TECHNICAL REPORT 22302453 – AUGUST 30TH 2023

Test Material	
ARCHA Sample Code	22302453
Supplier identification	OceanSafe AG
Material identification	POLYMER RESIN - 990111-naNea
Arrival date	March 08th, 2023
Thickness and grammage	Thickness = 161 ± 3 µm Grammage = 71,7 ± 2,2 g/m^2
Visual aspect	Color: white Granulates and fabric
Starting date for tests	March 16th, 2023

August 30th, 2023

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1. INTRODUCTION

This technical note describes the results obtained on the following sample:

Table 1. Test material information and identification.

Test Material	
ARCHA Sample Code	22302453
Supplier identification	OceanSafe AG
Material identification	POLYMER RESIN - 990111-naNea
Arrival date	March 08th, 2023
Thickness and grammage	Thickness = 161 ± 3 µm Grammage = 71,7 ± 2,2 g/m^2
Visual aspect	Color: white Granulates and fabric
Starting date for tests	March 16th, 2023

This technical report describes the overall results obtained by carrying out the experimental steps for the assessment of the conformity to the requirements as following listed:

1) Biodegradability in seawater at 30 ± 2 °C according to ASTM D6691

2. IDENTIFICATION OF THE PRODUCT

The previous Table 1 summarises the main information for the description of the test materials, in Figure 1, the picture of the POLYMER RESIN - 990111-NANEA sample is presented.

Figure 1. Picture of the POLYMER RESIN - 990111-NANEA sample.

- Material identification: 1.1.1. In form of Resin or Granulates, 1.1.2. In form of fabric
- Commercial name of the product: POLYMER RESIN - 990111-NANEA
- Product formulation: not available
- Production site: not available
- Color: white
- Thickness: 161 ± 3 µm
- Grammage = 71,7 ± 2,2 g/m^2
- Dimensions of sample: modular
- Other relevant information: none

3. BIODEGRADABILITY TEST IN THE MARINE ENVIRONMENT

Biodegradability is carried on according to ASTM D6691 – 17 official method at 30 ± 2 °C. In the Test Report:

- n. 22302453/2 for BIODEGRADABILITY TEST - MARINE (see ANNEX 1)

the results of the analysis are provided. **The test started on April 27th 2023 and ended on August 04th 2023 (for the plateau phase)**.

3.1. *Information on seawater and reference material (cellulose)*

The natural seawater was collected at Boccale, Livorno (43.475029 N, 10.329790 E) on April 27th 2023. The seawater was added with inorganic nutrients (0.5 g/l NH_4Cl and 0.1 g/l of KH_2PO_4). The pre-incubation of the inoculum has been performed for 5 hours at 30°C.

The reference material is microcrystalline cellulose, average dimension of the particles is 20 µm, produced by ALDRICH, distributed by SIGMA ALDRICH SRL, Code number 310697-500G, Lot number MKCL 9441, Expiration date September 28th 2023. The characterizations of this reference material are provided in Table 2 and Test Report n. 22302453/2, ANNEX 1.

Table 2. Main parameters and results for biodegradation test in Marine Environment.

Substrate - Marine biodegradability	
ARCHA REAGENT CODE	R01252001 (C2023001628)
Sampling location	Boccale (LI)
Arrival date	27/04/2023
NH4Cl - Lot number	20H274109
KH2(PO4) - Lot number	20D1556534

Parameter	C (% dm)	Dry matter (%)
Reference material (Cellulose)	45,4	98,2
Test material	60,4	99,7

3.2. *Preparation of the biodegradability test in the Marine Environment*

In Table 3, the main information about the amount of marine water and test material needed to start the biodegradation test are presented. The test material is used as it is. The test material was conditioned by immersion in distilled water for 24 hours at 23 ± 1 ° C.

Table 3. Vessels preparation to start the biodegradation test in Marine Environment.

Vessel	Blank 1	Blank 2	Blank 3	Reference 4	Reference 5	Reference 6	Test 7	Test 8	Test 9
Marine water volume (ml)	150,0	150,0	150,0	150,0	150,0	150,0	150,0	150,0	150,0
Actual material weight as it is (mg)	-	-	-	42,2	41,7	40,5	41,8	39,7	41,9
Actual dry material weight (mg)	-	-	-	41,4	40,9	39,8	41,7	39,6	41,8
Theoretical CO2 for test material (mg)	-	-	-	69,0	68,2	66,2	92,3	87,7	92,5

3.3. *Main characteristics of the equipment*

The equipment for biodegradation test in the Marine Environment is listed below:

- Climatic chamber (Set-point Temperature at 30°C)
- 250 ml glass bottles with cap equipped with gas inlet and outlet
- Orbital shakers (Set-point rotation at 175 ± 5 rpm)
- Air supply system, consisting of compressor, filtration and purification system and flow regulation
- Carbon dioxide determination system: continuous infrared analyzer.
- Flowmeter
- Pipes for the passage of gases, to connect the biodegradation vessels to the air supply and to the carbon dioxide determination system.
- Datalogger for temperature
- Analytical balance
- Mill (for cryogenic grinding, if needed)

Figure 2. Picture of the vessels in the climatic chamber for the biodegradation test in Marine Environment.

3.4. *Test temperature range for the biodegradation test in seawater*

The biodegradability test in the Marine Environment was carried out at fixed temperature (30°C) in the climatic chamber, with temperature monitoring: in Figure 3, the acquired data for temperature monitoring during the biodegradability test are presented.

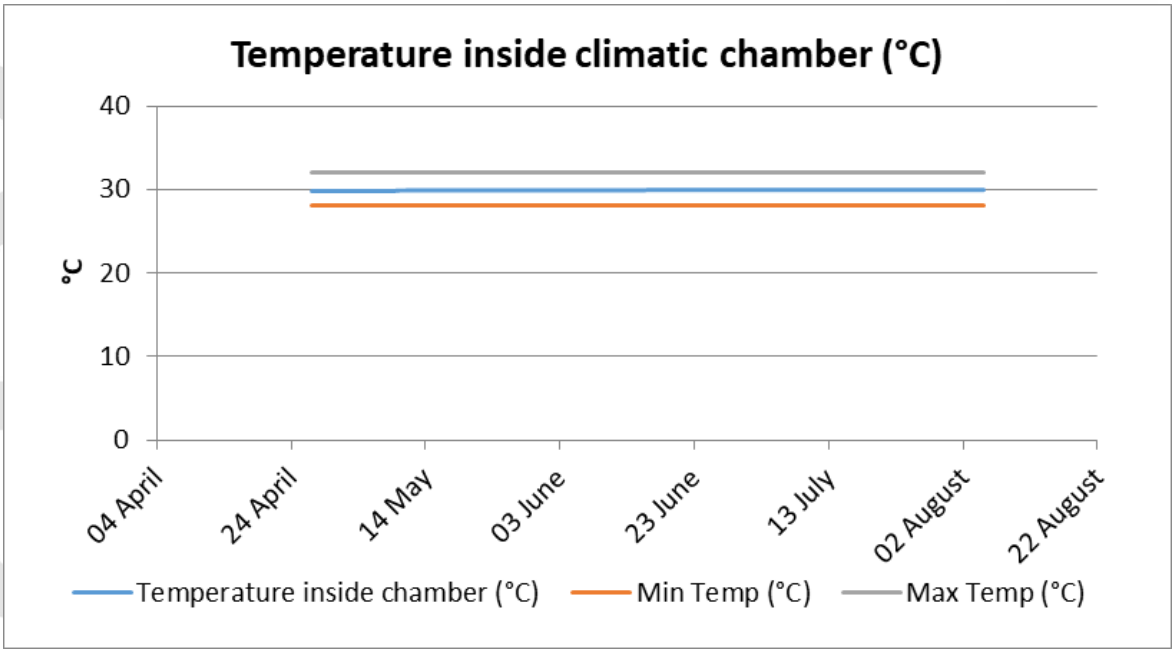

Figure 3. Temperature monitoring during biodegradability test in climatic chamber (30°C, temperature setting).

