 GESAMP. (2015). *Sources, fate and effects of microplastics in the marine environment: Part two of a global*  
2 *assessment* (P. J. K. a. C. M. Rochman Ed.). 4 Albert Embankment, London SE1 7SR: INTERNATIONAL  
3 MARITIME ORGANIZATION.
- 4 Halma, C. (2008). USB4000 Fiber Optic Spectrometer: Instalation and Operation Manual. Retrieved from  
5 [www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf](http://www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf)
- 6 Hochberg, E. J., Atkinson, M. J., & Andréfouët, S. (2003). Spectral reflectance of coral reef bottom-types worldwide  
7 and implications for coral reef remote sensing. *Remote Sensing of Environment*, 85(2), 159-173.  
8 doi:[https://doi.org/10.1016/S0034-4257\(02\)00201-8](https://doi.org/10.1016/S0034-4257(02)00201-8)
- 9 Hörig, B., Kühn, F., Oschütz, F., & Lehmann, F. (2001). HyMap hyperspectral remote sensing to detect  
10 hydrocarbons. *International Journal of Remote Sensing*, 22(8), 1413-1422. doi:10.1080/01431160120909
- 11 Huete, A. R. (1988). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, 25(3), 295-309.  
12 doi:[https://doi.org/10.1016/0034-4257\(88\)90106-X](https://doi.org/10.1016/0034-4257(88)90106-X)
- 13 Imhof, H. K., Sigl, R., Brauer, E., Feyl, S., Giesemann, P., Klink, S., Leupolz, K., Loder, M.G.J., Löschel, L.A., Missun,  
14 Jan Muszynski, S., Ramsperger, A.F. R. M., Schrank, I., Speck, S., Steibl, S., Trotter, B., Winter, I.,  
15 Laforsch, C. (2017). Spatial and temporal variation of macro-, meso- and microplastic abundance on a  
16 remote coral island of the Maldives, Indian Ocean. *Marine Pollution Bulletin*, 116(1), 340-347.  
17 doi:<https://doi.org/10.1016/j.marpolbul.2017.01.010>
- 18 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., Law, K. L. (2015).  
19 Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771. doi:10.1126/science.1260352
- 20 Jensen, J.R. (2004) *Introductory Digital Image Processing: A Remote Sensing Perspective*. 3rd Edition, Prentice-  
21 Hall, Inc., New York, 316.
- 22 Lillesand, Ralph W. Kiefer, & Chipman, J. (2015). *Remote Sensing and Image Interpretation*: John Wiley and Sons.
- 23 Mace, T. H. (2012). At-sea detection of marine debris: Overview of technologies, processes, issues, and options.  
24 *Marine Pollution Bulletin*, 65(1), 23-27. doi:<https://doi.org/10.1016/j.marpolbul.2011.08.042>
- 25 Maulana, F. (2016). *Identifikasi sampah laut di kawasan wisata pantai Kota Makassar*. (Skripsi), Universitas  
26 Hasanuddin, Makassar.
- 27 Michael E. Schaepman and Stefan Dangel 2000. *Solid laboratory calibration of a nonimaging spectroradiometer*,  
28 *Appl. Opt.*39, 3754-3764.
- 29 Moy, K., Neilson, B., Chung, A., Meadows, A., Castrence, M., Ambagis, S., & Davidson, K. (2018). Mapping coastal  
30 marine debris using aerial imagery and spatial analysis. *Marine Pollution Bulletin*, 132, 52-59.  
31 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.045>
- 32 Murphy, L. G., Peters, S., van Sebille, E., James, N. A., & Gibb, S. (2018). Concept for a hyperspectral remote sensing  
33 algorithm for floating marine macro plastics. *Marine Pollution Bulletin*, 126, 255-262.  
34 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.011>
- 35 NOAA. (2015). *Turning The Tide On Trash. A Learning Guide On Marine Debris*: NOAA PIFSC CRED.
- 36 Nolet C, Poortinga A, Roosjen P, Bartholomeus H, Ruessink G (2014) Measuring and Modeling the Effect of Surface  
37 Moisture on the Spectral Reflectance of Coastal Beach Sand. *PLOS ONE* 9(11): e112151.  
38 <https://doi.org/10.1371/journal.pone.0112151>
- 39 Pichel, W. G., Churnside, J. H., Veenstra, T. S., Foley, D. G., Friedman, K. S., Brainard, R. E., Nicoll, J.B., Zheng, Q.,  
40 Clemente-Colón, P. (2007). Marine debris collects within the North Pacific Subtropical Convergence  
41 Zone. *Marine Pollution Bulletin*, 54(8), 1207-1211. doi:<https://doi.org/10.1016/j.marpolbul.2007.04.010>
- 42 Shah, A. A., Hasan, F., Hameed, A., & Ahmed, S. (2008). Biological degradation of plastics: A comprehensive review.  
43 *Biotechnology Advances*, 26(3), 246-265. doi:<https://doi.org/10.1016/j.biotechadv.2007.12.005>
- 44 Thevenon F., C. C., Sousa J. (2014). *Plastic Debris in the Ocean. The Characterization of Marine Plastics and their*  
45 *Environmental Impacts. Situation Analysis Report*. Gland, Switzerland: IUCN
- 46 Van Cauwenberghe, L., Claessens, M., Vandegehuchte, M. B., Mees, J., & Janssen, C. R. (2013). Assessment of  
47 marine debris on the Belgian Continental Shelf. *Marine Pollution Bulletin*, 73(1), 161-169.  
48 doi:<https://doi.org/10.1016/j.marpolbul.2013.05.026>
- 49 Veenstra, T. S., & Churnside, J. H. (2012). Airborne sensors for detecting large marine debris at sea. *Marine*  
50 *Pollution Bulletin*, 65(1), 63-68. doi:<https://doi.org/10.1016/j.marpolbul.2010.11.018>
- 51

# Korespondensi 10

## 28-10-2019

Editor  
2019-10-28 02:29 PM

Subject: [IJG] Editor Decision: Substantial Revision Required

[DELETE](#)

Dear Dr. Ahmad Faizal,

Thank you for submitting the revision. I have now finished re-checking the content of your manuscript and found out that substantial improvements are still required before your manuscript can be published. Please see the attached file for my detailed comments.

Please carefully respond to my comments when submitting the revision and please clearly indicate the changes that you made (or highlight them) to address my comments. Or, you can also directly reply to the comments box. You should also use the template attached below. I will not process any revised paper without a specific response to my comments.

Once again, thank you for submitting your manuscript to the Indonesian Journal of Geography and I look forward to receiving your revision no later than 90 days from now. If you failed to meet the deadline, we may have to consider your paper rejected.

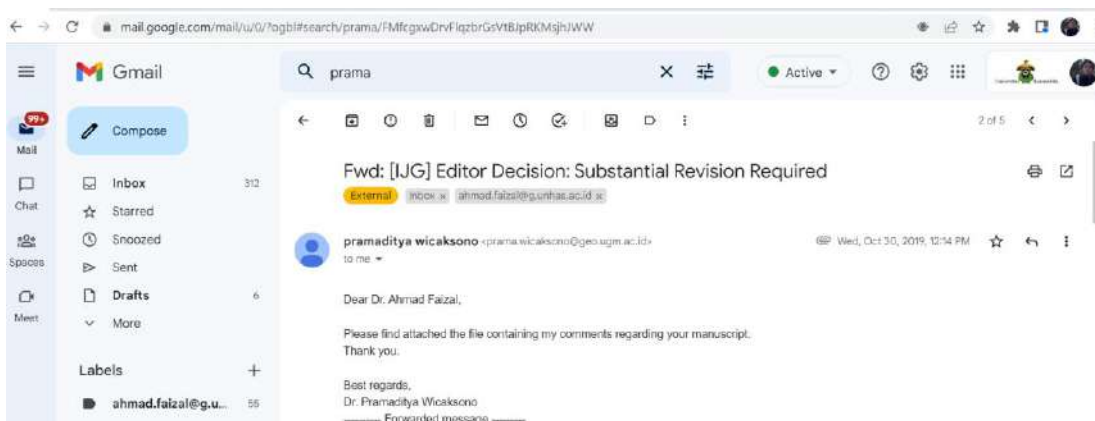
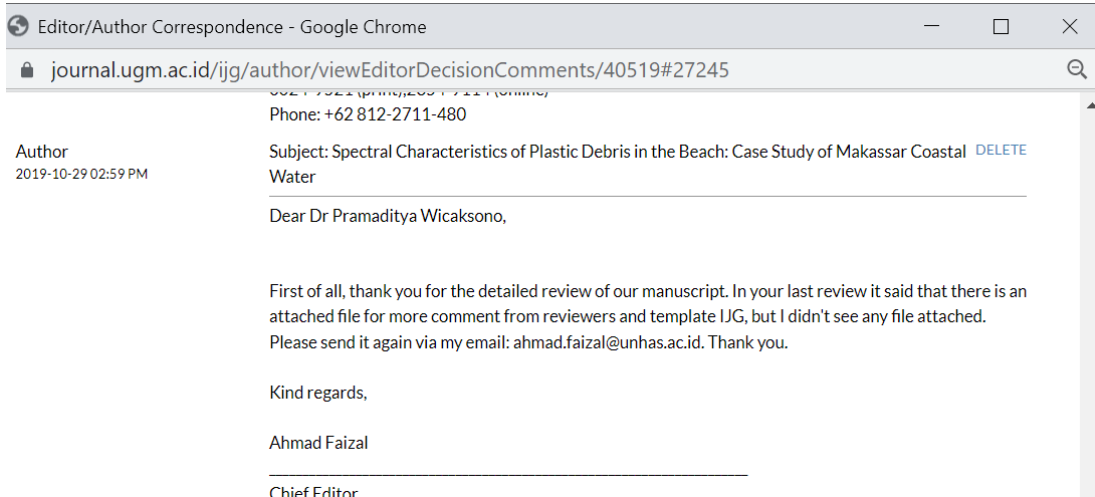
NB: Please use the follow the guideline in the attached template for your revision.

Best wishes,  
Dr. Pramaditya Wicaksono  
ID SCOPUS: 54279699900, Faculty of Geography Universitas Gadjah Mada, Yogyakarta  
Phone +6281391179917  
Fax +62274569595  
prama.wicaksono@geo.ugm.ac.id  
Section Editor  
Indonesian Journal of Geography  
Faculty of Geography, Universitas Gadjah Mada, Yogyakarta

---

Chief Editor  
Indonesian Journal of Geography  
<http://jurnal.ugm.ac.id/index.php/ijg>  
0024-9521 (print), 2354-9114 (online)  
Phone: +62 812-2711-480

# Tanggapan atas pesan di atas



# Lampiran email saran revisi

2 Attachments • Scanned by Gmail ⓘ



# 1 Spectral Characteristics of Plastic Debris in the Beach: Case Study 2 of Makassar Coastal Area

3 **Ahmad Faizal, Shinta Werorilangi, Wasir Samad**

4 Departement Ilmu Kelautan, Universitas Hasanuddin, Indonesia

5 [ahmad.faizal@unhas.ac.id](mailto:ahmad.faizal@unhas.ac.id)

6  
7 *Abstract* Plastic debris becomes a global problem that threatens the coastal ecosystems, and the supralittoral area (beach) turns  
8 to be a place for plastic debris to accumulate. Data from the United Nation (UN) states that Indonesia is the second plastic  
9 debris contributor in world waters. This study aimed to examine the spectral characteristics of plastic debris accumulated in  
10 the beach. The data was collected from the coast of Makassar at 3 different stations: Jenneberang River estuary, Losari Beach  
11 and Tallo River estuary. The spectral sample was measured using a 4000 A spectroradiometer that works on a wavelength  
12 spectrum 340 - 1040 nm. The results showed that the optimum value for plastic debris identification in the coastal area at low  
13 tide (dry sand) is 443-760 nm and at high tide (wet sand) is 443-950 nm. This value will be a reference in the remote sensing  
14 method, especially multispectral classification in mapping plastic debris found in coastal areas, and will be one solution to  
15 effectively mapping plastic debris.

16

17 **Key words:** plastic debris, wavelength, spectral

18  
19 *Abstrak* Sampah plastik menjadi masalah global yang mengancam kondisi ekosistem pesisir, dan daerah supralittoral (pantai)  
20 menjadi tempat penumpukan sampah plastik. Data United Nation (UN) menyebutkan bahwa Indonesia menjadi penyumbang  
21 sampah plastik nomer dua di perairan dunia. Penelitian ini bertujuan untuk mengkaji karakteristik spektral dari sampah  
22 plastik yang terakumulasi di daerah pantai. Data dikoleksi dari pesisir pantai makassar pada 3 stasiun yang berbeda yaitu di  
23 muara Sungai Jenneberang, Pantai Losari dan Muara Sungai Tallo. Spektral sampel diukur dengan menggunakan  
24 spektrodiodometer 4000 A yang bekerja pada spektrum panjang gelombang 340 - 1040 nm. Hasil penelitian menunjukkan nilai  
25 optimal untuk identifikasi sampah plastic di wilayah pantai pada kondisi pasir kering\_surut adalah 443-760 nm dan pada  
26 kondisi pasir basah-pasang adalah 443-950 nm. Nilai ini akan menjadi referensi dalam metode penginderaan jauh khususnya  
27 klasifikasi multispectral dalam memetakan sampah plasik yang terdapat di wilayah pesisir, dan akan menjadi salah satu solusi  
28 metode pemetaan sampah plastik yang efektif.

29

30 **Kata kunci :** Sampah plastik, Panjang Gelombang, spektral

## 31 1. Introduction

32 Marine debris is now a global problem that has affected all water bodies, especially the water surface in coastal  
33 areas. Its influence visibly shows towards the economy, ecology, public health, and environmental aesthetics.

34 Marine debris pollution is no longer a regional problem but has scaled up into a global or international problem.

35 Marine debris, especially plastic in waters, has transformed into agents that potentially bring toxic chemicals, such  
36 as PCBs and heavy metals to human. Whilst microplastics, fragmented from larger plastic debris, that are largely  
37 invisible to humans, can also accumulate in the food chain (Driedger et al., 2013).

Commented [A1]: Provide reference

Commented [A2]: Provide reference

Commented [A3]: Provide reference

Commented [A4]: Provide reference

1 Some time ago, it was estimated that around 10% of debris has been discharged into the waters (Van  
2 Cauwenberghe et al., 2013). Generally, marine debris with various forms (such as plastic, metal, wood, clothing,  
3 etc.) accumulates in coastal areas (NOAA, 2015). The main sources of debris in the waters are from recreational  
4 activities, wind or storm, illegal dumping, sewage treatment plants, and fishing industry (Driedger et al., 2013).  
5 In 2010, it was predicted that around 4.8 to 12.7 million metric tons of plastic debris had entered the ocean from  
6 192 countries and Indonesia is the second contributor to the sea debris after China. According to Jambeck et al.  
7 (2015) Indonesia contributed plastic debris to the sea by 1.29 million tons/year after China by 3.53 million  
8 tons/year in 2010. With regards to this condition, plastic debris pollution will add to a very large environmental  
9 and socio-economic problems in Indonesian waters (Driedger et al., 2013).