3.5. Experimental results for biodegradation test

The most meaningful results are presented:

- CO_2 cumulative production for single vessel of blank inoculum, reference material and tested sample, in graphical form, see Figure 4,
- CO_2 cumulative and average production for reference material and tested sample subtracted by the blank, in graphical form, see Figure 5
- CO_2 evolved for single vessel of blank, reference material and tested sample (not subtracted by the blank compost and not cumulative, as raw data) and average values, in tabular form, see Table 4,
- Biodegradability percentages by each vessel for reference and test materials, in graphical and tabular forms (Figure 6 and Figure 7, Table 5), absolute values;
- Average biodegradability percentages for reference and test materials, in graphical and tabular form (Figure 8, Table 5), absolute values.

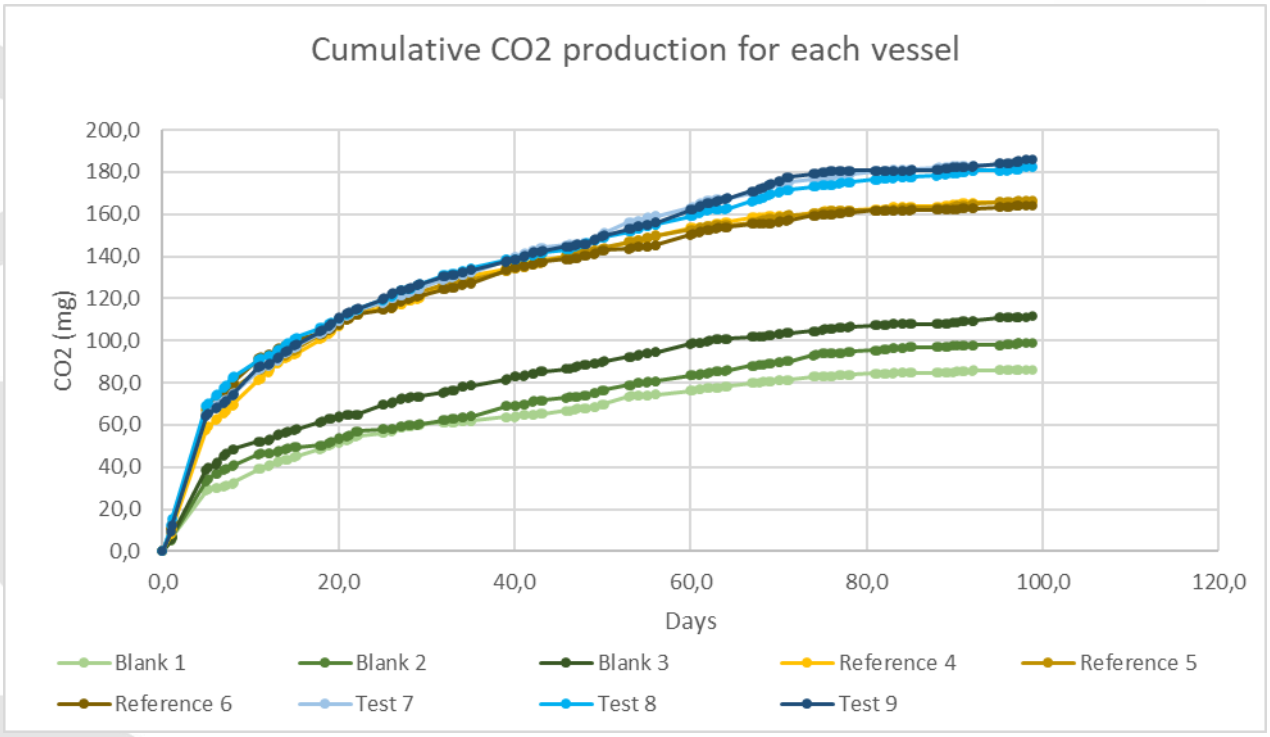

Figure 4. Cumulative measured CO_2 production for single vessel.

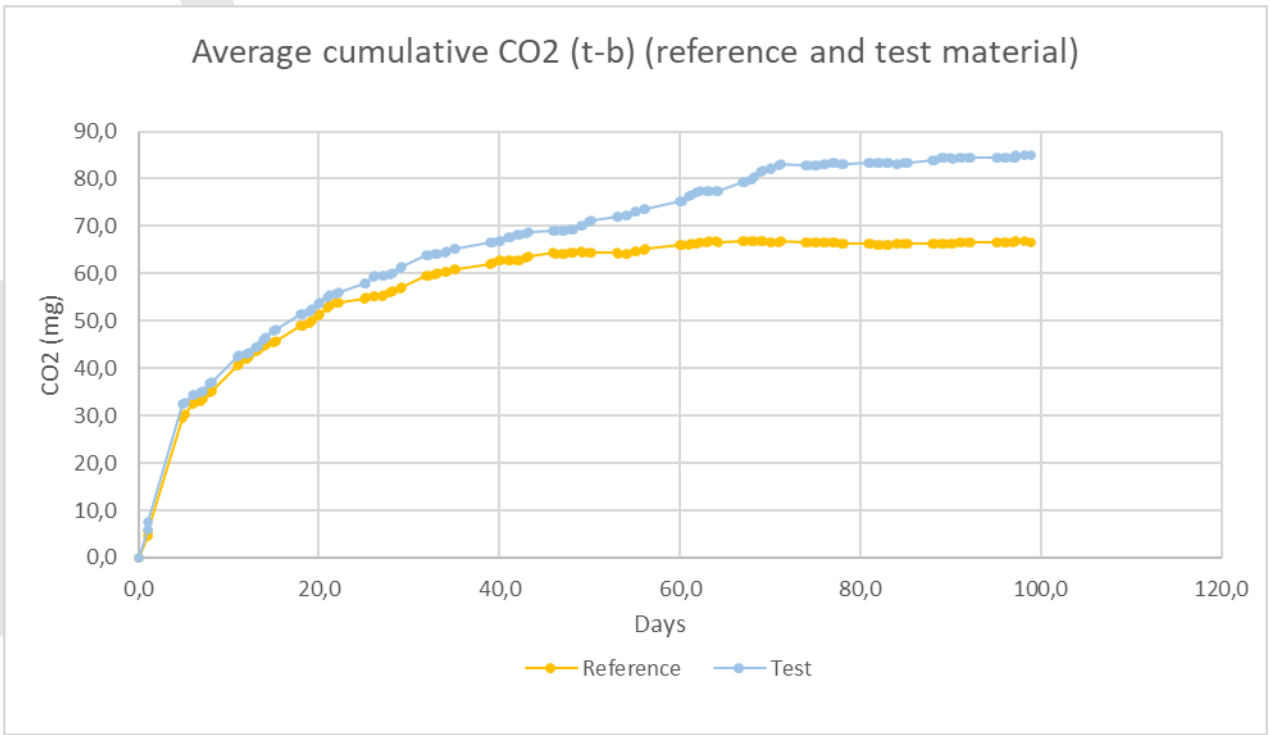

Figure 5. Average cumulative CO_2 (t-b) (reference and test material).

Table 4. Accumulated measured CO_2 production by each vessel for blank, reference and test materials and calculated average values.

TIME (days)	Blank 1	Blank 2	Blank 3	Average Blank	Reference 4	Reference 5	Reference 6	Average Reference	Test 7	Test 8	Test 9	Average Test
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
1,02	5,58	5,18	5,72	5,49	8,32	10,61	10,94	9,96	12,32	12,22	9,62	11,39
1,15	6,83	6,41	7,10	6,78	10,50	13,28	13,54	12,44	15,20	15,19	12,24	14,21
4,94	28,80	33,42	38,77	33,66	57,73	67,09	64,80	63,21	65,01	69,23	64,10	66,11
5,23	29,29	34,56	39,77	34,54	59,23	68,74	66,66	64,87	66,19	70,51	65,23	67,31
6,02	30,24	36,50	41,23	35,99	62,32	72,22	70,92	68,49	69,28	73,68	67,83	70,26
6,22	30,39	36,98	42,06	36,48	62,91	72,76	71,75	69,14	69,85	74,47	68,42	70,91
6,91	30,74	38,84	45,43	38,34	65,52	73,98	74,35	71,28	71,58	77,31	70,50	73,13
7,18	31,07	39,30	46,37	38,91	66,69	74,65	75,68	72,34	72,40	78,77	71,51	74,23
7,92	32,15	40,60	48,25	40,34	69,22	76,91	79,51	75,21	74,45	82,56	74,13	77,05
8,08	32,53	40,93	48,55	40,67	69,77	77,45	80,25	75,82	74,95	83,06	74,82	77,61
10,94	38,96	45,96	52,05	45,66	81,27	85,85	91,44	86,19	85,94	90,81	87,45	88,07
11,15	39,26	46,28	52,25	45,93	82,07	86,31	91,95	86,78	86,69	91,36	87,86	88,64
11,97	40,47	46,68	52,86	46,67	84,83	87,74	93,16	88,58	88,05	92,57	88,72	89,78
12,21	40,82	46,68	53,10	46,87	85,91	88,34	93,63	89,29	88,43	92,99	89,17	90,20
12,95	42,28	47,42	54,78	48,16	88,92	90,86	95,68	91,82	90,59	95,33	91,38	92,43
13,21	42,72	47,80	55,37	48,63	89,55	91,41	96,27	92,41	91,41	96,09	92,14	93,21
13,90	43,41	48,49	56,26	49,39	91,43	93,03	97,65	94,04	93,77	97,90	94,49	95,38
14,17	43,76	48,70	56,62	49,69	92,11	93,80	98,25	94,72	94,67	98,74	95,52	96,31
14,93	44,74	49,30	57,63	50,55	93,37	95,33	99,76	96,15	96,58	100,96	97,63	98,39
15,17	45,04	49,48	57,87	50,80	93,88	95,87	100,20	96,65	97,17	101,61	98,22	99,00
17,93	48,42	50,20	61,27	53,30	100,70	102,71	103,24	102,22	103,33	106,22	104,38	104,64
18,21	48,90	50,27	61,75	53,64	101,33	103,47	103,39	102,73	103,68	106,44	105,02	105,05
18,92	50,44	51,14	62,95	54,84	103,23	105,47	104,82	104,51	105,63	108,14	106,92	106,90
19,19	50,90	51,74	63,21	55,28	104,29	106,33	105,72	105,45	106,77	108,95	107,89	107,87
19,99	51,68	53,51	63,82	56,34	106,63	108,45	107,63	107,57	109,22	110,29	110,52	110,01
20,18	51,82	53,79	64,01	56,54	107,19	108,80	107,98	107,99	109,62	110,58	110,92	110,37
20,91	52,72	54,71	64,55	57,33	109,70	110,96	109,90	110,18	111,49	112,43	112,91	112,28
21,19	53,06	55,20	64,61	57,62	110,51	111,79	110,63	110,97	112,19	113,11	113,67	112,99
21,91	54,34	56,81	64,81	58,65	112,23	113,28	112,12	112,54	113,96	114,53	114,97	114,49
22,17	54,80	57,12	65,08	59,00	112,55	113,66	112,44	112,88	114,52	114,98	115,35	114,95
25,00	56,24	57,84	69,40	61,16	115,47	117,84	114,56	115,96	118,06	119,25	119,62	118,97
25,21	56,24	57,94	69,66	61,28	115,58	118,35	114,78	116,24	118,38	119,51	119,99	119,29
25,95	56,79	58,31	70,20	61,77	115,58	119,86	115,57	117,00	119,93	120,89	122,14	120,99
26,21	57,30	58,37	70,66	62,11	115,79	119,99	116,16	117,31	120,48	121,51	122,76	121,58
27,06	58,78	59,04	72,40	63,41	117,17	120,43	118,64	118,75	121,61	123,62	123,64	122,96
27,19	58,84	59,17	72,46	63,49	117,38	120,49	118,84	118,90	121,67	123,80	123,73	123,07
27,94	59,22	59,74	72,87	63,94	118,82	121,28	119,60	119,90	122,85	124,19	124,52	123,85
28,23	59,37	59,96	73,10	64,14	119,30	121,73	119,95	120,33	123,31	124,64	124,89	124,28
29,02	59,77	60,17	73,30	64,42	119,74	122,77	121,10	121,20	124,31	126,32	126,46	125,70
29,19	59,93	60,26	73,39	64,53	120,10	123,08	121,40	121,53	124,65	126,67	126,89	126,07
31,94	61,33	62,34	75,41	66,36	126,70	126,68	124,34	125,90	128,99	130,97	130,46	130,14