10 Marine debris, especially plastic debris in the waters, due to hydro-oceanographic influences were stranded and  
11 accumulated in the beach including in the coastal city of Makassar (Maulana, 2016). Identification of marine  
12 debris has been carried out using traditional survey methods (Driedger et al., 2013) including in South Sulawesi  
13 (Maulana, 2016). Another alternative that might be used is to employ the remote sensing method. The  
14 identification of objects using this method is generally based on the spectral characteristics of the object, each  
15 different material will give a different spectral curve, including plastic debris will give a different reflection curve  
16 to the surrounding object (Driedger et al., 2013; Hörig et al., 2001; Pichel et al., 2007). This second alternative  
17 enables relatively cheaper cost and faster time. The study of remote sensing of plastic debris in coastal areas was  
18 still experimental. However, several researchers have tried to monitor marine debris in various parts of the world  
19 (Aoyama, 2014; Jambeck et al., 2015; Mace, 2012; Veenstra & Churnside, 2012). This study aimed to examine  
20 spectral characteristics of the plastic debris in the beach and will be used as a reference for identifying plastic debris  
21 in coastal areas using satellite imagery.

## 22 23 2. The Methods

24 This research was carried out in coastal areas, especially in the beach of Makassar City, South Sulawesi Province,  
25 at three stations with adequately different characteristics (Figure 1.). All stations were connected to the water ways  
26 that comes from the city of Makassar that would potentially bring marine debris to the sea: Station 1, estuary of  
27 Jeneberang River, represented exposure area and the water influenced by Jeneberang River; station 2, Losari Beach,  
28 represented shelter area and the water influenced by the city small canals disemboque along Losari Beach; and  
29 station 3, estuary of Tallo River, which represented semi enclosed area and the water influenced by Paotere Canal  
30 and Tallo River.

31 The sample analysis was done at the Marine Ecology Laboratory, Marine Sciences Department, Hasanuddin  
32 University and the Remote Sensing and Ecology Laboratory Seameo BIOTROP, Bogor.

33

**Commented [A5]:** Provide reference

**Commented [A6]:** This part is not conducted in this research, and thus please fix or remove this part. Unless you integrate your spectra measurement with satellite image this statement should be omitted.

**Commented [A7]:** Your method section lack of necessary details that allow reader to replicate your work. Please provide explanation regarding:

1. How exactly did you collect the plastic samples?
2. Provide illustration or photos of the plastic samples that your measure
3. What is the color of your plastic samples?
4. Is the plastic samples dry or wet?
5. What is the background/or the color background of the plastic during spectra measurement?
6. How many plastic samples for spectra measurement?
7. Did you stack the plastic samples when you did the spectra measurement?



Figure 1. Makassar Coastal Water; Study area and sampling station

The spectral identification of plastic debris in the beach refers to the method used by Murphy et al. (2018) and its development with the implementation stages as follows:

a) *Sample collection*: sample collection was conducted in the beach of the coast of Makassar City, at three stations; Station 1 around the Jenneberang River Estuary, Station 2 around Losari Beach and Station 3 around the Tallo River Estuary up to the Paotere port. Furthermore, sorting of the collected sample was held in the Marine Ecology Laboratory, Marine Science Department with 10 plastic debris samples, with different characteristics.

b) *Sample Measurement*: The spectral value of the sample was measured using the Ocean Optics USB 4000 type spectrometer which works on a wavelength 340-1040 nm (nanometer). The spectral retrieval process involves spectrometers, light sources, optical fibers, and computers. One spectroradiometer part is connected to the light source and the other part is connected to the object being measured. The position of the light source does not directly face the sun but forms an angle of approximately 45° and 100 millisecond scanning time (Halma, 2008)

c) *Spectra Collection*: Reflectance values from samples are recorded using a computer equipped with software Ocean Optics Spectra Suite USB-4000. The spectroradiometer used has a wavelength range of 340-1040 nm with spectrometer components including 3648 linear silicon CCD Array elements, solar sources in the field, optical fibers with a diameter of 400 μm and a length of 2 meters, and a computer. The measurement steps are as follows:

- Dark Calibration, a calibration was taken with dark spectral technique and a reference. The dark spectral technique is a data spectral retrieval without light and samples, and a reference technique is taking spectral data using a reference from diffuse reflectance standard model WS-1, Ocean Optics USA.
- Reference Calibration/Light Calibration: Reference calibration is carried out by allowing light to reach an equilibrium (takes 30 minutes), making sure all cuvettes are clean of dust or dirt and are functioning

1 normally. The integration time is optimized to reach ~ 80%. The reference data obtained is stored as a  
2 reference for sample measurements.

3 - Setting Boxcar: The boxcar settings are adjusted to a value that is approximately the same as the spectral  
4 resolution of the spectrometer. When samples were recorded, the boxcar setting was adjusted to simple  
5 boxcar filtering which is a specialized case of Savitzky-Golay filtering where the polynomial order is 0  
6 (Halma, 2008).

7 - Spectral and Integration time measurement: At the time of measurement, one optic fiber section is  
8 connected to the light source and the spectrometer, other optic fiber parts are connected to the sample.  
9 Spectral reflectance of the plastic debris is measured twice, with integration time of 100 ms and resulting  
10 in 50 scans for each measurement, after which the spectral measurement were averaged

11 d. *Data analysis* used numeric data processing devices, the measurement data was classified by eliminating error  
12 values and cutting off visible and near-infrared light waves. Furthermore, the data was made into graphical form  
13 with smoothing graphs, and were statistically analysed using One-Way Analysis of Variance to evaluate differences  
14 of spectral reflectance curves among stations. The spectral reflectance curves were then compared to spectral  
15 reflectance of beach sand during dry conditions (occurring during low tide or beach sand which is not affected by  
16 tidal-range) and beach sand during wet conditions (occurs during high tide or beach sand which is still affected  
17 by tidal tides) by Nolet et al., 2014.

18

### 19 3. Result and Discussion

20 Spectral measurement results of each sample at each station are presented in Figure 2. The spectral reflectance  
21 curve of each sample shows the same reflectance pattern on each wavelength spectrum. Figure 2 shows a tendency  
22 of an increase in spectral reflectance curves for each station. At station 1 there is an increase in spectral curves at  
23 wavelengths of 500-625 nanometers (nm), at station 2 the tendency of the increase of spectral curves occurs at  
24 wavelengths of 470-600 nm and at station 3 the tendency of the increase spectral curves happens at wavelengths  
25 of 450-570 nm. The graph in Figure 2 shows the difference of the amount of data, this is due to noise that occurred  
26 when the recording started so the spectral reflectance curve is smaller than 0%, the value is eventually selected and  
27 considered as error data and not employed. The measurement of plastic debris spectral reflectance using a  
28 radiation source directly from the sun, which has a high wavelength (> 800 nm), was found to have a lot of noise  
29 that appears most likely caused by low primary light intensity at the time of measurement. According to Michael  
30 and Stefan (2000) and Dennis et al. (2004), noises occur at spectral reflectance recording are due to poor primary  
31 light intensity from sun and so noise comes up and enters. They also stated that the noise is further enhanced as a  
32 result of high sample attenuation and making the transmitted light intensity is very poor and thus gets noisy.

33

34

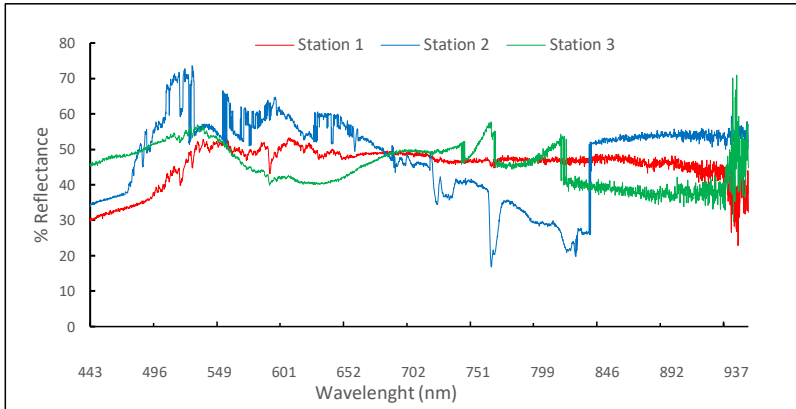


Figure 2. Spectral Reflectance Curve of plastic debris for each sample at all stations.

The difference in the spectral characteristics of plastic debris at each station is shown in Figure 2. The characteristics of each station are obtained from the average spectral reflectance value of each sample at each station. The average spectral reflectance value of each station shows the similarity of spectral reflectance patterns. The spectral reflectance pattern of each station starts to show an increase in the wavelength of 500 nm (blue wavelength) and decreases at a wavelength of 800 nm (red wavelength).

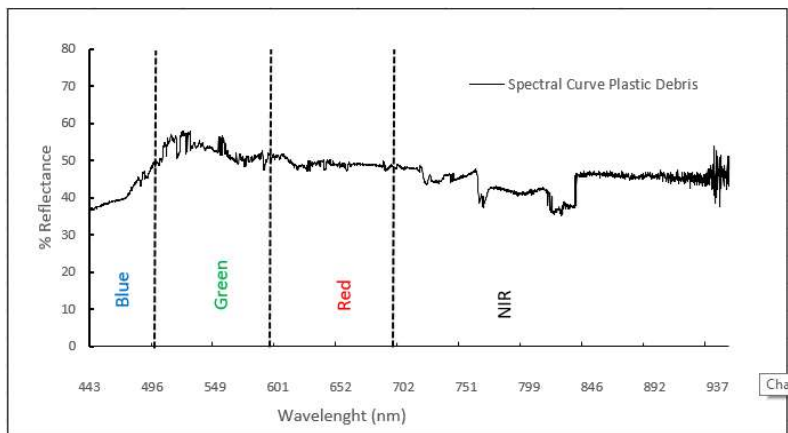


Figure 3. Comparisons of averaged spectral curve plastic debris with divisions based on wavelength.

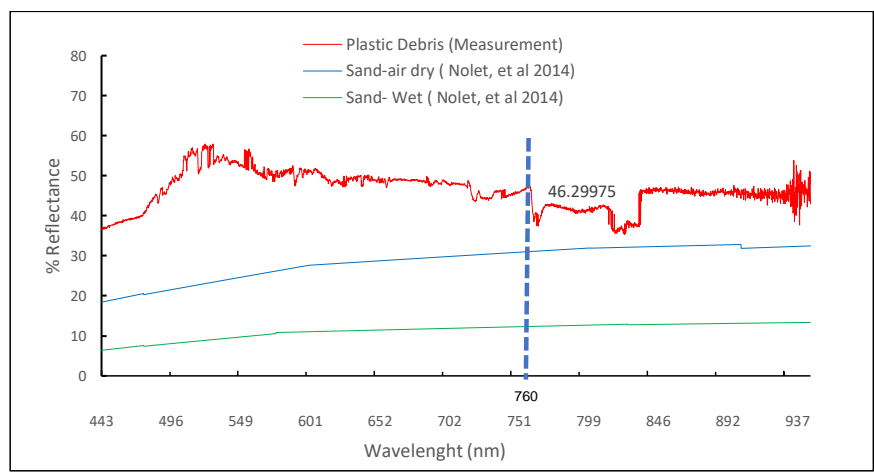
Figure 2 denotes the difference in spectral reflectance curves between each sample with the same pattern tendency. The difference in spectral reflectance curves of each object is influenced by several factors; characteristics of object or sample, the amount of light penetration received by objects (Murphy et al., 2018). Plastics found at the study site have different chemical compositions which will give different reflectance, plastic debris consists of several types; polyethylene (PE), poly-propylene (PP), polyvinylchloride (PVC), poly-amide (nylon) and polystyrene (PS) (Andrady, 2015). Different chemical compositions resulted in different spectral reflectance values as well (Imhof et al., 2017). Another factor is because the found samples have been degraded and have weathered naturally or

1 partially fragmented into microplastic (GESAMP, 2015; Shah et al., 2008; Thevenon F., 2014). In different time  
 2 and weather conditions, the sunlight's penetration that reaches to the earth's surface also varies, the number of  
 3 wavelengths that reach the earth's surface or the object is affected by the amount of scattering and absorption of  
 4 particles in the atmosphere (Lillesand et al., 2015; Murphy et al., 2018).  
 5 The tendency of reflectance pattern of each sample at every station (Figure 2) is almost the same, this is due to  
 6 similarity of the main chemical component of the plastic (Andrady, 2015). In several hyperspectral studies with  
 7 different objects and similar main components, have similar spectral patterns, such as vegetation (Huete, 1988),  
 8 coral reefs (Hochberg et al., 2003), soil (Lillesand et al., 2015) and others.  
 9 The spectral reflectance pattern of plastic debris found in the beach at all observation stations (Figure 3) shows  
 10 various spectral values with optimum spectral reflectance values at 500 - 700 nm. Based on wavelengths division,  
 11 that range is at the visible wavelength (400 - 700 nm). In detail, the visible wavelength is divided into 3 wavelengths;  
 12 Blue (400 - 500 nm), Green (500 - 600 nm) and Red (600 - 700 nm). One factor that might cause differences in  
 13 the spectral characteristics of each station is the presence of macroalgae that began to grow in various samples,  
 14 will automatically influence the spectral reflection of each object at each station (Diaz and Rosenberg, 1995).  
 15 The analysis of variance on the data of all stations showed no differences in the spectral characteristics of each  
 16 station ( $p > 0.05$ ) therefore the spectral values of each station were averaged and compiled with the spectral  
 17 reflectance curves from sand beach at two conditions of volumetric moisture content of 32% (wet or saturation)  
 18 and 0.01% (air-dry) (Nolet et al., 2014) as in Figure 4.

**Commented [A8]:** Check the reference for Thevenon

**Commented [A9]:** Do not use and other, etc. Check all manuscript

**Commented [A10]:** Optimum to what? When you say optimum it means you have to compare at least two spectra, so that you can say the optimum range of wavelengths to differentiate plastic debris and other associated objects.



20 Figure 4. Comparison of the average value of plastic reflectance with sand reflectance by Nolet, et al :2014

**Commented [A11]:** The sand spectra seem to have different spectral resolution with the plastic debris? Please explain this.

22 The reflectance graph in Figure 4 shows there is a difference in reflectance curves between plastic debris and sand  
 23 both in dry air conditions (air-dry) and in conditions of wet sand (saturation). The wavelength range of 443-760  
 24 nm is the best wavelength for identification of plastic debris in the condition of air-dry beach, in the case of wet  
 25 beach sand the overall wavelength range of 443-950 nm is optimal for use. If it is connected with a range of visible

1 light waves, the results show that in dry beach sand conditions, identification of plastic debris can be carried out  
2 at blue, green and red wavelengths and in wet sand conditions it can use all visible and near infrared waves.  
3 The use of multispectral classification techniques by utilizing spectral values of objects can be done in a broad  
4 scale mapping (Jensen, 2004). Including the utilization of the spectral curve from plastic waste, a multispectral  
5 classification can also be carried out for mapping the distribution of plastic debris. But in its implementation the  
6 identification of plastic debris objects can only be done: 1) in the locations of accumulated plastic debris, and it is  
7 less likely to be used to detect the distribution of small amount or scattered plastic debris, 2) to detect plastic debris  
8 on the surface of the substrates, another obstacle to the identification of plastic debris is related to spatial  
9 resolution, the lower the resolution, the lower the recognition of objects (Moy et al., 2018).

10 The difference in the spectral value of an object, including plastic debris, will be a reference in the remote sensing  
11 method, especially in multispectral classification. Our result of plastic debris spectral curve could be a reference  
12 for plastic debris mapping in coastal area. The mapping of plastic debris distribution with the remote sensing  
13 method will be a solution in effectively mapping the plastic debris.