32,19	61,33	62,53	75,60	66,49	126,96	126,81	124,54	126,10	129,25	131,23	130,59	130,35
32,90	61,33	62,89	76,34	66,85	127,92	127,19	125,10	126,74	130,13	131,74	131,15	131,00
33,15	61,33	62,89	76,67	66,96	128,18	127,38	125,29	126,95	130,44	131,86	131,28	131,19
34,01	61,55	63,53	78,01	67,70	129,57	128,05	126,62	128,08	131,36	133,01	132,21	132,19
34,18	61,59	63,70	78,22	67,83	129,93	128,14	126,75	128,27	131,49	133,27	132,51	132,42
34,99	61,79	63,90	78,63	68,11	130,83	128,79	127,16	128,93	132,14	134,15	133,38	133,22
35,15	61,91	63,98	78,67	68,19	130,91	128,92	127,37	129,06	132,31	134,27	133,47	133,35
39,02	63,88	68,90	81,55	71,44	134,01	132,95	133,57	133,51	138,37	138,31	137,51	138,06
39,18	63,88	69,07	81,75	71,56	134,18	133,16	133,79	133,71	138,62	138,44	137,63	138,23
40,02	63,88	69,28	82,78	71,98	135,24	133,98	134,83	134,68	139,46	138,65	138,27	138,79
40,15	63,97	69,28	82,84	72,03	135,36	134,13	134,95	134,81	139,61	138,78	138,52	138,97
40,98	64,78	69,70	83,27	72,58	136,00	134,94	135,57	135,51	141,02	139,43	139,96	140,14
41,16	64,82	69,97	83,45	72,74	136,09	135,03	135,67	135,60	141,32	139,52	140,13	140,32
41,95	65,02	71,14	84,24	73,47	136,73	136,07	136,07	136,29	142,74	140,53	141,58	141,62
42,21	65,08	71,27	84,57	73,64	136,94	136,34	136,40	136,56	143,02	140,74	141,93	141,90
42,93	65,26	71,44	85,30	74,00	137,75	136,91	137,13	137,26	143,77	141,49	142,32	142,53
43,19	65,33	71,51	85,36	74,07	138,03	137,38	137,32	137,58	144,04	141,76	142,53	142,78
45,94	66,69	72,83	86,69	75,41	140,11	140,32	138,72	139,72	145,44	143,09	144,70	144,41
46,17	66,86	73,06	86,80	75,57	140,33	140,32	138,72	139,79	145,56	143,26	144,88	144,57
46,95	67,43	73,45	87,58	76,15	140,71	141,08	139,10	140,30	145,56	144,58	145,47	145,20
47,18	67,60	73,50	87,91	76,34	140,83	141,47	139,38	140,56	145,56	145,19	145,59	145,45
47,90	67,78	74,04	88,63	76,81	141,53	142,00	140,26	141,26	146,12	146,08	145,77	145,99
48,15	67,85	74,16	88,82	76,94	141,78	142,07	140,44	141,43	146,39	146,15	145,96	146,17
49,05	68,29	75,03	89,26	77,53	142,64	142,51	141,12	142,09	147,36	147,58	147,87	147,60
49,16	68,45	75,21	89,29	77,65	142,69	142,62	141,25	142,19	147,59	147,78	148,13	147,83
49,90	69,73	76,31	89,84	78,62	143,07	143,54	142,53	143,05	150,22	148,74	149,47	149,48
50,20	69,95	76,68	90,21	78,95	143,45	143,99	142,90	143,45	151,12	149,04	150,00	150,05
53,04	73,39	78,83	92,34	81,52	147,02	146,88	143,62	145,84	156,21	151,88	152,82	153,64
53,22	73,66	78,96	92,48	81,70	147,20	146,97	143,76	145,98	156,44	152,06	153,02	153,84
54,03	74,08	79,77	93,07	82,31	147,59	147,37	144,36	146,44	156,85	152,87	154,05	154,59
54,22	74,08	79,87	93,26	82,40	147,64	147,56	144,45	146,55	157,00	153,11	154,23	154,78
54,97	74,08	80,24	93,80	82,71	148,38	148,85	144,82	147,35	158,10	154,04	154,96	155,70
55,18	74,08	80,40	93,91	82,79	148,73	149,05	144,82	147,53	158,35	154,29	155,21	155,95
55,99	74,28	80,60	94,53	83,13	149,72	149,65	145,23	148,20	158,95	155,09	156,00	156,68
56,15	74,40	80,68	94,61	83,23	149,83	149,76	145,43	148,34	159,11	155,21	156,15	156,82
60,00	76,35	83,62	98,43	86,13	153,60	152,55	150,33	152,16	162,93	158,92	161,96	161,27
60,21	76,35	83,72	98,68	86,25	153,71	152,65	150,53	152,30	163,24	159,18	162,22	161,55
61,02	76,96	83,92	99,07	86,65	153,71	153,24	151,51	152,82	164,90	160,42	163,46	162,93
61,19	77,17	84,00	99,16	86,78	153,79	153,53	151,80	153,04	165,24	160,76	163,80	163,27
61,94	77,55	84,57	99,71	87,28	154,15	154,46	152,54	153,72	166,38	161,90	165,11	164,46
62,19	77,55	84,76	99,90	87,40	154,33	154,58	152,72	153,88	166,63	162,02	165,50	164,72
62,90	77,73	85,29	100,43	87,82	155,37	154,75	153,41	154,51	166,98	162,37	166,04	165,13
63,18	77,80	85,36	100,50	87,89	155,65	154,75	153,63	154,68	166,98	162,51	166,25	165,25
63,93	78,17	85,72	100,86	88,25	156,19	154,75	154,01	154,98	167,36	162,51	167,17	165,68
64,19	78,37	85,98	100,99	88,44	156,44	154,75	154,01	155,07	167,50	162,58	167,49	165,86
66,93	79,74	87,99	101,67	89,80	158,44	156,14	155,37	156,65	170,14	165,96	170,87	168,99