#### 14 4. Conclusion

15 This study aims to examine the spectral characteristics of plastic debris in the coastal area (beach) of Makassar  
16 City with different type of exposure. Our results showed spectral characteristics of plastic debris were not different  
17 between stations, therefore the substrates where plastic debris found were not affecting the spectral reflection  
18 curve of plastic debris. The optimal value for identification of plastic debris in the coastal beach under conditions  
19 of dry sand-low tide is 443-760 nm and in the condition of wet sand-high tide is 443-950 nm. This value will be a  
20 reference in the remote sensing method, especially multispectral classification in mapping plastic debris found in  
21 coastal areas, and will be one solution to effectively mapping plastic debris.

#### 22 Acknowledgement

23 This research was done with research funding from the Competency-Based Research Scheme (Penelitian Berbasis  
24 Kompetensi) with Contract Number L 1715 / UN4.21 / PL.00.00 / 2018. This research, in addition, was also carried  
25 out with participation of Widodo, Researcher in the Laboratory of Remote Sensing and Ecology, SEAMEO  
26 Biotrop, also Sunarto and Muhammad Ilham from the Faculty of Marine and Fisheries, Hasanuddin University.  
27  
28

#### 29 References

- 30  
31 Andrady, A. L. (2015). Persistence of plastic litter in the oceans. In M. In: Bergmann, Gutow, L., Klages, M (Ed.),  
32 *Marine Anthropogenic Litter* (pp. 57-22): Springer International Publishing AG Switzerland.  
33 Aoyama, T. (2014). *Monitoring of marine debris in the sea of Japan using multi-spectral satellite images* Paper  
34 presented at the SPIE Asia-Pacific Remote Sensing.  
35 Dennis F. Flanigan, Alan C. Samuels, and Avishai Ben-David 2004 . Noise assessment of a Fourier transform  
36 infrared spectroradiometer subject to the stability of a conventional laboratory blackbody source," Appl.  
37 Opt. 43, 2767-2776 .  
38 Diaz R.J. & Rosenberg R., 1995. Marine benthic hypoxia: A review of its ecological effects and the behavioural  
39 responses of benthic macrofauna. *Oceanography and Marine Biology – An Annual Review*, 33: 245-303.  
40 Driedger, H. Durr, K. Mitchel, J. Flannery, E. Brancazi, & Cappelen, P. V. (2013). *Plastic Debris; Remote sensing  
41 and characterization*. Canada: University of Waterloo.

**Commented [A12]:** Your research is more relevant to hyperspectral data instead of multispectral data since you did not perform hyperspectral to multispectral resampling of your spectra. In order to check if your result can be used as a reference for multispectral data, you need perform multispectral resampling.

**Commented [A13]:** Substrate is insitu and your measurement of spectra was performed in lab? How both points are related? Also, you did not discuss anything about substrate in the manuscript, and thus do not put it in the conclusion.

**Commented [A14]:** Therefore, for both dry and wet sand, the wavelengths between 443 – 760 nm were overlapping? Thus, they only unique between 760 – 950 nm. Also, see my comments regarding "optimum" in previous sections.

**Commented [A15]:** Check previous comments

**Commented [A16]:** Please strictly follow the APA reference style used by our journal  
Text in yellow is not consistent with what was written in the manuscript

1 GESAMP. (2015). *Sources, fate and effects of microplastics in the marine environment: Part two of a global*  
2 *assessment* (P. J. K. a. C. M. Rochman Ed.). 4 Albert Embankment, London SE1 7SR: INTERNATIONAL  
3 MARITIME ORRGANIZATION.

4 Halma, C. (2008). USB4000 Fiber Optic Spectrometer: Instalation and Operation Manual. Retrieved from  
5 [www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf](http://www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf)

6 Hochberg, E. J., Atkinson, M. J., & Andréfouët, S. (2003). Spectral reflectance of coral reef bottom-types worldwide  
7 and implications for coral reef remote sensing. *Remote Sensing of Environment*, 85(2), 159-173.  
8 doi:[https://doi.org/10.1016/S0034-4257\(02\)00201-8](https://doi.org/10.1016/S0034-4257(02)00201-8)

9 Hörig, B., Kühn, F., Oschütz, F., & Lehmann, F. (2001). HyMap hyperspectral remote sensing to detect  
10 hydrocarbons. *International Journal of Remote Sensing*, 22(8), 1413-1422. doi:10.1080/01431160120909

11 Huete, A. R. (1988). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, 25(3), 295-309.  
12 doi:[https://doi.org/10.1016/0034-4257\(88\)90106-X](https://doi.org/10.1016/0034-4257(88)90106-X)

13 Imhof, H. K., Sigl, R., Brauer, E., Feyl, S., Giesemann, P., Klink, S., Leupolz, K., Loder, M.G.J., Löschel, L.A., Missun,  
14 Jan Muszynski, S., Ramsperger, A.F. R. M., Schrank, I., Speck, S., Steibl, S., Trotter, B., Winter, I.,  
15 Laforsch, C. (2017). Spatial and temporal variation of macro-, meso- and microplastic abundance on a  
16 remote coral island of the Maldives, Indian Ocean. *Marine Pollution Bulletin*, 116(1), 340-347.  
17 doi:<https://doi.org/10.1016/j.marpolbul.2017.01.010>

18 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., Law, K. L. (2015).  
19 Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771. doi:10.1126/science.1260352

20 Jensen, J.R. (2004) *Introductory Digital Image Processing: A Remote Sensing Perspective*. 3rd Edition, Prentice-  
21 Hall, Inc., New York, 316.

22 Lillesand, Ralph W. Kiefer, & Chipman, J. (2015). *Remote Sensing and Image Interpretation*: John Wiley and Sons.

23 Mace, T. H. (2012). At-sea detection of marine debris: Overview of technologies, processes, issues, and options.  
24 *Marine Pollution Bulletin*, 65(1), 23-27. doi:<https://doi.org/10.1016/j.marpolbul.2011.08.042>

25 Maulana, F. (2016). *Identifikasi sampah laut di kawasan wisata pantai Kota Makassar*. (Skripsi), Universitas  
26 Hasanuddin, Makassar.

27 Michael E. Schaepman and Stefan Dangel 2000. *Solid laboratory calibration of a nonimaging spectroradiometer*,  
28 *Appl. Opt.*39, 3754-3764.

29 Moy, K., Neilson, B., Chung, A., Meadows, A., Castrence, M., Ambagis, S., & Davidson, K. (2018). Mapping coastal  
30 marine debris using aerial imagery and spatial analysis. *Marine Pollution Bulletin*, 132, 52-59.  
31 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.045>

32 Murphy, L. G., Peters, S., van Sebille, E., James, N. A., & Gibb, S. (2018). Concept for a hyperspectral remote sensing  
33 algorithm for floating marine macro plastics. *Marine Pollution Bulletin*, 126, 255-262.  
34 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.011>

35 NOAA. (2015). *Turning The Tide On Trash. A Learning Guide On Marine Debris*: NOAA PIFSC CRED.

36 Nolet C, Poortinga A, Roosjen P, Bartholomeus H, Ruessink G (2014) Measuring and Modeling the Effect of Surface  
37 Moisture on the Spectral Reflectance of Coastal Beach Sand. *PLOS ONE* 9(11): e112151.  
38 <https://doi.org/10.1371/journal.pone.0112151>

39 Pichel, W. G., Churnside, J. H., Veenstra, T. S., Foley, D. G., Friedman, K. S., Brainard, R. E., Nicoll, J.B., Zheng, Q.,  
40 Clemente-Colón, P. (2007). Marine debris collects within the North Pacific Subtropical Convergence  
41 Zone. *Marine Pollution Bulletin*, 54(8), 1207-1211. doi:<https://doi.org/10.1016/j.marpolbul.2007.04.010>

42 Shah, A.A., Hasan, F., Hameed, A., & Ahmed, S. (2008). Biological degradation of plastics: A comprehensive review.  
43 *Biotechnology Advances*, 26(3), 246-265. doi:<https://doi.org/10.1016/j.biotechadv.2007.12.005>

44 Thevenon F., C. C., Sousa J. (2014). *Plastic Debris in the Ocean. The Characterization of Marine Plastics and their*  
45 *Environmental Impacts. Situation Analysis Report*. Gland, Switzerland: IUCN

46 Van Cauwenberghe, L., Claessens, M., Vandegehuchte, M. B., Mees, J., & Janssen, C. R. (2013). Assessment of  
47 marine debris on the Belgian Continental Shelf. *Marine Pollution Bulletin*, 73(1), 161-169.  
48 doi:<https://doi.org/10.1016/j.marpolbul.2013.05.026>

49 Veenstra, T. S., & Churnside, J. H. (2012). Airborne sensors for detecting large marine debris at sea. *Marine*  
50 *Pollution Bulletin*, 65(1), 63-68. doi:<https://doi.org/10.1016/j.marpolbul.2010.11.018>

51

# INDONESIAN JOURNAL OF GEOGRAPHY

## RESPOND TO REVIEWER'S COMMENTS

**Paper ID** :

**Paper Title** :

No.	Page	Reviewer's comments	Author's responses

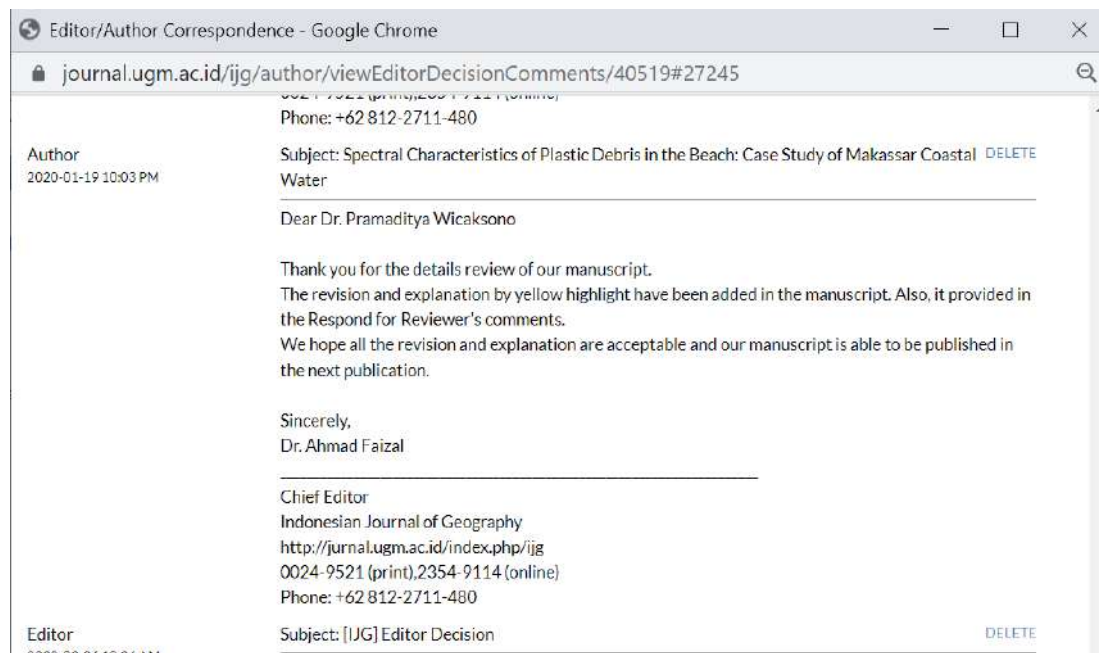
### **Important!**

Please also indicate your changes in the revised manuscript using track changes or highlighted text.

# Korespondensi 11

## Revisi

### 19-01-2020



## Lampiran Perbaikan atas Revisi

[40519-119685-6-ED.DOCX](#) 2020-01-19 [DELETE](#)  
[40519-119685-7-ED.DOCX](#) 2020-01-19 [DELETE](#)

# 1 Spectral Characteristics of Plastic Debris in the Beach: Case Study 2 of Makassar Coastal Area

3 Ahmad Faizal, Shinta Werorilangi, Wasir Samad

4 Departement Ilmu Kelautan, Universitas Hasanuddin, Indonesia

5 [ahmad.faizal@unhas.ac.id](mailto:ahmad.faizal@unhas.ac.id)

6

7 **Abstract** Plastic debris becomes a global problem that threatens the coastal ecosystems, and the supralittoral area (beach) turns  
8 to be a place for plastic debris to accumulate. Data from the United Nations (UN) states that Indonesia is the second plastic  
9 debris contributor in world waters. This study aimed to examine the spectral characteristics of plastic debris accumulated on  
10 the beach. The data was collected from the coast of Makassar at 3 different stations: Jenneberang River estuary, Losari Beach  
11 and Tallo River estuary. The spectral sample was measured using a 4000 A spectroradiometer that works on a wavelength  
12 spectrum of 340 - 1040 nm. The results showed that the optimum value for plastic debris identification in the coastal area at  
13 low tide (dry sand) is 450-670 nm and at high tide (wet sand) is 450-950 nm. This value will be a reference in the remote  
14 sensing method, especially multispectral classification in mapping plastic debris found in coastal areas, and will be one solution  
15 to effectively mapping plastic debris.

16

17 **Keywords:** plastic debris, wavelength, spectral

18

19 **Abstrak** Sampah plastik menjadi masalah global yang mengancam kondisi ekosistem pesisir, dan daerah supralittoral (pantai)  
20 menjadi tempat penumpukan sampah plastik. Data United Nation (UN) menyebutkan bahwa Indonesia menjadi penyumbang  
21 sampah plastik nomer dua di perairan dunia. Penelitian ini bertujuan untuk mengkaji karakteristik spektral dari sampah plastik  
22 yang terakumulasi di daerah pantai. Data dikoleksi dari pesisir pantai makassar pada 3 stasiun yang berbeda yaitu di muara  
23 Sungai Jenneberang, Pantai Losari dan Muara Sungai Tallo. Spektral sampel diukur dengan menggunakan spektrometri  
24 4000 A yang bekerja pada spektrum panjang gelombang 340 - 1040 nm. Hasil penelitian menunjukkan nilai optimal untuk  
25 identifikasi sampah plastik di wilayah pantai pada kondisi pasir kering\_surut adalah 450-670 nm dan pada kondisi pasir basah-  
26 pasang adalah 450-950 nm. Nilai ini akan menjadi referensi dalam metode penginderaan jauh khususnya klasifikasi  
27 multispectral dalam memetakan sampah plastik yang terdapat di wilayah pesisir, dan akan menjadi salah satu solusi metode  
28 pemetaan sampah plastik yang efektif.

29

30 **Kata kunci:** Sampah plastik, Panjang Gelombang, spektral

## 31 1. Introduction

32 Marine debris is now a global problem that has affected all water bodies, especially the water surface in coastal  
33 areas (Gregory, 2009; Thevenon et al., 2014, Pawar et al., 2016). Its influence visibly shows towards the economy,  
34 ecology, public health, and environmental aesthetics (STAP, 2012; Krelling, 2017). Marine debris pollution is no  
35 longer a regional problem but has scaled up into a global or international problem (McIlgorm et al., 2011; Van  
36 Franeker, 2015). Marine debris, especially plastic in waters, has transformed into agents that potentially bring toxic  
37 chemicals, such as PCBs and heavy metals to humans (Webb et al., 2013; Thevenonet al., 2014). Whilst

1 microplastics, fragmented from larger plastic debris, that are largely invisible to humans, can also accumulate in  
2 the food chain (Driedger et al., 2013).

3 Some time ago, it was estimated that around 10% of debris has been discharged into the waters (Van  
4 Cauwenberghe, 2013). Generally, marine debris from various categories (such as plastic, metal, wood, clothing,  
5 etc.) accumulates in coastal areas (NOAA, 2015). The main sources of debris in the waters are from recreational  
6 activities, wind or storm, illegal dumping, sewage treatment plants, and fishing industry (Driedger et al., 2013).

7 In 2010, it was predicted that around 4.8 to 12.7 million metric tons of plastic debris had entered the ocean from  
8 192 countries and Indonesia is the second contributor to the sea debris, 1.29 million tons/year after China by 3.53  
9 million tons/year (Jambeck et al., 2015). With regards to this condition, plastic debris pollution will add to a very  
10 large environmental and socio-economic problems in Indonesian waters (Driedger et al., 2013).

11 Marine debris, especially plastic debris in the waters, due to hydro-oceanographic influences were stranded and  
12 accumulated in the beach including in the coastal city of Makassar (Maulana, 2016). The identification of marine  
13 debris has been carried out using traditional survey methods (Driedger et al., 2013) including in South Sulawesi  
14 (Maulana, 2016). Another alternative that might be used is to employ the remote sensing method. The  
15 identification of objects using this method is generally based on the spectral characteristics of the object, each  
16 different material will give a different spectral curve, including plastic debris will give a different reflection curve  
17 to the surrounding object (Hörig et al., 2001; Pichel et al., 2007; Driedger et al., 2013). This second alternative  
18 enables a relatively cheaper cost and faster time. The study of remote sensing of plastic debris in coastal areas was  
19 still experimental. However, several researchers have tried to monitor marine debris in various parts of the world  
20 (Mace, 2012; Veenstra & Churnside, 2012; Aoyama, 2014; Jambeck et al., 2015). This study aimed to examine the  
21 spectral characteristics of the plastic debris on the beach.

22

## 23 **2.The Methods**

24 This research was carried out in coastal areas, especially in the beach of Makassar City, South Sulawesi Province  
25 (5.195 S, 119.352 E dan 5.081 S, 119.429 E), at three stations with adequately different characteristics (Figure 1.).  
26 All stations were connected to the waterways that come from the city of Makassar that would potentially bring  
27 marine debris to the sea: Station 1, estuary of Jeneberang River, represented exposure area and the water influenced  
28 by Jeneberang River; station 2, Losari Beach, represented shelter area and the water influenced by the city small  
29 canals disembugue along Losari Beach; and station 3, estuary of Tallo River, which represented semi-enclosed area  
30 and the water influenced by Paotere Canal and Tallo River.

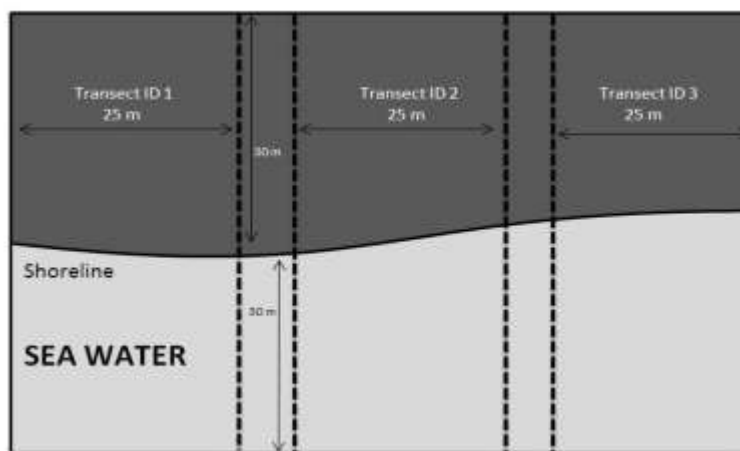
31 The sample analysis was done at the Marine Ecology Laboratory, Marine Sciences Department, Hasanuddin  
32 University and the Remote Sensing and Ecology Laboratory Seameo BIOTROP, Bogor.

33



1  
2

Figure 1. Makassar Coastal Water; Study area and sampling station



3

4 **Figure 2. Layout of plastic debris collection at each location (Based on NOAA, 2013)**

4

5 The spectral identification of plastic debris in the beach refers to the method used by Murphy et al., (2018) and its  
6 development with the implementation stages as follows:

- 7 a. **Sample collection:** plastic debris were collected in three transects lines (25 x 60 m) at each station during low  
8 tide, sampling is only done on land (NOAA, 2013; Figure 2). In each transect plastic wastes were collected with a  
9 minimum size of 5 x 5 cm in a trash bag. From each station, 10 dry samples were selected based on a different form  
10 of plastic wastes for spectral analysis (Figure 3).

10



Figure 3. Some of the plastic debris collected from each station

b) *Sample Measurement*: the spectral value of the sample was measured using the Ocean Optics USB 4000 type spectrometer which works on a wavelength of 340-1040 nm (nanometer). The measurement of each sample was conducted outdoor with sun exposure (Figure 4). The spectral retrieval process involves spectrometers, light sources, optical fibers, and computers. One spectroradiometer part was connected to the light source and the other part was connected to the object being measured. The position of the light source did not directly face the sun but forms an angle of approximately 45° and 100 millisecond scanning time (Halma, 2008).



Figure 4. Spectral measurement of plastic debris using Ocean Optics USB 4000

c) *Spectra Collection*: Reflectance values from samples were recorded using a computer equipped with software Ocean Optics Spectra Suite USB-4000. The spectroradiometer used had a wavelength range of 340-1040 nm with spectrometer components including 3648 linear silicon CCD Array elements, solar sources in the field, optical fibers with a diameter of 400  $\mu\text{m}$  and a length of 2 meters, and a computer. The measurement steps were as follows:

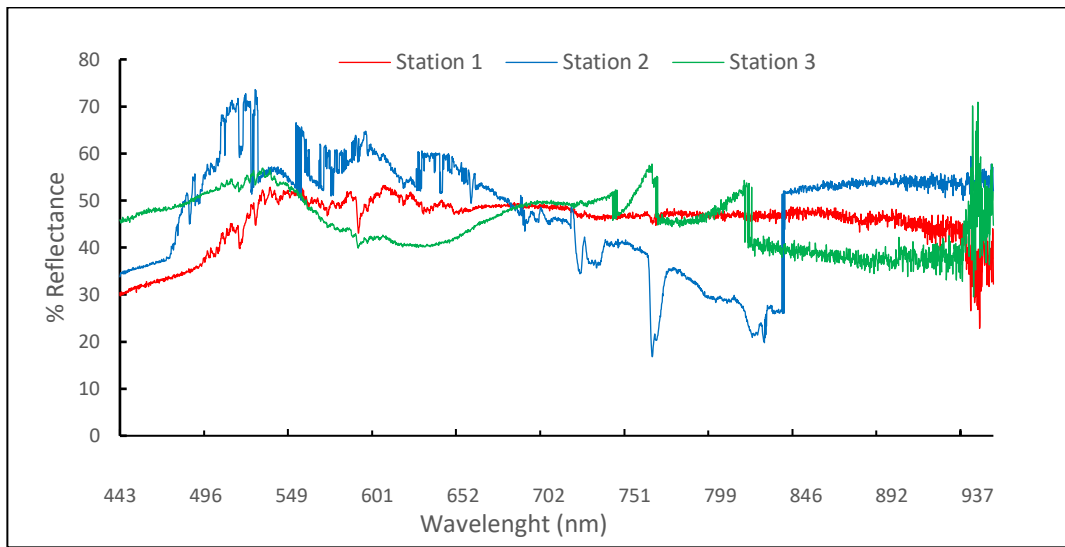
- 1 - Dark Calibration, a calibration was taken with a dark spectral technique and a reference. The dark spectral  
2 technique was a data spectral retrieval without light and samples, and a reference technique was taking  
3 spectral data using a reference from diffuse reflectance standard model WS-1, Ocean Optics USA.
- 4 - Reference Calibration/Light Calibration: Reference calibration was carried out by allowing light to reach  
5 an equilibrium (takes 30 minutes), making sure all cuvettes were clean of dust or dirt and were functioning  
6 normally. The integration time is optimized to reach ~ 80%. The reference data obtained was stored as a  
7 reference for sample measurements.
- 8 - Setting Boxcar: The boxcar settings were adjusted to a value that was approximately the same as the spectral  
9 resolution of the spectrometer. When samples were recorded, the boxcar setting was adjusted to simple  
10 boxcar filtering which is a specialized case of Savitzky-Golay filtering where the polynomial order was 0  
11 (Halma, 2008).
- 12 - Spectral and Integration time measurement: At the time of measurement, one optic fiber section was  
13 connected to the light source and the spectrometer, other optic fiber parts were connected to the sample.  
14 Spectral reflectance of the plastic debris was measured twice, with an integration time of 100 ms and  
15 resulting in 50 scans for each measurement, after which the spectral measurement was averaged
- 16 d. *Data analysis* used numeric data processing devices, the measurement data was classified by eliminating error  
17 values and cutting off visible and near-infrared light waves. Furthermore, the data was made into graphical form  
18 with smoothing graphs and were statistically analyzed using One-Way Analysis of Variance to evaluate differences  
19 of spectral reflectance curves among stations. The spectral reflectance curves were then compared to spectral  
20 reflectance of beach sand during dry conditions (occurring during low tide or beach sand which was not affected  
21 by tidal-range) and beach sand during wet conditions (occurs during high tide or beach sand which was still  
22 affected by tidal rides) by Nolet et al., 2014.

23

### 24 **3.Result and Discussion**

25 Spectral measurement results of each sample at each station are presented in Figure 5. The spectral reflectance  
26 curve of each sample shows the same reflectance pattern on each wavelength spectrum. Figure 5 shows a tendency  
27 of an increase in spectral reflectance curves for each station. At station 1 there is an increase in spectral curves at  
28 wavelengths of 500-625 nanometers (nm), at station 2 the tendency of the increase of spectral curves occurs at  
29 wavelengths of 470-600 nm and at station 3 the tendency of the increase spectral curves happen at wavelengths of  
30 450-570 nm. The graph in Figure 5 shows the difference in the amount of data, this is due to noise that occurred  
31 when the recording started so the spectral reflectance curve is smaller than 0%, the value is eventually selected and  
32 considered as error data and not employed. The measurement of plastic debris spectral reflectance using radiation  
33 sourced directly from the sun, which has a high wavelength (> 800 nm), was found to have a lot of noise that  
34 appears most likely caused by the low primary light intensity at the time of measurement. According to Schaepman  
35 & Dangel (2000) and Flanigan et al., (2004), noises occur at spectral reflectance recording are due to poor primary  
36 light intensity from the sun and so noise comes up and enters. They also stated that the noise is further enhanced  
37 as a result of high sample attenuation and making the transmitted light intensity is very poor and thus gets noisy.

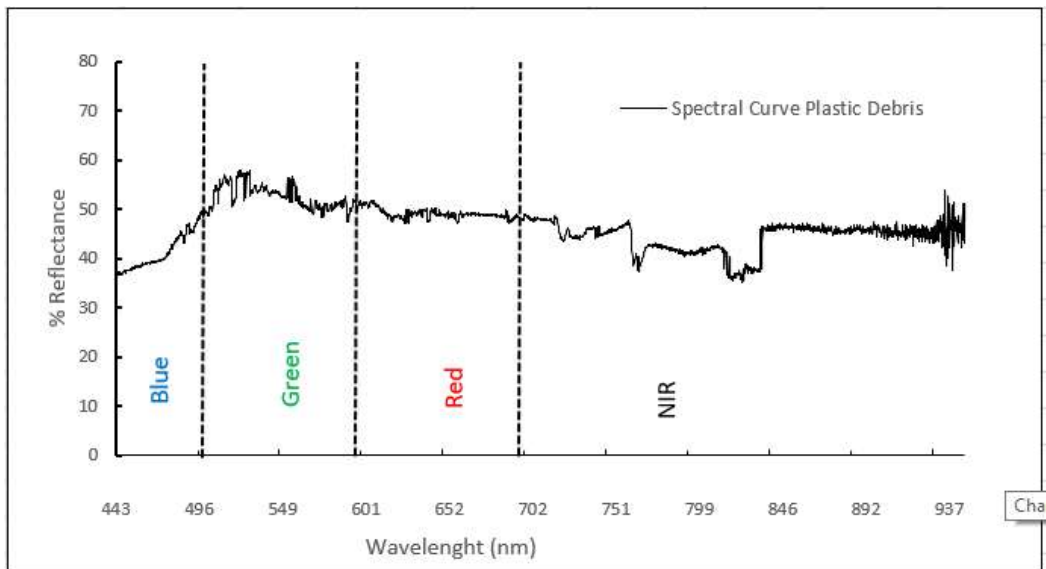
1  
2



3  
4  
5  
6  
7  
8  
9  
10

Figure 5. Spectral Reflectance Curve of plastic debris for each sample at all stations.

The difference in the spectral characteristics of plastic debris at each station is shown in Figure 5. The characteristics of each station are obtained from the average spectral reflectance value of each sample at each station. The average spectral reflectance value of each station shows the similarity of spectral reflectance patterns. The spectral reflectance pattern of each station starts to show an increase in the wavelength of 500 nm (blue wavelength) and decreases at a wavelength of 800 nm (Near-infrared wavelength).



11  
12  
13  
14  
15  
16  
17

Figure 6. Comparisons of averaged spectral curve plastic debris with divisions based on wavelength.

Figure 5 denotes the difference in spectral reflectance curves between each sample with the same pattern tendency. The difference in spectral reflectance curves of each object is influenced by several factors; characteristics of object or sample, the amount of light penetration received by objects (Murphy et al., 2018). Plastics found at the study site have different chemical compositions which will give different reflectance, plastic debris consists of several types; polyethylene (PE), polypropylene (PP), polyvinylchloride (PVC), polyamide (nylon) and polystyrene (PS) (

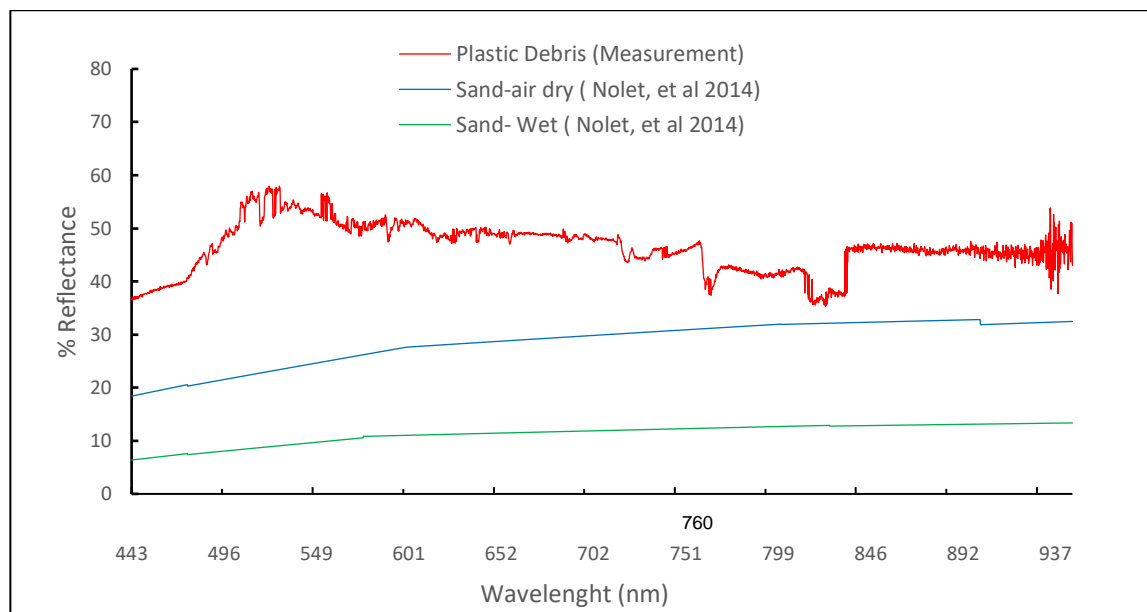
1 Andrady, 2015). Different chemical compositions resulted in different spectral reflectance values as well (Imhof  
2 et al., 2017). Another factor is because the found samples have been degraded and have weathered naturally or  
3 partially fragmented into microplastic (Shah et al., 2008; Thevenon et al., 2014; GESAMP, 2015). In different time  
4 and weather conditions, the sunlight's penetration that reaches to the earth's surface also varies, the number of  
5 wavelengths that reach the earth's surface or the object is affected by the amount of scattering and absorption of  
6 particles in the atmosphere (Lillesand et al., 2015; Murphy et al., 2018).