67,19	79,81	88,06	101,73	89,87	158,57	156,41	155,49	156,82	170,39	166,21	171,07	169,22
67,94	80,18	88,42	102,10	90,23	158,76	156,97	155,49	157,08	171,54	167,12	171,82	170,16
68,22	80,39	88,69	102,23	90,44	158,83	157,25	155,56	157,22	172,25	167,73	172,30	170,76
68,92	80,74	89,21	102,41	90,79	159,00	157,95	155,73	157,56	173,69	169,13	173,72	172,18
69,19	80,81	89,28	102,47	90,85	159,00	158,14	155,73	157,62	173,96	169,46	174,19	172,54
69,98	81,01	89,87	103,08	91,32	159,00	158,71	156,34	158,02	174,36	170,42	175,58	173,45
70,15	81,05	90,03	103,29	91,46	159,00	158,79	156,46	158,09	174,49	170,67	175,91	173,69
70,94	81,24	90,23	103,69	91,72	159,00	159,37	156,87	158,41	175,08	171,46	177,29	174,61
71,20	81,44	90,36	103,76	91,85	159,13	159,57	157,20	158,63	175,34	171,65	177,55	174,85
73,93	82,83	93,11	104,43	93,46	160,49	160,23	159,28	160,00	176,70	172,99	179,01	176,23
74,19	82,83	93,30	104,57	93,57	160,61	160,29	159,28	160,06	176,76	173,18	179,21	176,39
74,90	82,83	93,82	105,28	93,98	161,29	160,80	159,62	160,57	177,46	173,52	179,72	176,90
75,15	82,90	93,95	105,47	94,11	161,41	160,98	159,74	160,71	177,65	173,52	179,92	177,03
75,95	83,10	93,95	105,67	94,24	161,41	161,56	159,74	160,91	178,04	173,52	180,34	177,30
76,21	83,10	93,95	105,80	94,28	161,41	161,68	159,87	160,99	178,36	173,71	180,34	177,47
76,95	83,46	93,95	106,15	94,52	161,41	161,68	160,23	161,11	178,89	174,60	180,34	177,94
77,18	83,62	94,01	106,15	94,59	161,41	161,68	160,23	161,11	178,89	174,77	180,34	178,00
77,90	83,80	94,55	106,52	94,96	161,59	161,86	160,75	161,40	178,89	174,95	180,52	178,12
78,19	83,88	94,77	106,74	95,13	161,73	161,93	161,03	161,56	179,04	175,09	180,59	178,24
80,91	84,57	95,43	107,41	95,80	162,40	161,93	161,70	162,01	180,43	176,44	180,59	179,15
81,17	84,57	95,43	107,41	95,80	162,40	161,93	161,70	162,01	180,43	176,44	180,59	179,15
81,93	84,57	95,81	107,41	95,93	162,40	161,93	161,70	162,01	180,43	176,63	180,59	179,22
82,15	84,57	95,97	107,52	96,02	162,51	161,98	161,70	162,07	180,48	176,79	180,59	179,29
82,91	84,57	96,35	107,90	96,27	163,25	162,16	161,70	162,37	180,85	177,16	180,59	179,53
83,19	84,64	96,42	107,90	96,32	163,39	162,31	161,70	162,47	180,92	177,23	180,59	179,58
83,94	84,82	96,61	107,90	96,44	163,58	162,69	161,70	162,66	180,92	177,41	180,59	179,64
84,19	84,82	96,67	107,90	96,46	163,65	162,75	161,70	162,70	180,92	177,41	180,59	179,64
84,91	84,82	96,84	107,90	96,52	163,65	162,94	161,88	162,82	181,11	177,58	180,77	179,82
85,21	84,82	96,92	107,90	96,54	163,65	162,94	161,96	162,85	181,18	177,65	180,85	179,89
87,92	84,82	96,92	107,90	96,54	163,65	162,94	161,96	162,85	181,89	178,31	180,85	180,35
88,16	84,82	96,92	107,90	96,54	163,65	162,94	161,96	162,85	182,08	178,49	180,97	180,51
88,98	84,82	96,92	107,90	96,54	163,84	162,94	161,96	162,91	182,49	178,90	181,59	180,99
89,18	84,82	96,97	108,00	96,59	163,99	162,98	161,96	162,98	182,54	179,00	181,73	181,09
89,90	85,17	97,50	108,73	97,13	164,68	163,50	162,30	163,50	182,90	179,35	182,25	181,50
90,19	85,32	97,64	108,88	97,28	164,89	163,79	162,45	163,71	182,97	179,42	182,40	181,60
90,90	85,50	97,82	109,05	97,46	165,25	164,15	162,62	164,01	182,97	179,94	182,58	181,83
91,19	85,57	97,89	109,13	97,53	165,32	164,29	162,69	164,10	182,97	180,09	182,58	181,88
91,98	85,77	97,89	109,33	97,66	165,32	164,87	162,69	164,29	182,97	180,47	182,58	182,01
92,21	85,83	97,89	109,44	97,72	165,32	164,92	162,69	164,31	182,97	180,58	182,70	182,08
95,02	85,83	97,89	110,82	98,18	165,32	165,60	163,37	164,77	182,97	180,58	184,13	182,56
95,15	85,83	97,89	110,85	98,19	165,32	165,63	163,44	164,80	182,97	180,58	184,13	182,56
95,93	85,83	98,27	110,85	98,32	165,32	165,63	163,64	164,86	182,97	180,77	184,32	182,69
96,22	85,83	98,42	110,85	98,36	165,32	165,77	163,64	164,91	182,97	180,85	184,39	182,73
96,93	85,83	98,59	111,03	98,48	165,50	166,12	163,99	165,20	182,97	181,20	184,75	182,97
97,19	85,83	98,65	111,09	98,52	165,63	166,12	164,11	165,29	182,97	181,39	184,95	183,10
97,90	85,83	98,65	111,09	98,52	165,81	166,46	164,11	165,46	182,97	181,91	185,47	183,45

98,21	85,83	98,65	111,24	98,57	165,81	166,61	164,11	165,51	182,97	182,21	185,77	183,65
98,90	86,16	98,65	111,58	98,79	165,81	166,61	164,11	165,51	182,97	182,54	186,12	183,88

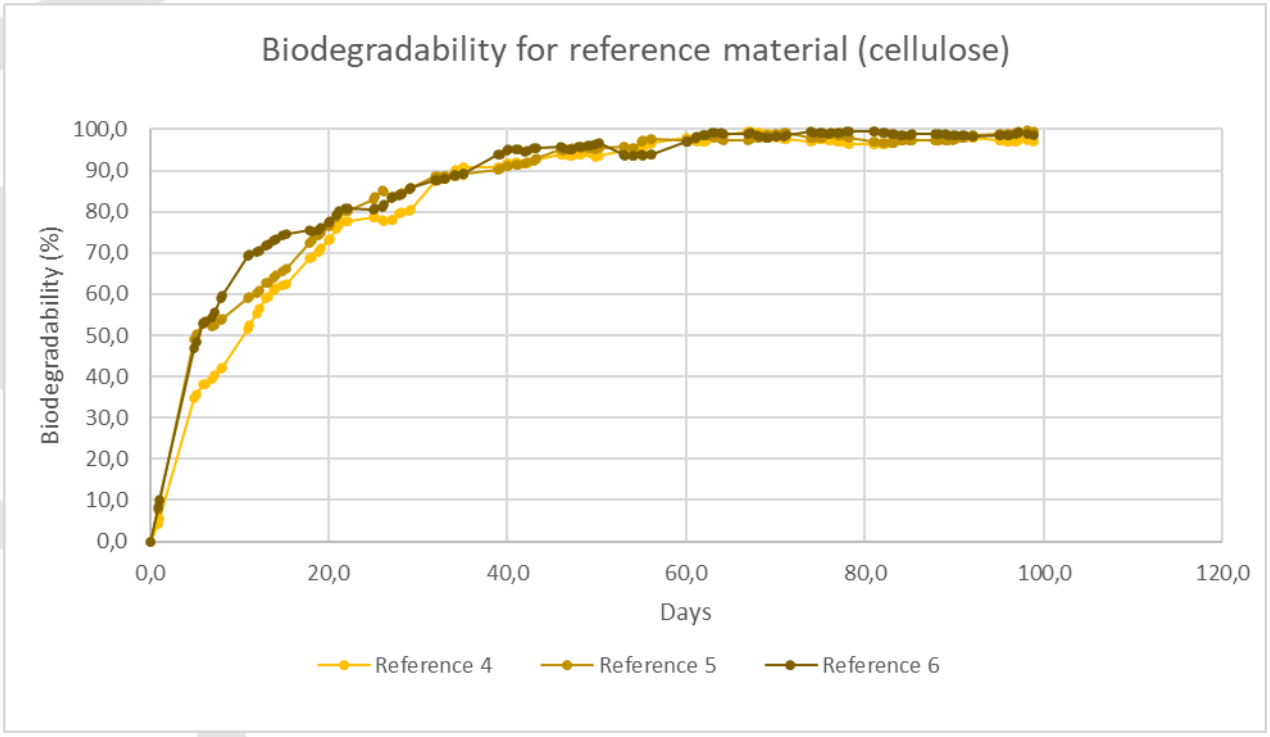

Figure 6. Biodegradation degree of reference material (each vessel).