7 The tendency of reflectance pattern of each sample at every station (Figure 5) is almost the same, this is due to the  
8 similarity of the main chemical component of the plastic (Andrady, 2015). In several hyperspectral studies with  
9 different objects and similar main components, have similar spectral patterns, such as vegetation (Huete, 1988),  
10 coral reefs (Hochberg et al., 2003), and soil (Lillesand et al., 2015).

11 The spectral reflectance pattern of plastic debris found in the beach at all observation stations (Figure 6) shows  
12 various spectral values with optimum records at the wavelength of 500 - 700 nm. This wavelength range includes  
13 a visible wavelength of 450 670 nm. In detail, the visible wavelength is divided into 3 wavelengths; Blue (450 - 510  
14 nm), Green (510 - 580 nm) and Red (580 - 670 nm). One factor that might cause differences in the spectral  
15 characteristics of each station is the presence of macroalgae that began to grow in various samples, will  
16 automatically influence the spectral reflection of each object at each station (Diaz & Rosenberg, 1995).

17 The analysis of variance on the data of all stations showed no differences in the spectral characteristics of each  
18 station ( $p > 0.05$ ) therefore the spectral values of each station were averaged and compiled with the spectral  
19 reflectance curves from sand beach at two conditions of volumetric moisture content of 32% (wet or saturation)  
20 and 0.01% (air-dry) (Nolet et al., 2014) as in Figure 7.

21



22  
23 Figure 7. Comparison of the average value of plastic reflectance with sand reflectance by Nolet et al., (2014)

24  
25

Table 1. The Range of plastic debris spectral reflectance on the visible ( blue, green and red) and the near-infrared (NIR) wavelength. Value is the average±SE

Sample and Reference	Blue (450 – 510nm)	Green (510-580 nm)	Red (580-670 nm)	NIR (670-950 nm)
Plastic*	41.68 ± 4.11 <sup>a</sup>	46.08 ± 7.59 <sup>a</sup>	47.54 ± 4.54 <sup>a</sup>	44.41 ± 1.35 <sup>ab</sup>
Air-dry Sand**	20.65 ± 0.18 <sup>b</sup>	24.94 ± 0.40 <sup>bc</sup>	28.63 ± 0.21 <sup>b</sup>	31.37 ± 0.36 <sup>ab</sup>
Wet Sand **	7.30 ± 0.39 <sup>c</sup>	11.09 ± 0.39 <sup>bc</sup>	11.91 ± 0.67 <sup>c</sup>	12.42 ± 0.19 <sup>c</sup>

\*This study

\*\*Spectral reflectance by Nolet et al., (2014)

The reflectance graph in Figure 7 shows there is a difference in reflectance curves between plastic debris and sand both in dry air conditions (air-dry) and in conditions of wet sand (saturation). One-Way Analysis of Variance (ANOVA) in Table 1 shows differences in spectral reflection between plastics and air-dry sand at blue ( $p=0.002$ ), green ( $p=0.003$ ) and red wavelengths ( $p=0.006$ ) and also between plastic and wet sand at the visible and NIR wavelengths ( $p<0.05$ ). However, there are no differences detected between plastic and air-dry sand at NIR wavelengths. ( $p=0.07$ ) The differences in the ANOVA test allow the identification of plastic debris from its substrate and the absence of statistical differences implies indistinguishable between plastic debris and the substrate, therefore the identification cannot be completed.

The wavelength range of 450-670 nm (visible wavelength) is the best wavelength for identification of plastic debris in the condition of air-dry sand beach, in the case of wet beach sand, the overall wavelength range of 450-950 nm (visible and NIR wavelength) is optimal for use. The results of this study are very possible to be used as a reference in the identification of plastic debris in coastal areas under sandy substrate conditions, both in wet sand or in dry sand conditions.

The use of multispectral classification techniques by utilizing spectral values of objects can be done in a broad scale mapping (Jensen, 2004). Including the utilization of the spectral curve from plastic debris, a hyperspectral classification can also be carried out for mapping the distribution of plastic debris. But in its implementation the identification of plastic debris objects can only be done: 1) in the locations of accumulated plastic debris, and it is less likely to be used to detect the distribution of small amount of scattered plastic debris, 2) to detect plastic debris on the surface of the substrates, another obstacle to the identification of plastic debris is related to spatial resolution, the lower the resolution, the lower the recognition of objects (Moy et al., 2018).

The difference in the spectral value of an object, including plastic debris, will be a reference in the remote sensing method, especially in hyperspectral classification. Our result of the plastic debris spectral curve could be a reference for plastic debris mapping in the coastal area. The mapping of plastic debris distribution with the remote sensing method will be a solution in effectively mapping the plastic debris.

#### 4. Conclusion

This study aims to examine the spectral characteristics of plastic debris in the coastal area (beach) of Makassar City with a different type of exposure. Our results showed spectral characteristics of plastic debris were not different between stations. The optimal value for the identification of plastic debris in the coastal beach under conditions of the dry sand-low tide is 450-670 nm and the condition of the wet sand-high tide is 450-950 nm. This value will be a

1 reference in the remote sensing method, especially hyperspectral classification in mapping plastic debris found in  
2 coastal areas, and will be one solution to effectively mapping plastic debris.

3

#### 4 **Acknowledgment**

5 This research was done with research funding from the Competency-Based Research Scheme (Penelitian Berbasis  
6 Kompetensi) with Contract Number L 1715 / UN4.21 / PL.00.00 / 2018. This research, in addition, was also carried  
7 out with the participation of Widodo, Researcher in the Laboratory of Remote Sensing and Ecology, SEAMEO  
8 Biotrop, also Sunarto and Muhammad Ilham from the Faculty of Marine and Fisheries, Hasanuddin University.

9

#### 10 **References**

- 11 Andrady, A. L. (2015). Persistence of plastic litter in the oceans. In M. In: Bergmann, Gutow, L., Klages, M (Ed.),  
12 *Marine Anthropogenic Litter* (pp. 57-22): Springer International Publishing AG Switzerland.
- 13 Aoyama, T. (2014). *Monitoring of marine debris in the sea of Japan using multi-spectral satellite images* Paper  
14 presented at the SPIE Asia-Pacific Remote Sensing.
- 15 Diaz R.J. & Rosenberg R., (1995). Marine benthic hypoxia: A review of its ecological effects and the behavioural  
16 responses of benthic macrofauna. *Oceanography and Marine Biology – An Annual Review*, 33: 245-303.
- 17 Driedger, H. Durr, K. Mitchel, J. Flannery, E. Brancazi, & Cappelen, P. V. (2013). *Plastic Debris; Remote sensing  
18 and characterization*. Canada: University of Waterloo.
- 19 Flanigan, D. F., Samuels, A. C., & Ben-David, A. (2004). Noise assessment of a Fourier transform infrared  
20 spectroradiometer subject to the stability of a conventional laboratory blackbody source. *Applied Optics*,  
21 43(13), 2767-2776. DOI:10.1364/AO.43.002767
- 22 GESAMP. (2015). *Sources, fate, and effects of microplastics in the marine environment: Part two of a global  
23 assessment* (P. J. K. a. C. M. Rochman Ed.). 4 Albert Embankment, London SE1 7SR: INTERNATIONAL  
24 MARITIME ORGANIZATION.
- 25 Gregory M. R. (2009). Environmental implications of plastic debris in marine settings--entanglement, ingestion,  
26 smothering, hangers-on, hitch-hiking and alien invasions. *Philosophical transactions of the Royal Society  
27 of London. Series B, Biological Sciences*, 364(1526), 2013–2025. DOI:<https://10.1098/rstb.2008.0265>
- 28 Halma, C. (2008). *USB4000 Fiber Optic Spectrometer: Installation and Operation Manual*. Retrieved from  
29 [www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf](http://www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf)
- 30 Hochberg, E. J., Atkinson, M. J., & Andréfouët, S. (2003). Spectral reflectance of coral reef bottom-types worldwide  
31 and implications for coral reef remote sensing. *Remote Sensing of Environment*, 85(2), 159-173.  
32 DOI:[https://doi.org/10.1016/S0034-4257\(02\)00201-8](https://doi.org/10.1016/S0034-4257(02)00201-8)
- 33 Hörig, B., Kühn, F., Oschütz, F., & Lehmann, F. (2001). HyMap hyperspectral remote sensing to detect  
34 hydrocarbons. *International Journal of Remote Sensing*, 22(8), 1413-1422.  
35 DOI:<https://10.1080/01431160120909>
- 36 Huete, A. R. (1988). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, 25(3), 295-309.  
37 DOI:[https://doi.org/10.1016/0034-4257\(88\)90106-X](https://doi.org/10.1016/0034-4257(88)90106-X)
- 38 Imhof, H. K., Sigl, R., Brauer, E., Feyl, S., Giesemann, P., Klink, S., Leupolz, K., Loder, M.G.J., Löschel, L.A., Missun,  
39 Jan Muszynski, S., Ramsperger, A.F. R. M., Schrank, I., Speck, S., Steibl, S., Trotter, B., Winter, I., &  
40 Laforsch, C. (2017). Spatial and temporal variation of macro-, meso- and microplastic abundance on a  
41 remote coral island of the Maldives, Indian Ocean. *Marine Pollution Bulletin*, 116(1), 340-347.  
42 DOI:<https://doi.org/10.1016/j.marpolbul.2017.01.010>
- 43 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015).  
44 Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771. DOI:10.1126/science.1260352
- 45 Jensen, J.R. (2004) *Introductory Digital Image Processing: A Remote Sensing Perspective*. 3rd Edition, Prentice-  
46 Hall, Inc., New York, pp.316.
- 47 Krelling, A. P., Williams, A. T., & Turra, A. (2017). Differences in perception and reaction of tourist groups to beach  
48 marine debris that can influence a loss of tourism revenue in coastal areas. *Marine Policy*, 85, 87-99.  
49 DOI:<https://doi.org/10.1016/j.marpol.2017.08.021>
- 50
- 51 Lillesand, T., Kiefer, R. W., & Chipman, J. (2015). *Remote Sensing and Image Interpretation, 7th Edition*: Wiley.  
52 Pp.736

- 1 Mace, T. H. (2012). At-sea detection of marine debris: Overview of technologies, processes, issues, and options.  
2 *Marine Pollution Bulletin*, 65(1), 23-27. DOI:<https://doi.org/10.1016/j.marpolbul.2011.08.042>
- 3 Maulana, F. (2016). *Identifikasi sampah laut di kawasan wisata pantai Kota Makassar*. (Skripsi), Universitas  
4 Hasanuddin, Makassar.
- 5 McIlgorm, A., H. F. Campbell, & Rule M. J. (2011). The economic cost and control of marine debris damage in the  
6 Asia-Pacific region. *Ocean & Coastal Management*, 54(9), 643-651.  
7 DOI:<https://doi.org/10.1016/j.ocecoaman.2011.05.007>
- 8 Moy, K., Neilson, B., Chung, A., Meadows, A., Castrence, M., Ambagis, S., & Davidson, K. (2018). Mapping coastal  
9 marine debris using aerial imagery and spatial analysis. *Marine Pollution Bulletin*, 132, 52-59.  
10 DOI:<https://doi.org/10.1016/j.marpolbul.2017.11.045>
- 11 Murphy, L. G., Peters, S., van Sebille, E., James, N. A., & Gibb, S. (2018). Concept for a hyperspectral remote sensing  
12 algorithm for floating marine macro plastics. *Marine Pollution Bulletin*, 126, 255-262.  
13 DOI:<https://doi.org/10.1016/j.marpolbul.2017.11.011>
- 14 NOAA [National Oceanic and Atmospheric Administration]. (2013). *Progammatic Enviromental Assessment*  
15 *(PEA) for the NOAA Marine Debris Program (MDP)*. Maryland: pp168
- 16 NOAA. (2015). *Turning The Tide On Trash. A Learning Guide On Marine Debris*: NOAA PIFSC CRED.
- 17 Nolet, C., Poortinga, A., Roosjen, P., Bartholomeus, H., & Ruessink, G. (2014). Measuring and Modeling the Effect  
18 of Surface Moisture on the Spectral Reflectance of Coastal Beach Sand. *PLOS ONE*, 9(11), e112151.  
19 doi:10.1371/journal.pone.0112151
- 20 Pawar, P., Shirgaonkar, S., & affiliations, R. (2016). Plastic marine debris: Sources, distribution and impacts on  
21 coastal and ocean biodiversity. *PENCIL Publication of Biological Sciences (OCEANOGRAPHY)*. 3(1):  
22 40-54. (ISSN: 2408-5561). 3, 40-54.
- 23 Pichel, W. G., Churnside, J. H., Veenstra, T. S., Foley, D. G., Friedman, K. S., Brainard, R. E., Nicoll, J.B., Zheng, Q.,  
24 & Clemente-Colón, P. (2007). Marine debris collects within the North Pacific Subtropical Convergence  
25 Zone. *Marine Pollution Bulletin*, 54(8), 1207-1211. DOI:<https://doi.org/10.1016/j.marpolbul.2007.04.010>
- 26 Shah, A. A., Hasan, F., Hameed, A., & Ahmed, S. (2008). Biological degradation of plastics: A comprehensive review.  
27 *Biotechnology Advances*, 26(3), 246-265. DOI:<https://doi.org/10.1016/j.biotechadv.2007.12.005>
- 28 Schaepman, M. E., & Dangel, S. (2000). Solid laboratory calibration of a nonimaging spectroradiometer. *Applied*  
29 *Optics*, 39(21), 3754-3764. doi:10.1364/AO.39.003754
- 30 STAP [Secetariat of the Convention on Biological Diversity and the Scientific and Technical Advisory Panel] -GEF  
31 (2012). *Impacts of Marine Debris on Biodiversity: Current Status and Potential Solutions*, Montreal,  
32 Techincal Series No 67, 61 p
- 33 Thevenon, F., Carroll, C., & Sousa, J. (2014). *Plastic Debris in the Ocean. The Characterization of Marine Plastics*  
34 *and their Environmental Impacts. Situation Analysis Report*. Gland, Switzerland: IUCN
- 35 Van Cauwenberghe, L., Claessens, M., Vandegehuchte, M. B., Mees, J., & Janssen, C. R. (2013). Assessment of marine  
36 debris on the Belgian Continental Shelf. *Marine Pollution Bulletin*, 73(1), 161-169.  
37 DOI:<https://doi.org/10.1016/j.marpolbul.2013.05.026>
- 38 Van Franeker, J. A., & Law, K. L. (2015). Seabirds, gyres and global trends in plastic pollution. *Environmental*  
39 *Pollution*, 203, 89-96. DOI:<https://doi.org/10.1016/j.envpol.2015.02.034>
- 40 Veenstra, T. S., & Churnside, J. H. (2012). Airborne sensors for detecting large marine debris at sea. *Marine Pollution*  
41 *Bulletin*, 65(1), 63-68. DOI:<https://doi.org/10.1016/j.marpolbul.2010.11.018>
- 42 Webb, H. K., Arnott, J., Crawford, R. J., & Ivanova, E. P. (2013). Plastic Degradation and Its Environmental  
43 Implications with Special Reference to Poly(ethylene terephthalate). *Polymers*, 5(1), 1-18  
44  
45

# INDONESIAN JOURNAL OF GEOGRAPHY

## RESPOND TO REVIEWER'S COMMENTS

Paper ID : 40519

Paper Title : Spectral Characteristics of Plastic Debris in the Beach: Case Study of Makassar Coastal Area

No.	Page	Reviewer's comments	Author's responses
1	1	Provide reference : line 32-33	Has been added references (Block Yellow Highlight) page 1 line 33; (Gregory, 2009; Thevenon et al., 2014, Pawar et al., 2016).
2	1	Provide reference : line 33	Has been added references (Block Yellow Highlight) page 1 line 34; (STAP, 2011, Krelling, 2017
3	1	Provide reference : line 34	Has been added references (Block Yellow Highlight) page 1 line 35-36 ; (McIlgorm et al., 2011., Van Franeker, 2015
4	1	Provide reference : line 35-36	Has been added references (Block Yellow Highlight) page 1 line 37; Webb et al., 2013, Thevenon et al., 2014
5	2	Provide reference : line 5-6	Has been added reference and correction (Block Yellow Highlight) page 2 line 7-9: In 2010, it was predicted that around 4.8 to 12.7 million metric tons of plastic debris had entered the ocean from 192 countries and Indonesia is the second contributor to the sea debris, 1.29 million tons/year after China by 3.53 million tons/year (Jambeck et al, 2015
6	2	This part is not conducted in this research, and thus please fix or remove this part. Unless you integrate your spectra measurement with satellite image this statement should be omitted. Line 20-21 "	Has been deleted text in page 2: line 20-21

		and will be used as a reference for identifying plastic debris in coastal areas using satellite imagery.	
7	2-3	<p><b>The Methods :</b></p> <p>Your method section lack of necessary details that allow reader to replicate your work. Please provide explanation regarding:</p> <ol style="list-style-type: none"> <li>1. How exactly did you collect the plastic samples?</li> <li>2. Provide illustration or photos of the plastic samples that your measure</li> <li>3. What is the color of your plastic samples?</li> <li>4. Is the plastic samples dry or wet?</li> <li>5. What is the background/or the color background of the plastic during spectra measurement?</li> <li>6. How many plastic samples for spectra measurement?</li> </ol> <p>Did you stack the plastic samples when you did the spectra measurement?</p>	Method has been explained in detail, that is in the form of text, illustration and photo according to reviewer comment. In page 3-4
8	6	Check the reference for Thevenon : Line 1	The page has been corrected in page7 line 3
9	6	Do not use and other, etc. Check all manuscript: Line 8	Has been corrected and deleted (and others.): in page 7 line 10
10	6	Optimum to what? When you say optimum it means you have to compare at least two spectra, so that you can say the optimum range of wavelengths to differentiate plastic debris and other associated objects: line 10	Has been corrected. The word optimum refers to the recording capability of the spectrometer. At the wavelength of >700 nm, noises had occurred and it gave a bad result. In page 7 line 12-14
11	6	The sand spectra seem to have different spectral resolution with the plastic debris? Please explain this. ,line 21	Has been revised by adding explanation in line .. The author adds statistical analysis of ANOVA in page 8 line 1 until page 8 line 18

12	7	<p>Your research is more relevant to hyperspectral data instead of multispectral data since you did not perform hyperspectral to multispectral resampling of your spectra.</p> <p>In order to check if your result can be used as a reference for multispectral data, you need perform multispectral resampling. ( Line 10 -13</p>	<p>Has been corrected to hyperspectral</p> <p>Page 8 line 19 and line 27</p>
13	7	<p>Substrate is insitu and your measurement of spectra was performed in lab? How both points are related?</p> <p>Also, you did not discuss anything about substrate in the manuscript, and thus do not put it in the conclusion. (line 18)</p>	<p>Has been corrected and deleted page 8 line 3-34</p>
14	7	<p>Therefore, for both dry and wet sand, the wavelengths between 443 – 760 nm were overlapping? Thus, they only unique between 760 – 950 nm.</p> <p>Also, see my comments regarding “optimum” in previous sections.</p> <p>Line 19-20</p>	<p>The author has explained in the result and discussion at page 8 and line 35</p>
15	7	<p>Check previous comments</p> <p>Line 20-22</p>	<p>Has been corrected in page 8 line 35 and page 9 line1-2</p>
16	7-8	<p>Please strictly follow the APA reference style used by our journal</p>	<p>Has been revised according to reviewer suggestion. Page 9 and 10</p>

		Text in yellow is not consistent with what was written in the manuscript Reference page 7-8	
--	--	--	--

**Important!**

Please also indicate your changes in the revised manuscript using track changes or highlighted text.

# Korespondensi ke 12

26-02-2020

Editor/Autor Correspondence - Google Chrome

journal.ugm.ac.id/ijg/author/viewEditorDecisionComments/40519#27245

0024-9521 (print),2354-9114 (online)  
Phone: +62 812-2711-480

Editor  
2020-02-26 10:26 AM

Subject: [IJG] Editor Decision [DELETE](#)

Dear Mr. Ahmad Faizal,

I'm happy with the revised version of your manuscript and planning to involve your manuscript in the next issue of Indonesian Journal of Geography. Therefore, I invite you to respond to my questions as follow:

1. In Figure 3, you show some examples of plastic debris. However, the figure also includes a carton pack of drink and rubber flip-flops. These are not made from plastic and should not be included. If you included these, then it is called marine litter, not plastic debris.
2. Figure 5 should be the averaged reflectance from each station. Is it correct?
3. Please use reference management tools for your reference.

Thank you and I'm looking forward to your revision.

Best wishes,  
Dr. Pramaditya Wicaksono  
Faculty of Geography Universitas Gadjah Mada, Yogyakarta  
Phone +6281391179917  
Fax +62274569595  
prama.wicaksono@geo.ugm.ac.id  
Section Editor  
Indonesian Journal of Geography  
Faculty of Geography, Universitas Gadjah Mada, Yogyakarta

---

Chief Editor  
Indonesian Journal of Geography  
<http://jurnal.ugm.ac.id/index.php/ijg>  
0024-9521 (print),2354-9114 (online)  
Phone: +62 812-2711-480

## Tanggapan atas pesan tersebut di atas

Editor/Author Correspondence - Google Chrome

journal.ugm.ac.id/ijg/author/viewEditorDecisionComments/40519#27245

0024-9521 (print),2354-9114 (online)  
Phone: +62 812-2711-480

Author  
2020-03-04 12:17 PM

Subject: Spectral Characteristics of Plastic Debris in the Beach: Case Study of Makassar Coastal Water [DELETE](#)

Dear Dr Pramaditya Wicaksono,

Thank you for your kind reply and we are glad that our manuscript has been reviewed with only minor revisions. Herewith, our response to the questions asked:

1. Yes, we made a mistake by putting the wrong pictures of plastic debris. We have revised that in Fig.3 in the manuscript.
2. Yes, it is correct, it should be an average of reflectance from each station. We have revised that legend figure 5
3. We already used Endnote in the reference.

We hope to wait for the good news of publication.

Sincerely,

Dr Ahmad Faizal

---

Chief Editor  
Indonesian Journal of Geography  
<http://jurnal.ugm.ac.id/index.php/ijg>  
0024-9521 (print),2354-9114 (online)  
Phone: +62 812-2711-480

## Lampiran Perbaikan

40519-119685-8-ED.DOCX 2020-03-04 [DELETE](#)

# 1 Spectral Characteristics of Plastic Debris in the Beach: Case Study 2 of Makassar Coastal Area

3 Ahmad Faizal, Shinta Werorilangi, Wasir Samad

4 Departement Ilmu Kelautan, Universitas Hasanuddin, Indonesia

5 [ahmad.faizal@unhas.ac.id](mailto:ahmad.faizal@unhas.ac.id)

6

7 **Abstract** Plastic debris becomes a global problem that threatens the coastal ecosystems, and the supralittoral area (beach) turns  
8 to be a place for plastic debris to accumulate. Data from the United Nations (UN) states that Indonesia is the second plastic  
9 debris contributor in world waters. This study aimed to examine the spectral characteristics of plastic debris accumulated on  
10 the beach. The data was collected from the coast of Makassar at 3 different stations: Jenneberang River estuary, Losari Beach  
11 and Tallo River estuary. The spectral sample was measured using a 4000 A spectroradiometer that works on a wavelength  
12 spectrum of 340 - 1040 nm. The results showed that the optimum value for plastic debris identification in the coastal area at  
13 low tide (dry sand) is 450-670 nm and at high tide (wet sand) is 450-950 nm. This value will be a reference in the remote sensing  
14 method, especially multispectral classification in mapping plastic debris found in coastal areas, and will be one solution to  
15 effectively mapping plastic debris.

16

17 **Keywords:** plastic debris, wavelength, spectral

18

19 **Abstrak** Sampah plastik menjadi masalah global yang mengancam kondisi ekosistem pesisir, dan daerah supralittoral (pantai)  
20 menjadi tempat penumpukan sampah plastik. Data United Nation (UN) menyebutkan bahwa Indonesia menjadi penyumbang  
21 sampah plastik nomer dua di perairan dunia. Penelitian ini bertujuan untuk mengkaji karakteristik spektral dari sampah plastik  
22 yang terakumulasi di daerah pantai. Data dikoleksi dari pesisir pantai makassar pada 3 stasiun yang berbeda yaitu di muara  
23 Sungai Jenneberang, Pantai Losari dan Muara Sungai Tallo. Spektral sampel diukur dengan menggunakan spektrometri  
24 4000 A yang bekerja pada spektrum panjang gelombang 340 – 1040 nm. Hasil penelitian menunjukkan nilai optimal untuk  
25 identifikasi sampah plastik di wilayah pantai pada kondisi pasir kering\_surut adalah 450-670 nm dan pada kondisi pasir basah-  
26 pasang adalah 450-950 nm. Nilai ini akan menjadi referensi dalam metode penginderaan jauh khususnya klasifikasi  
27 multispectral dalam memetakan sampah plasik yang terdapat di wilayah pesisir, dan akan menjadi salah satu solusi metode  
28 pemetaan sampah plastik yang efektif.

29 **Kata kunci:** Sampah plastik, Panjang Gelombang, spektral

30

## 31 1. Introduction

32 Marine debris is now a global problem that has affected all water bodies, especially the water surface in coastal  
33 areas (Gregory, 2009; Pawar et al., 2016; Thevenon et al., 2014). Its influence visibly shows towards the economy,  
34 ecology, public health, and environmental aesthetics (Krelling et al., 2017; SCBD-STAP-GEF, 2012). Marine debris  
35 pollution is no longer a regional problem but has scaled up into a global or international problem (McIlgorm et  
36 al., 2011; van Franeker & Law, 2015). Marine debris, especially plastic in waters, has transformed into agents that  
37 potentially bring toxic chemicals, such as PCBs and heavy metals to humans (Thevenon et al., 2014; Webb et al.,

1 2013). Whilst microplastics, fragmented from larger plastic debris, that are largely invisible to humans, can also  
2 accumulate in the food chain (Driedger et al., 2013).  
3 Some time ago, it was estimated that around 10% of debris has been discharged into the waters (Van Cauwenberghe  
4 et al., 2013). Generally, marine debris from various categories (such as plastic, metal, wood, clothing, etc.)  
5 accumulates in coastal areas (NOAA, 2015). The main sources of debris in the waters are from recreational  
6 activities, wind or storm, illegal dumping, sewage treatment plants, and fishing industry (Driedger et al., 2013).  
7 In 2010, it was predicted that around 4.8 to 12.7 million metric tons of plastic debris had entered the ocean from  
8 192 countries and Indonesia is the second contributor to the sea debris, 1.29 million tons/year after China by 3.53  
9 million tons/year (Jambeck et al., 2015). With regards to this condition, plastic debris pollution will add to a very  
10 large environmental and socio-economic problems in Indonesian waters (Driedger et al., 2013).  
11 Marine debris, especially plastic debris in the waters, due to hydro-oceanographic influences were stranded and  
12 accumulated in the beach including in the coastal city of Makassar (Maulana, 2016). The identification of marine  
13 debris has been carried out using traditional survey methods (Driedger et al., 2013), including in South Sulawesi  
14 (Maulana, 2016). Another alternative that might be used is to employ the remote sensing method. The  
15 identification of objects using this method is generally based on the spectral characteristics of the object, each  
16 different material will give a different spectral curve, including plastic debris will give a different reflection curve  
17 to the surrounding object (Driedger et al., 2013; Horig et al., 2001; Pichel et al., 2007). This second alternative  
18 enables a relatively cheaper cost and faster time. The study of remote sensing of plastic debris in coastal areas was  
19 still experimental. However, several researchers have tried to monitor marine debris in various parts of the world  
20 (Aoyama, 2014; Jambeck et al., 2015; Mace, 2012; Veenstra & Churnside, 2012). This study aimed to examine the  
21 spectral characteristics of the plastic debris on the beach.

22

## 23 **2.The Methods**

24 This research was carried out in coastal areas, especially in the beach of Makassar City, South Sulawesi Province  
25 (5.195 S, 119.352 E dan 5.081 S, 119.429 E), at three stations with adequately different characteristics (Figure 1.).  
26 All stations were connected to the waterways that come from the city of Makassar that would potentially bring  
27 marine debris to the sea: Station 1, estuary of Jeneberang River, represented exposure area and the water influenced  
28 by Jeneberang River; station 2, Losari Beach, represented shelter area and the water influenced by the city small  
29 canals disembugue along Losari Beach; and station 3, estuary of Tallo River, which represented semi-enclosed area  
30 and the water influenced by Paotere Canal and Tallo River.

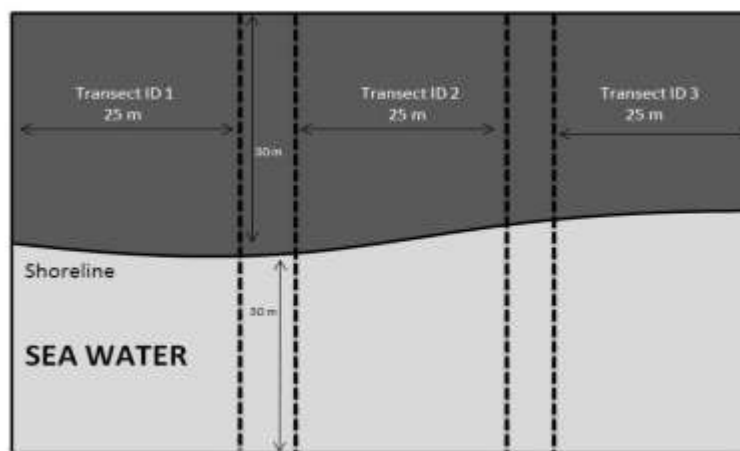
31 The sample analysis was done at the Marine Ecology Laboratory, Marine Sciences Department, Hasanuddin  
32 University and the Remote Sensing and Ecology Laboratory Seameo BIOTROP, Bogor.