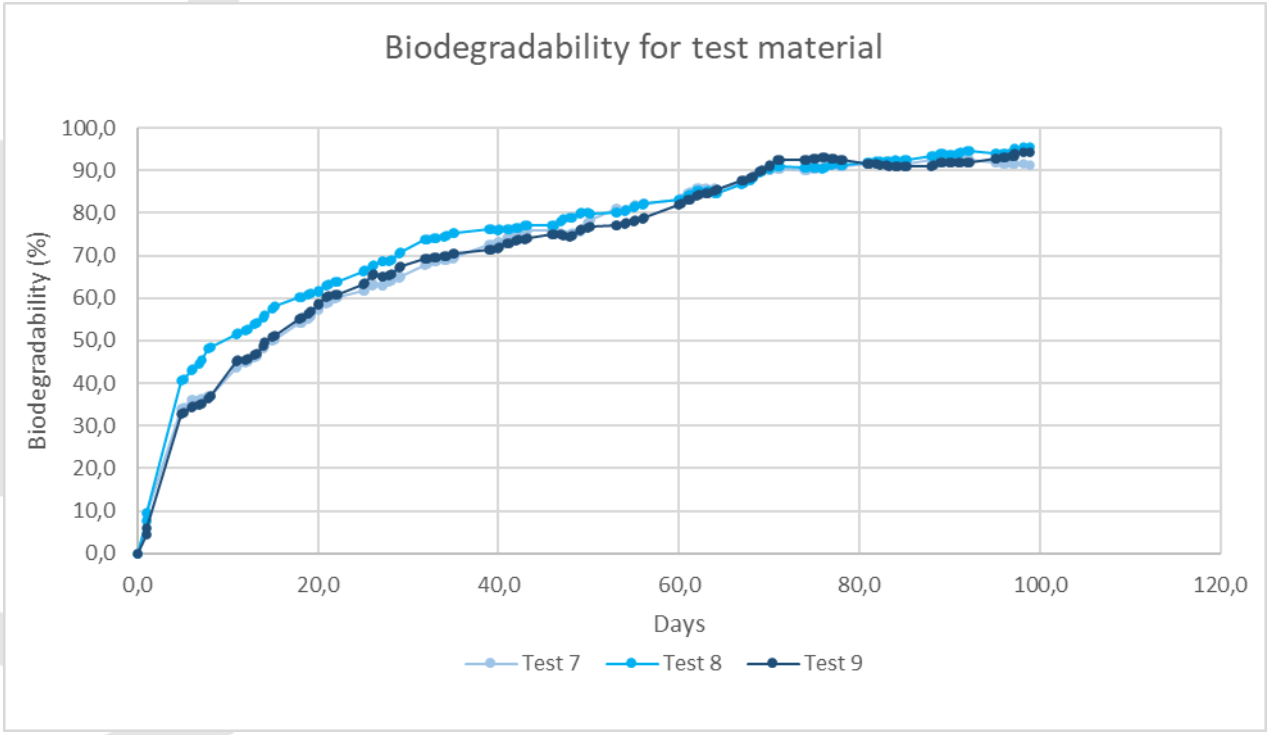

Figure 7. Biodegradation degrees (as absolute values) of test material (each vessel).

Table 5. Biodegradability % by each vessel for reference and test materials and average absolute values.

TIME (days)	Reference 4	Reference 5	Reference 6	Average Reference	Test 7	Test 8	Test 9	Average Test
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
1,02	4,09	7,51	8,22	6,61	7,40	7,68	4,46	6,51
1,15	5,39	9,54	10,22	8,38	9,13	9,60	5,90	8,21
4,94	34,89	49,05	47,04	43,66	33,96	40,57	32,90	35,81
5,23	35,79	50,17	48,52	44,83	34,29	41,03	33,17	36,16
6,02	38,18	53,15	52,77	48,03	36,07	42,99	34,41	37,82
6,22	38,33	53,24	53,28	48,28	36,15	43,33	34,52	38,00
6,91	39,41	52,29	54,40	48,70	36,01	44,46	34,76	38,41
7,18	40,27	52,43	55,54	49,41	36,27	45,46	35,23	38,99
7,92	41,88	53,66	59,18	51,57	36,96	48,17	36,53	40,55
8,08	42,18	53,96	59,79	51,98	37,14	48,35	36,91	40,80
10,94	51,63	58,97	69,16	59,92	43,64	51,51	45,17	46,77
11,15	52,39	59,24	69,52	60,38	44,16	51,82	45,32	47,10
11,97	55,33	60,25	70,22	61,93	44,83	52,36	45,45	47,55
12,21	56,60	60,85	70,64	62,70	45,03	52,62	45,73	47,79
12,95	59,09	62,64	71,79	64,51	45,97	53,80	46,71	48,83
13,21	59,32	62,76	71,96	64,68	46,35	54,13	47,02	49,16
13,90	60,95	64,02	72,90	65,96	48,08	55,33	48,74	50,72
14,17	61,49	64,71	73,34	66,51	48,72	55,95	49,53	51,40
14,93	62,07	65,70	74,33	67,37	49,86	57,50	50,88	52,75
15,17	62,46	66,13	74,63	67,74	50,24	57,96	51,26	53,15
17,93	68,72	72,49	75,44	72,22	54,20	60,36	55,21	56,59
18,21	69,15	73,11	75,16	72,47	54,21	60,23	55,53	56,66
18,92	70,14	74,28	75,49	73,30	55,02	60,79	56,28	57,37
19,19	71,05	74,89	76,20	74,05	55,78	61,22	56,86	57,95
19,99	72,92	76,45	77,48	75,62	57,29	61,54	58,56	59,13
20,18	73,43	76,66	77,70	75,93	57,50	61,64	58,77	59,30
20,91	75,93	78,68	79,41	78,01	58,68	62,85	60,07	60,54
21,19	76,67	79,46	80,07	78,73	59,11	63,29	60,58	60,99
21,91	77,66	80,15	80,77	79,53	59,92	63,73	60,87	61,51
22,17	77,64	80,20	80,73	79,52	60,15	63,86	60,90	61,64
25,00	78,73	83,16	80,67	80,86	61,65	66,26	63,18	63,70
25,21	78,72	83,74	80,83	81,09	61,86	66,42	63,45	63,91
25,95	78,01	85,23	81,28	81,50	63,02	67,44	65,25	65,23
26,21	77,82	84,92	81,65	81,46	63,24	67,75	65,54	65,51
27,06	77,95	83,66	83,43	81,68	63,05	68,68	65,10	65,61
27,19	78,12	83,63	83,61	81,79	63,03	68,79	65,11	65,64
27,94	79,55	84,12	84,07	82,58	63,82	68,72	65,47	66,01
28,23	79,96	84,48	84,31	82,92	64,09	69,01	65,66	66,25
29,02	80,21	85,61	85,63	83,82	64,89	70,61	67,06	67,52
29,19	80,57	85,90	85,91	84,13	65,14	70,89	67,40	67,81
31,94	87,47	88,49	87,58	87,85	67,85	73,70	69,27	70,28
32,19	87,67	88,50	87,69	87,96	67,99	73,85	69,28	70,37