33



1  
2

Figure 1. Makassar Coastal Water; Study area and sampling station



3  
4  
5  
6  
7  
8  
9  
10

Figure 2. Layout of plastic debris collection at each location (Based on NOAA- Lippiatt et al. (2013))

The spectral identification of plastic debris in the beach refers to the method used by Murphy et al. (2018) and its development with the implementation stages as follows:

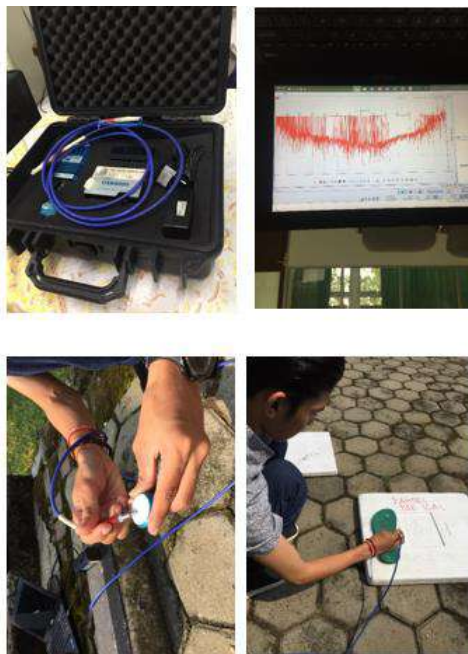
- a. **Sample collection:** plastic debris were collected in three transects lines (25 x 60 m) at each station during low tide, sampling is only done on land (Figure 2) (Lippiatt et al., 2013). In each transect plastic wastes were collected with a minimum size of 5 x 5 cm in a trash bag. From each station, 10 dry samples were selected based on a different form of plastic wastes for spectral analysis (Figure 3).



1

2 **Figure 3. Some of the plastic debris collected from each station ( A=station 1; B=Station 2; and C=Station 3)**

3 b) *Sample Measurement*: the spectral value of the sample was measured using the Ocean Optics USB 4000 type  
 4 spectrometer which works on a wavelength of 340-1040 nm (nanometer). **The measurement of each sample was**  
 5 **conducted outdoor with sun exposure** (Figure 4). The spectral retrieval process involves spectrometers, light  
 6 sources, optical fibers, and computers. One spectroradiometer part was connected to the light source and the other  
 7 part was connected to the object being measured. The position of the light source did not directly face the sun but  
 8 forms an angle of approximately 45° and 100 millisecond scanning time (Halma, 2008).



9

10 **Figure 4. Spectral measurement of plastic debris using Ocean Optics USB 4000**

11 c) *Spectra Collection*: Reflectance values from samples were recorded using a computer equipped with software  
 12 Ocean Optics Spectra Suite USB-4000. The spectroradiometer used had a wavelength range of 340-1040 nm with

1 spectrometer components including 3648 linear silicon CCD Array elements, solar sources in the field, optical  
2 fibers with a diameter of 400  $\mu\text{m}$  and a length of 2 meters, and a computer. The measurement steps were as follows:

- 3 - Dark Calibration, a calibration was taken with a dark spectral technique and a reference. The dark spectral  
4 technique was a data spectral retrieval without light and samples, and a reference technique was taking  
5 spectral data using a reference from diffuse reflectance standard model WS-1, Ocean Optics USA.
- 6 - Reference Calibration/Light Calibration: Reference calibration was carried out by allowing light to reach  
7 an equilibrium (takes 30 minutes), making sure all cuvettes were clean of dust or dirt and were functioning  
8 normally. The integration time is optimized to reach  $\sim 80\%$ . The reference data obtained was stored as a  
9 reference for sample measurements.
- 10 - Setting Boxcar: The boxcar settings were adjusted to a value that was approximately the same as the spectral  
11 resolution of the spectrometer. When samples were recorded, the boxcar setting was adjusted to simple  
12 boxcar filtering which is a specialized case of Savitzky-Golay filtering where the polynomial order was 0  
13 (Halma, 2008).
- 14 - Spectral and Integration time measurement: At the time of measurement, one optic fiber section was  
15 connected to the light source and the spectrometer, other optic fiber parts were connected to the sample.  
16 Spectral reflectance of the plastic debris was measured twice, with an integration time of 100 ms and  
17 resulting in 50 scans for each measurement, after which the spectral measurement was averaged

18 d. *Data analysis* used numeric data processing devices, the measurement data was classified by eliminating error  
19 values and cutting off visible and near-infrared light waves. Furthermore, the data was made into graphical form  
20 with smoothing graphs and were statistically analyzed using One-Way Analysis of Variance to evaluate differences  
21 of spectral reflectance curves among stations. The spectral reflectance curves were then compared to spectral  
22 reflectance of beach sand during dry conditions (occurring during low tide or beach sand which was not affected  
23 by tidal-range) and beach sand during wet conditions (occurs during high tide or beach sand which was still  
24 affected by tidal rides) by Nolet et al. (2014).

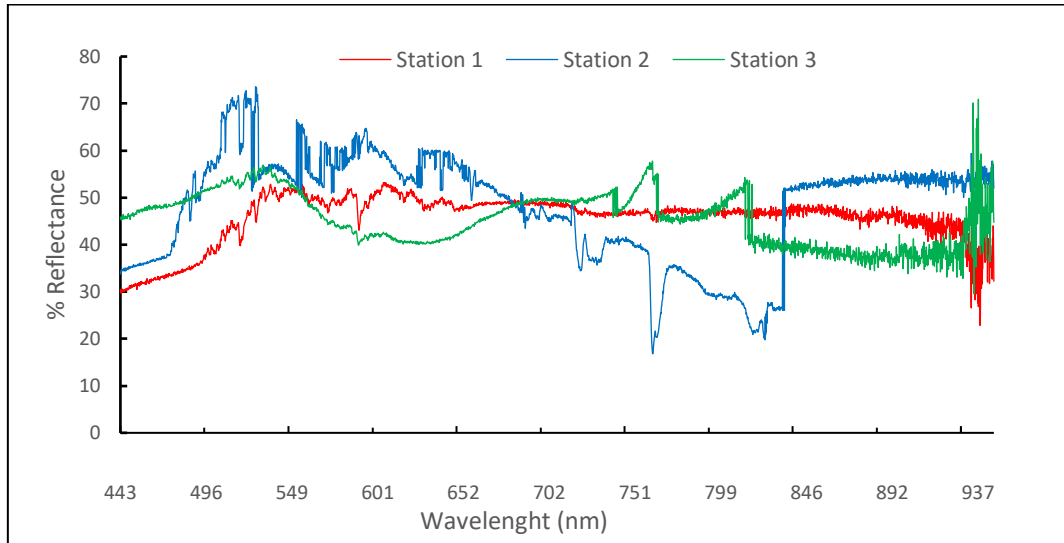
25

### 26 **3.Result and Discussion**

27 Spectral measurement results of each sample at each station are presented in Figure 5. The average spectral  
28 reflectance curve of each sample shows the same reflectance pattern on each wavelength spectrum. Figure 5 shows  
29 a tendency of an increase in spectral reflectance curves for each station. At station 1 there is an increase in spectral  
30 curves at wavelengths of 500-625 nanometers (nm), at station 2 the tendency of the increase of spectral curves  
31 occurs at wavelengths of 470-600 nm and at station 3 the tendency of the increase spectral curves happen at  
32 wavelengths of 450-570 nm. The graph in Figure 5 shows the difference in the amount of data, this is due to noise  
33 that occurred when the recording started so the spectral reflectance curve is smaller than 0%, the value is eventually  
34 selected and considered as error data and not employed. The measurement of plastic debris spectral reflectance  
35 using radiation sourced directly from the sun, which has a high wavelength ( $> 800$  nm), was found to have a lot of  
36 noise that appears most likely caused by the low primary light intensity at the time of measurement. According  
37 Schaepman and Dangel (2000) and Flanigan et al. (2004), noises occur at spectral reflectance recording are due to  
38 poor primary light intensity from the sun and so noise comes up and enters. They also stated that the noise is

1 further enhanced as a result of high sample attenuation and making the transmitted light intensity is very poor and  
2 thus gets noisy.

3

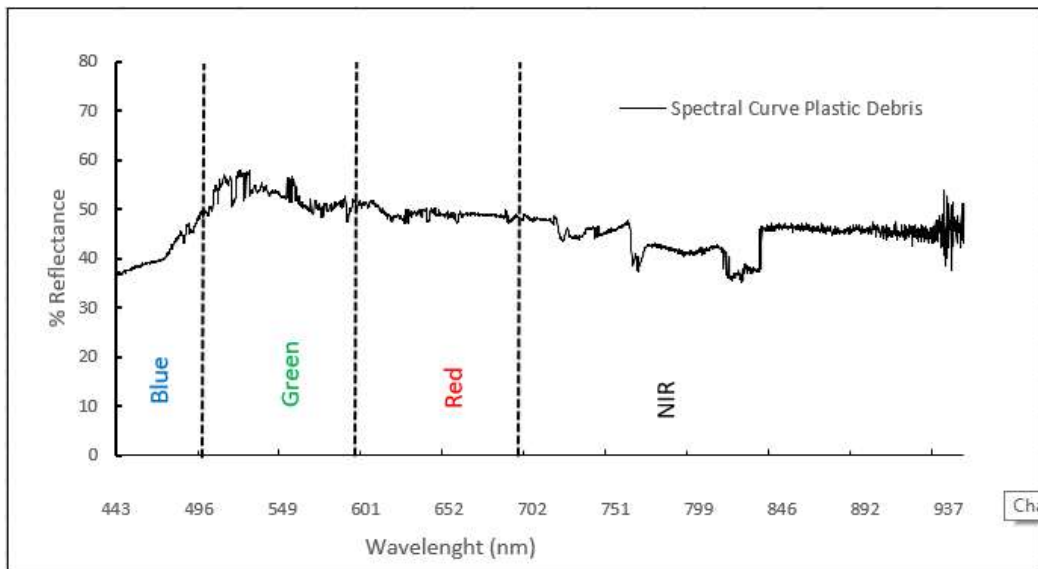


4

5 Figure 5. Average Spectral Reflectance Curve of plastic debris for each sample at all stations.

6 The difference in the spectral characteristics of plastic debris at each station is shown in Figure 5. The  
7 characteristics of each station are obtained from the average spectral reflectance value of each sample at each  
8 station. The average spectral reflectance value of each station shows the similarity of spectral reflectance patterns.  
9 The spectral reflectance pattern of each station starts to show an increase in the wavelength of 500 nm (blue  
10 wavelength) and decreases at a wavelength of 800 nm (Near-infrared wavelength).

11

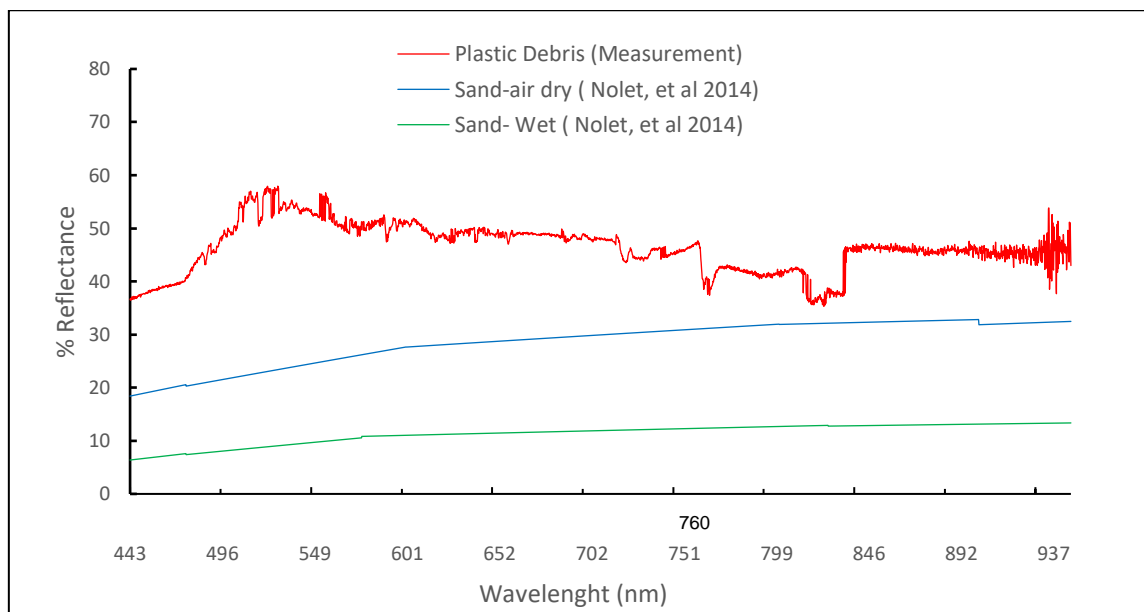


12

13 Figure 6. Comparisons of averaged spectral curve plastic debris with divisions based on wavelength.

14 Figure 5 denotes the difference in spectral reflectance curves between each sample with the same pattern tendency.  
15 The difference in spectral reflectance curves of each object is influenced by several factors; characteristics of object  
16 or sample, the amount of light penetration received by objects (Murphy et al., 2018). Plastics found at the study  
17 site have different chemical compositions which will give different reflectance, plastic debris consists of several

1 types; polyethylene (PE), polypropylene (PP), polyvinylchloride (PVC), polyamide (nylon) and polystyrene (PS)  
2 (Andrady, 2015). Different chemical compositions resulted in different spectral reflectance values as well (Imhof  
3 et al., 2017). Another factor is because the found samples have been degraded and have weathered naturally or  
4 partially fragmented into microplastic (GESAMP, 2015; Shah et al., 2008; Thevenon et al., 2014). In different time  
5 and weather conditions, the sunlight's penetration that reaches to the earth's surface also varies, the number of  
6 wavelengths that reach the earth's surface or the object is affected by the amount of scattering and absorption of  
7 particles in the atmosphere (Lillesand et al., 2015; Murphy et al., 2018) (Lillesand et al., 2015; Murphy et al., 2018).  
8 The tendency of reflectance pattern of each sample at every station (Figure 5) is almost the same, this is due to the  
9 similarity of the main chemical component of the plastic (Andrady, 2015). In several hyperspectral studies with  
10 different objects and similar main components, have similar spectral patterns, such as vegetation (Huete, 1988),  
11 coral reefs (Hochberg et al., 2003), and soil (Lillesand et al., 2015).  
12 The spectral reflectance pattern of plastic debris found in the beach at all observation stations (Figure 6) shows  
13 various spectral values with optimum records at the wavelength of 500 - 700 nm. This wavelength range includes  
14 a visible wavelength of 450 670 nm. In detail, the visible wavelength is divided into 3 wavelengths; Blue (450 - 510  
15 nm), Green (510 - 580 nm) and Red (580 - 670 nm). One factor that might cause differences in the spectral  
16 characteristics of each station is the presence of macroalgae that began to grow in various samples, will  
17 automatically influence the spectral reflection of each object at each station (Diaz & Rosenberg, 1995).  
18 The analysis of variance on the data of all stations showed no differences in the spectral characteristics of each  
19 station ( $p > 0.05$ ) therefore the spectral values of each station were averaged and compiled with the spectral  
20 reflectance curves from sand beach at two conditions of volumetric moisture content of 32% (wet or saturation)  
21 and 0.01% (air-dry) (Nolet et al., 2014) as in Figure 7.



22  
23 Figure 7. Comparison of the average value of plastic reflectance with sand reflectance by Nolet et al. (2014).  
24  
25

1 Table 1. The Range of plastic debris spectral reflectance on the visible ( blue, green and red) and the near-  
 2 infrared (NIR) wavelength. Value is the average±SE

Sample and Reference	Blue (450 – 510nm)	Green (510-580 nm)	Red (580-670 nm)	NIR (670-950 nm)
Plastic*	41.68 ± 4.11 <sup>a</sup>	46.08 ± 7.59 <sup>a</sup>	47.54 ± 4.54 <sup>a</sup>	44.41 ± 1.35 <sup>ab</sup>
Air-dry Sand**	20.65 ± 0.18 <sup>b</sup>	24.94 ± 0.40 <sup>b,c</sup>	28.63 ± 0.21 <sup>b</sup>	31.37 ± 0.36 <sup>ab</sup>
Wet Sand **	7.30 ± 0.39 <sup>c</sup>	11.09 ± 0.39 <sup>b,c</sup>	11.91 ± 0.67 <sup>c</sup>	12.42 ± 0.19 <sup>c</sup>

3 \*This study

4 \*\*Spectral reflectance by (Nolet et al., 2014).

5  
 6 The reflectance graph in Figure 7 shows there is a difference in reflectance curves between plastic debris and sand  
 7 both in dry air conditions (air-dry) and in conditions of wet sand (saturation). One Way Analysis of Variance in  
 8 Table 1 shows differences in spectral reflection between plastics and air-dry sand at blue (p=0.002), green (p=0.003)  
 9 and red wavelengths (p=0.006) and also between plastic and wet sand at the visible and NIR wavelengths (p<0.05).  
 10 However, there are no differences detected between plastic and air-dry sand at NIR wavelengths. (p=0.07) The  
 11 differences in the One Way Analysis of Variance test allow the identification of plastic debris from its substrate  
 12 and the absence of statistical differences implies indistinguishable between plastic debris and the substrate,  
 13 therefore the identification cannot be completed.

14 The wavelength range of 450-670 nm (visible wavelength) is the best wavelength for identification of plastic debris  
 15 in the condition of air-dry sand beach, in the case of wet beach sand, the overall wavelength range of 450-950 nm  
 16 (visible and NIR wavelength) is optimal for use. The results of this study are very possible to be used as a reference  
 17 in the identification of plastic debris in coastal areas under sandy substrate conditions, both in wet sand or in dry  
 18 sand conditions.

19 The use of multispectral classification techniques by utilizing spectral values of objects can be done in a broad scale  
 20 mapping (Jensen, 2004). Including the utilization of the spectral curve from plastic debris, a hyperspectral  
 21 classification can also be carried out for mapping the distribution of plastic debris. But in its implementation the  
 22 identification of plastic debris objects can only be done: 1) in the locations of accumulated plastic debris, and it is  
 23 less likely to be used to detect the distribution of small amount of scattered plastic debris, 2) to detect plastic debris  
 24 on the surface of the substrates, another obstacle to the identification of plastic debris is related to spatial resolution,  
 25 the lower the resolution, the lower the recognition of objects (Moy et al., 2018) .

26 The difference in the spectral value of an object, including plastic debris, will be a reference in the remote sensing  
 27 method, especially in hyperspectral classification. Our result of the plastic debris spectral curve could be a reference  
 28 for plastic debris mapping in the coastal area. The mapping of plastic debris distribution with the remote sensing  
 29 method will be a solution in effectively mapping the plastic debris.

#### 30 4.Conclusion

31  
 32 This study aims to examine the spectral characteristics of plastic debris in the coastal area (beach) of Makassar City  
 33 with a different type of exposure. Our results showed spectral characteristics of plastic debris were not different  
 34 between stations. The optimal value for the identification of plastic debris in the coastal beach under conditions of  
 35 the dry sand-low tide is 450-670 nm and the condition of the wet sand-high tide is 450-950 nm. This value will be

1 a reference in the remote sensing method, especially hyperspectral classification in mapping plastic debris found  
2 in coastal areas, and will be one solution to effectively mapping plastic debris.

3

#### 4 **Acknowledgment**

5 This research was done with research funding from the Competency-Based Research Scheme (Penelitian Berbasis  
6 Kompetensi) with Contract Number L 1715 / UN4.21 / PL.00.00 / 2018. This research, in addition, was also carried  
7 out with the participation of Widodo, Researcher in the Laboratory of Remote Sensing and Ecology, SEAMEO  
8 Biotrop, also Sunarto and Muhammad Ilham from the Faculty of Marine and Fisheries, Hasanuddin University.

9

#### 10 **References**

- 11 Andrady, A. L. (2015). Persistence of plastic litter in the oceans. In M. In: Bergmann, Gutow, L., Klages, M (Ed.),  
12 *Marine Anthropogenic Litter* (pp. 57-22): Springer International Publishing AG Switzerland.
- 13 Aoyama, T. (2014). *Monitoring of marine debris in the sea of Japan using multi-spectral satellite images* Paper  
14 presented at the SPIE Asia-Pacific Remote Sensing.
- 15 Diaz, R., & Rosenberg, R. (1995). Marine benthic hypoxia: A review of its ecological effects and the behavioural  
16 response of benthic macrofauna. *Oceanography and Marine Biology-an Annual Review*, 33(33), 245-133.
- 17 Driedger, H. Durr, K. Mitchel, J. Flannery, E. Brancazi, & Cappelen, P. V. (2013). Plastic Debris; Remote sensing  
18 and characterization. Canada: University of Waterloo.
- 19 Flanigan, D. F., Samuels, A. C., & Ben-David, A. (2004). Noise assessment of a Fourier transform infrared  
20 spectroradiometer subject to the stability of a conventional laboratory blackbody source. *Applied Optics*,  
21 43(13), 2767-2776. doi:10.1364/AO.43.002767
- 22 GESAMP. (2015). *Sources, fate and effects of microplastics in the marine environment: Part two of a global*  
23 *assessment* (P. J. K. a. C. M. Rochman Ed.). 4 Albert Embankment, London SE1 7SR: INTERNATIONAL  
24 MARITIME ORRGANIZATION.
- 25 Gregory, M. R. (2009). Environmental implications of plastic debris in marine settings-entanglement, ingestion,  
26 smothering, hangers-on, hitch-hiking and alien invasions. *Philosophical Transactions of the Royal*  
27 *Society B: Biological Sciences*, 364(1526), 2013-2025. doi:doi:10.1098/rstb.2008.0265
- 28 Halma, C. (2008). USB4000 Fiber Optic Spectrometer: Instalation and Operation Manual. Retrieved from  
29 [www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf](http://www.oceanoptics.com/technical/USB4000OperatingInstructions.pdf)
- 30 Hochberg, E. J., Atkinson, M. J., & Andréfouët, S. (2003). Spectral reflectance of coral reef bottom-types worldwide  
31 and implications for coral reef remote sensing. *Remote Sensing of Environment*, 85(2), 159-173.  
32 doi:[https://doi.org/10.1016/S0034-4257\(02\)00201-8](https://doi.org/10.1016/S0034-4257(02)00201-8)
- 33 Hörig, B., Kühn, F., Oschütz, F., & Lehmann, F. (2001). HyMap hyperspectral remote sensing to detect  
34 hydrocarbons. *International Journal of Remote Sensing*, 22(8), 1413-1422. doi:10.1080/01431160120909
- 35 Huete, A. R. (1988). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, 25(3), 295-309.  
36 doi:[https://doi.org/10.1016/0034-4257\(88\)90106-X](https://doi.org/10.1016/0034-4257(88)90106-X)
- 37 Imhof, H. K., Sigl, R., Brauer, E., Feyl, S., Giesemann, P., Klink, S., Leupolz, K., Löder, M. G. J., Löschel, L. A.,  
38 Missun, J., Muszynski, S., Ramsperger, A. F. R. M., Schrank, I., Speck, S., Steibl, S., Trotter, B., Winter, I.,  
39 & Laforsch, C. (2017). Spatial and temporal variation of macro-, meso- and microplastic abundance on a  
40 remote coral island of the Maldives, Indian Ocean. *Marine Pollution Bulletin*, 116(1), 340-347.  
41 doi:<https://doi.org/10.1016/j.marpolbul.2017.01.010>
- 42 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015).  
43 Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771. doi:10.1126/science.1260352
- 44 Jensen, J. R. (2004). *Introductory Digital Image Processing: A Remote Sensing Perspective.*: Prentice-Hall, Inc,  
45 New York.
- 46 Krelling, A. P., Williams, A. T., & Turra, A. (2017). Differences in perception and reaction of tourist groups to  
47 beach marine debris that can influence a loss of tourism revenue in coastal areas. *Marine Policy*, 85, 87-  
48 99. doi:<https://doi.org/10.1016/j.marpol.2017.08.021>
- 49 Lillesand, T., Kiefer, R. W., & Chipman, J. (2015). *Remote Sensing and Image Interpretation, 7th Edition*: Wiley.
- 50 Lippiatt, S., Opfer, S., & Arthur, C. (2013). *Marine Debris Monitoring and Assessment*: NOAA Technical  
51 Memorandum NOS-OR&R-46.

- 1 Mace, T. H. (2012). At-sea detection of marine debris: Overview of technologies, processes, issues, and options.  
2 *Marine Pollution Bulletin*, 65(1), 23-27. doi:<https://doi.org/10.1016/j.marpolbul.2011.08.042>
- 3 Maulana, F. (2016). *Identifikasi sampah laut di kawasan wisata pantai Kota Makassar*. (Skripsi), Universitas  
4 Hasanuddin, Makassar.
- 5 McIlgorm, A., Campbell, H. F., & Rule, M. J. (2011). The economic cost and control of marine debris damage in  
6 the Asia-Pacific region. *Ocean & Coastal Management*, 54(9), 643-651.  
7 doi:<https://doi.org/10.1016/j.ocecoaman.2011.05.007>
- 8 Moy, K., Neilson, B., Chung, A., Meadows, A., Castrence, M., Ambagis, S., & Davidson, K. (2018). Mapping coastal  
9 marine debris using aerial imagery and spatial analysis. *Marine Pollution Bulletin*, 132, 52-59.  
10 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.045>
- 11 Murphy, L. G., Peters, S., van Sebille, E., James, N. A., & Gibb, S. (2018). Concept for a hyperspectral remote sensing  
12 algorithm for floating marine macro plastics. *Marine Pollution Bulletin*, 126, 255-262.  
13 doi:<https://doi.org/10.1016/j.marpolbul.2017.11.011>
- 14 NOAA. (2015). *Turning The Tide On Trash. A Learning Guide On Marine Debris*. NOAA PIFSC CRED.
- 15 Nolet, C., Poortinga, A., Roosjen, P., Bartholomeus, H., & Ruessink, G. (2014). Measuring and Modeling the Effect  
16 of Surface Moisture on the Spectral Reflectance of Coastal Beach Sand. *PLOS ONE*, 9(11), e112151.  
17 doi:10.1371/journal.pone.0112151
- 18 Pawar, P., Shirgaonkar, S., & affiliations, R. (2016). Plastic marine debris: Sources, distribution and impacts on  
19 coastal and ocean biodiversity. *PENCIL Publication of Biological Sciences (OCEANOGRAPHY)*. 3(1):  
20 40-54. (ISSN: 2408-5561). 3, 40-54.
- 21 Pichel, W. G., Churnside, J. H., Veenstra, T. S., Foley, D. G., Friedman, K. S., Brainard, R. E., Nicoll, J. B., Zheng,  
22 Q., & Clemente-Colón, P. (2007). Marine debris collects within the North Pacific Subtropical  
23 Convergence Zone. *Marine Pollution Bulletin*, 54(8), 1207-1211.  
24 doi:<https://doi.org/10.1016/j.marpolbul.2007.04.010>
- 25 SCBD-STAP-GEF. (2012). *Impacts of Marine Debris on Biodiversity: Current Status and Potential Solutions*.  
26 Montreal: Technical Series.
- 27 Schaeppman, M. E., & Dangel, S. (2000). Solid laboratory calibration of a nonimaging spectroradiometer. *Applied*  
28 *Optics*, 39(21), 3754-3764. doi:10.1364/AO.39.003754
- 29 Shah, A. A., Hasan, F., Hameed, A., & Ahmed, S. (2008). Biological degradation of plastics: A comprehensive  
30 review. *Biotechnology Advances*, 26(3), 246-265. doi:<https://doi.org/10.1016/j.biotechadv.2007.12.005>
- 31 Thevenon, F., Carroll, C., & Sousa, J. (2014). *Plastic Debris in the Ocean. The Characterization of Marine Plastics*  
32 *and their Environmental Impacts. Situation Analysis Report*. Gland, Switzerland: IUCN
- 33 Van Cauwenberghe, L., Claessens, M., Vandegehuchte, M. B., Mees, J., & Janssen, C. R. (2013). Assessment of  
34 marine debris on the Belgian Continental Shelf. *Marine Pollution Bulletin*, 73(1), 161-169.  
35 doi:<https://doi.org/10.1016/j.marpolbul.2013.05.026>
- 36 van Franeker, J. A., & Law, K. L. (2015). Seabirds, gyres and global trends in plastic pollution. *Environmental*  
37 *Pollution*, 203, 89-96. doi:<https://doi.org/10.1016/j.envpol.2015.02.034>
- 38 Veenstra, T. S., & Churnside, J. H. (2012). Airborne sensors for detecting large marine debris at sea. *Marine*  
39 *Pollution Bulletin*, 65(1), 63-68. doi:<https://doi.org/10.1016/j.marpolbul.2010.11.018>
- 40 Webb, H. K., Arnott, J., Crawford, R. J., & Ivanova, E. P. (2013). Plastic Degradation and Its Environmental  
41 Implications with Special Reference to Poly(ethylene terephthalate). *Polymers*, 5(1), 1-18.

# Pemberitahuan Accepted

Editor/Author Correspondence - Google Chrome

journal.ugm.ac.id/ijg/author/viewEditorDecisionComments/40519#27245

Editor  
2020-03-05 04:26 PM

Subject: [IJG] Editor Decision: Manuscript Accepted DELETE

Dear Dr. Ahmad Faizal,

Congratulations! After considering your responses to the reviewer's and editor's comments, We have reached the decision regarding your submission to Indonesian Journal of Geography, "Spectral Characteristics of Plastic Debris in the Beach: Case Study of Makassar Coastal Area" to Accept your manuscript to be published in Indonesian Journal of Geography.

You will receive emails regarding the details of your publication. We may also request a technical edit of your manuscript if necessary.

Thank you for submitting to the Indonesian Journal of Geography and we look forward to receiving your manuscript in the future.

Best wishes,  
Dr. Pramaditya Wicaksono  
Faculty of Geography Universitas Gadjah Mada, Yogyakarta  
Phone +6281391179917  
Fax +62274569595  
prama.wicaksono@geo.ugm.ac.id  
Section Editor  
Indonesian Journal of Geography  
Faculty of Geography, Universitas Gadjah Mada, Yogyakarta

---

Chief Editor  
Indonesian Journal of Geography  
<http://jurnal.ugm.ac.id/index.php/ijg>  
0024-9521 (print), 2354-9114 (online)  
Phone: +62 812-2711-480

Close