32,90	88,53	88,52	87,99	88,35	68,55	74,01	69,49	70,68
33,15	88,75	88,64	88,12	88,50	68,77	74,03	69,51	70,77
34,01	89,71	88,55	89,01	89,09	68,97	74,50	69,72	71,06
34,18	90,03	88,48	88,99	89,16	68,96	74,65	69,90	71,17
34,99	90,93	89,04	89,21	89,72	69,38	75,33	70,55	71,75
35,15	90,93	89,10	89,40	89,81	69,47	75,38	70,55	71,80
39,02	90,72	90,25	93,85	91,60	72,51	76,27	71,40	73,39
39,18	90,78	90,37	93,99	91,72	72,65	76,28	71,41	73,45
40,02	91,71	90,96	94,94	92,54	73,11	76,05	71,65	73,60
40,15	91,81	91,11	95,04	92,66	73,22	76,14	71,86	73,74
40,98	91,95	91,49	95,16	92,87	74,15	76,25	72,82	74,41
41,16	91,84	91,38	95,05	92,76	74,30	76,17	72,83	74,43
41,95	91,72	91,84	94,57	92,71	75,05	76,50	73,62	75,06
42,21	91,77	91,99	94,80	92,85	75,16	76,54	73,80	75,17
42,93	92,41	92,29	95,36	93,35	75,59	76,99	73,84	75,47
43,19	92,74	92,89	95,55	93,73	75,81	77,22	74,00	75,68
45,94	93,81	95,24	95,64	94,90	75,88	77,21	74,90	75,99
46,17	93,89	94,99	95,39	94,76	75,82	77,20	74,91	75,98
46,95	93,60	95,25	95,08	94,64	75,19	78,05	74,92	76,06
47,18	93,49	95,55	95,23	94,76	74,99	78,54	74,84	76,12
47,90	93,82	95,64	95,84	95,10	75,09	79,01	74,52	76,21
48,15	93,99	95,54	95,92	95,15	75,24	78,94	74,60	76,26
49,05	94,40	95,34	96,06	95,27	75,66	79,91	76,03	77,20
49,16	94,30	95,32	96,08	95,23	75,78	80,00	76,17	77,32
49,90	93,43	95,24	96,53	95,07	77,57	79,98	76,57	78,04
50,20	93,51	95,43	96,61	95,18	78,19	79,96	76,79	78,31
53,04	94,96	95,88	93,81	94,89	80,91	80,25	77,06	79,41
53,22	94,96	95,75	93,74	94,82	80,97	80,25	77,07	79,43
54,03	94,65	95,45	93,74	94,61	80,76	80,48	77,54	79,59
54,22	94,58	95,59	93,73	94,63	80,81	80,65	77,64	79,70
54,97	95,21	97,04	93,82	95,36	81,68	81,37	78,09	80,38
55,18	95,59	97,21	93,69	95,50	81,85	81,56	78,27	80,56
55,99	96,53	97,59	93,80	95,97	82,14	82,08	78,75	80,99
56,15	96,56	97,62	93,96	96,05	82,21	82,10	78,81	81,04
60,00	97,81	97,45	96,97	97,41	83,20	83,03	81,95	82,73
60,21	97,79	97,42	97,10	97,44	83,41	83,19	82,11	82,90
61,02	97,21	97,70	97,99	97,63	84,77	84,15	83,02	83,98
61,19	97,15	97,94	98,23	97,77	85,00	84,40	83,24	84,21
61,94	96,95	98,56	98,59	98,03	85,70	85,12	84,13	84,98
62,19	97,03	98,56	98,68	98,09	85,84	85,12	84,40	85,12
62,90	97,93	98,20	99,09	98,41	85,77	85,04	84,54	85,12
63,18	98,24	98,10	99,31	98,55	85,69	85,12	84,69	85,17
63,93	98,49	97,56	99,33	98,46	85,71	84,71	85,30	85,24
64,19	98,58	97,28	99,04	98,30	85,64	84,56	85,44	85,21
66,93	99,51	97,33	99,04	98,63	87,04	86,87	87,62	87,17
67,19	99,61	97,62	99,14	98,79	87,24	87,09	87,76	87,36

67,94	99,36	97,92	98,59	98,62	88,08	87,70	88,18	87,99
68,22	99,15	98,02	98,38	98,52	88,64	88,16	88,48	88,43
68,92	98,89	98,53	98,10	98,51	89,81	89,36	89,63	89,60
69,19	98,80	98,71	98,01	98,51	90,03	89,66	90,07	89,92
69,98	98,13	98,88	98,22	98,41	89,97	90,23	91,07	90,42
70,15	97,93	98,79	98,20	98,30	89,95	90,35	91,28	90,53
70,94	97,54	99,26	98,41	98,40	90,31	90,96	92,48	91,25
71,20	97,54	99,35	98,71	98,53	90,45	91,03	92,62	91,36
73,93	97,18	97,96	99,44	98,19	90,18	90,72	92,46	91,12
74,19	97,20	97,89	99,27	98,12	90,13	90,82	92,56	91,17
74,90	97,59	98,03	99,16	98,26	90,44	90,73	92,67	91,28
75,15	97,58	98,12	99,15	98,28	90,51	90,59	92,75	91,28
75,95	97,39	98,76	98,95	98,37	90,79	90,43	93,05	91,42
76,21	97,32	98,89	99,08	98,43	91,09	90,60	93,01	91,56
76,95	96,98	98,54	99,26	98,26	91,41	91,35	92,75	91,84
77,18	96,87	98,43	99,14	98,15	91,33	91,45	92,67	91,82
77,90	96,60	98,15	99,38	98,04	90,94	91,24	92,47	91,55
78,19	96,56	98,00	99,55	98,04	90,91	91,21	92,37	91,50
80,91	96,56	97,01	99,55	97,71	91,68	91,98	91,64	91,77
81,17	96,56	97,01	99,55	97,71	91,68	91,98	91,64	91,77
81,93	96,37	96,83	99,36	97,52	91,54	92,05	91,50	91,70
82,15	96,39	96,77	99,22	97,46	91,50	92,13	91,40	91,68
82,91	97,10	96,67	98,84	97,54	91,63	92,26	91,13	91,68
83,19	97,24	96,82	98,77	97,61	91,66	92,29	91,08	91,68
83,94	97,34	97,19	98,59	97,71	91,52	92,36	90,95	91,61
84,19	97,40	97,26	98,56	97,74	91,50	92,33	90,93	91,59
84,91	97,32	97,44	98,74	97,83	91,64	92,46	91,06	91,72
85,21	97,28	97,40	98,81	97,83	91,69	92,52	91,11	91,78
87,92	97,28	97,40	98,81	97,83	92,46	93,27	91,11	92,28
88,16	97,28	97,40	98,81	97,83	92,66	93,47	91,24	92,46
88,98	97,57	97,40	98,81	97,93	93,11	93,95	91,91	92,99
89,18	97,70	97,40	98,74	97,95	93,11	94,00	92,01	93,04
89,90	97,92	97,37	98,45	97,91	92,91	93,78	92,00	92,89
90,19	98,02	97,58	98,44	98,01	92,83	93,69	92,00	92,84
90,90	98,28	97,85	98,44	98,19	92,64	94,09	92,00	92,91
91,19	98,28	97,95	98,44	98,23	92,56	94,17	91,92	92,89
91,98	98,09	98,60	98,24	98,31	92,42	94,46	91,78	92,89
92,21	98,01	98,60	98,15	98,25	92,36	94,52	91,85	92,91
95,02	97,34	98,92	98,48	98,25	91,86	94,00	92,90	92,92
95,15	97,33	98,95	98,57	98,28	91,85	93,98	92,89	92,91
95,93	97,14	98,76	98,67	98,19	91,71	94,06	92,95	92,91
96,22	97,07	98,90	98,60	98,19	91,66	94,09	92,97	92,91
96,93	97,16	99,23	98,95	98,45	91,53	94,35	93,24	93,04
97,19	97,29	99,17	99,08	98,51	91,49	94,52	93,41	93,14
97,90	97,55	99,67	99,08	98,77	91,49	95,11	93,97	93,52
98,21	97,47	99,82	99,01	98,77	91,43	95,40	94,25	93,69

98,90	97,15	99,49	98,67	98,44	91,19	95,53	94,38	93,70

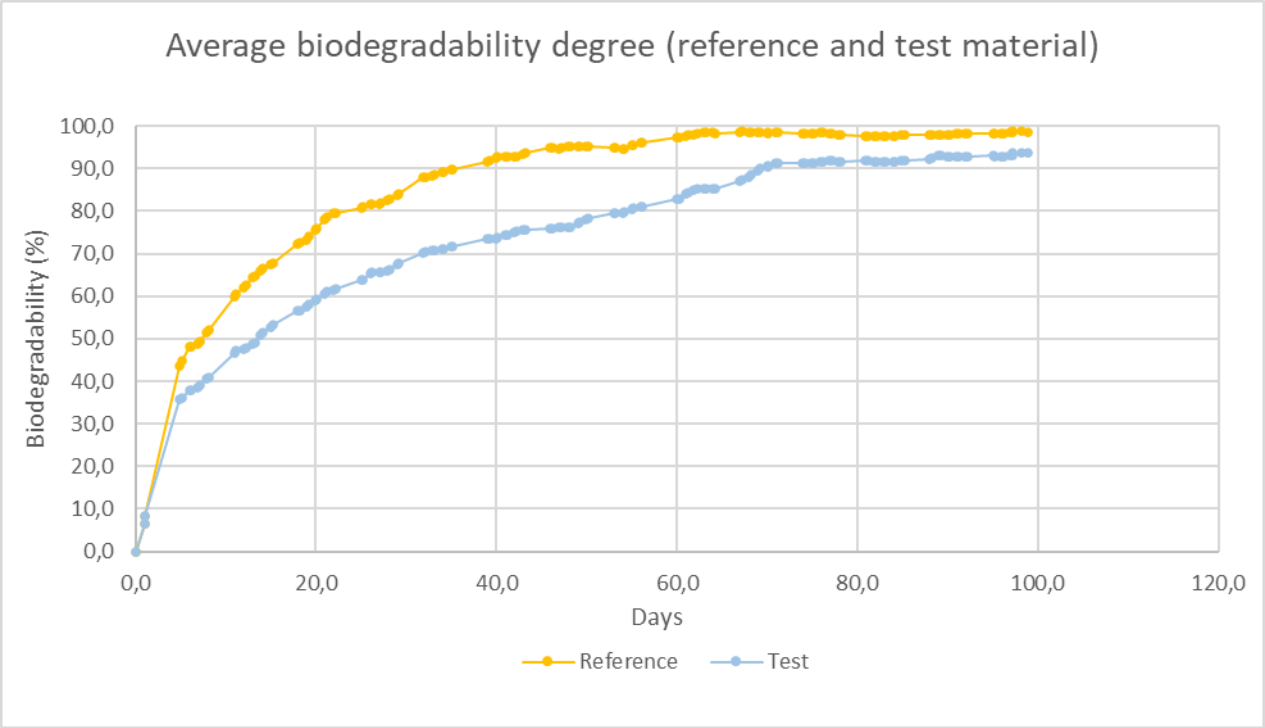

Figure 8. Average biodegradation degrees for reference and test materials (as absolute values).

3.6. Requirements for the biodegradation test in marine environment

The biodegradation test met the requirement for its validation, according to the validity criteria, as detailed in Table 6: the degree of biodegradation of the reference material is > 70% at the end of the test (98,4% as experimental value).

Table 6. Compliance with the requirements for validity of the MARINE biodegradation test.

	Blank 1	Blank 2	Blank 3	Reference 4	Reference 5	Reference 6	Test 7	Test 8	Test 9
Plateau reached?	-	-	-	YES	YES	YES	YES	YES	YES
Plateau D (%)	-	-	-	97,2	98,1	98,2	91,5	95,4	94,4
Plateau time (days)	-	-	-	73,9	75,2	70,1	97,2	98,2	98,9
Final D (%) (all samples)	-	-	-	97,2	99,5	98,7	91,2	95,5	94,4
Final time (days)	-	-	-	98,9			98,9		
Compliance [D>70%]	-	-	-	Compliant	Compliant	Compliant	-	-	-
D average (%)	-	-	-	98,4			93,7		
D relative (%)	-	-	-	-			**95,2**		

The test material complies with the requirements of the biodegradability degree in marine environment, providing:

- **average absolute biodegradation degree 93,7% ± 2,0% after 99 days,**
- **average relative biodegradation degree 95,2% ± 2,2% after 99 days,**
- **lag phase duration is lower than 1 day.**

The residual percentage of not-detected CO2 could be due to the experimental uncertainty and measurements during the overall test duration.

6. Test Results (Start measurements: 27/04/2023 - End measurements: 04/08/2023)

Test	UM	Result	LQ	U	Method Description
VOLATILE SOLIDS	% w/w (d.m.)	32,7		± 1,1	APHA Standard Methods 2540 G 1997
		-			
BIODEGRADATION DEGREE	%	98,4		± 2,5 §	ASTM D 6691-17
BIODEGRADATION DEGREE	%	93,7		± 2,9 §	ASTM D 6691-17
		-			
BIODEGRADATION DEGREE	%	95,2		± 3,4 §	ASTM D 6691-17

The characterization data of reference (cellulose) lot number MKCL9441, expiration date september 28th 2023 are:
TOC = 45,4 % w/w (d.m.) determination on 20/03/2023
Dry residue = 98,19 % w/w determination on 17/03/2023

7. Opinions and interpretations

None

End of Test Report

Rapporto di Prova firmato digitalmente
Dott. Yuri Pelosi
Ordine dei Chimici della Toscana
N. 1680 SEZIONE A