Prediction of Biodegradation of Polymeric Materials in Soil

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The studies on biodegradable plastics with respect to biodegradation behavior are important for their application in environment. We have biodegradation data of typical polymeric materials in soil which were obtained from a joint research with local governmental research institutes in Japan. The data covered with all Japanese area. However, the tested places have much variation, that is, kind of soil, location, climate, composition of soil, distribution of microorganism, etc. We have been studying factors affecting biodegradation of polyesters in soil.

To promote application of BDPs in the environment,

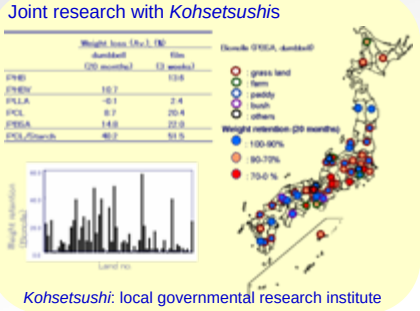
It is important to make clear soil degradation of BDPs.
→ agricultural, horticultural and geotextile use

Factors affecting biodegradation of polyesters in soil
- kind of land (farm, paddy, grass land, bush,..)
- climate
- physical & chemical characteristic of soil
- soil microorganism
- BDP-degrading microorganism

(1) Soil Degradation Test of Typical BDPs in Japan

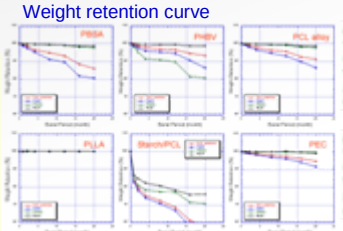
Soil biodegradation of typical polymeric materials, such as synthetic polyesters, microbial polymers and a polymer alloy were examined. Biodegradation was affected by the kind of materials, soils, rain precipitation, and average temperature etc.

Joint research with *Kohsetsushi*s

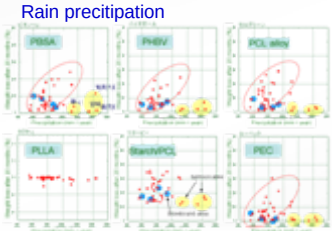


Kohsetsushi: local governmental research institute

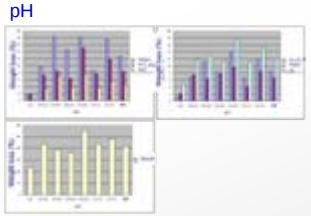
Weight retention curve



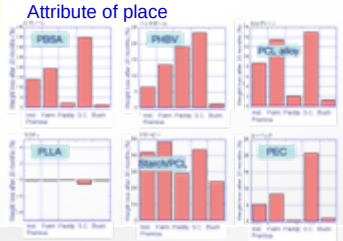
Rain precipitation



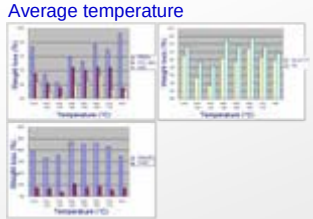
pH



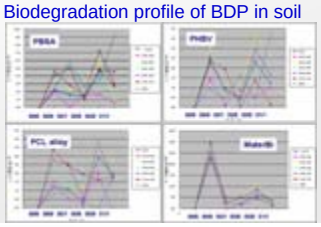
Attribute of place



Average temperature



Biodegradation profile of BDP in soil

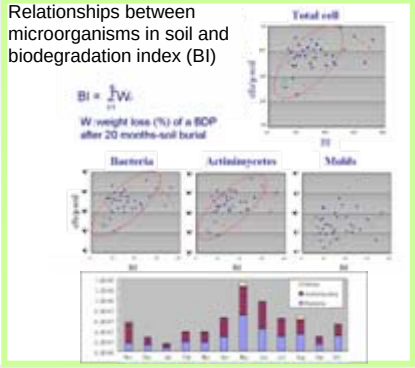


PBSA: Poly(butylene succinate / adipate)
PHBV: Poly(hydroxybutyrate / valeryrate)
PCL alloy: Poly(e-caprolactone) & PBSA
PLLA: Poly(L-lactic acid)
PEC: Polyester carbonate

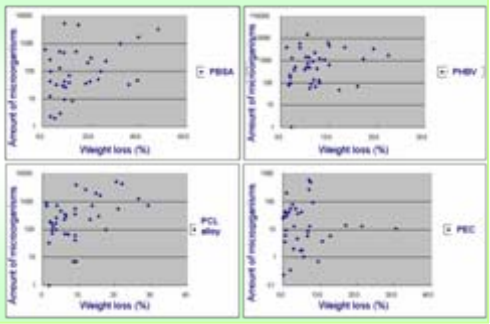
(2) Relationships between Soil Burial Biodegradation and Microorganisms

More than 90% of microorganisms in soil were bacteria and actinomycetes. The amounts of them and the biodegradation of polyesters are deeply related. The numbers of biodegrading microorganism partly showed a relationship with soil degradation. Biodegradable activity is also one of the important factors.

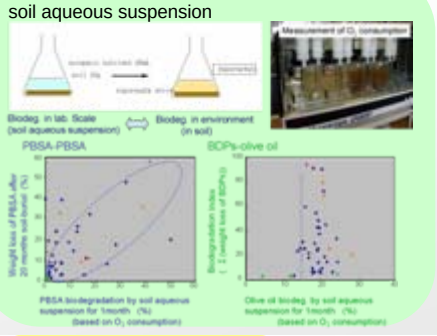
Relationships between microorganisms in soil and biodegradation index (BI)



Relationship between biodegradation in soil and amount of polymer-degrading microorganisms



Organic compounds Biodegradable activity of soil aqueous suspension



(3) Prediction of Biodegradation of Polymeric Materials in Soil

In order to predict environmental degradation of polyesters in soil, various factors such as kinds of resin, climate, location, soil and microorganism parameters were expressed numerically and functionally.

Material

	PHBV	Mater-Bi	PLLA	PBSA	PCL alloy	PEC
Ratio	0.28	**1.00**	0.00	0.28	0.18	0.10

Land

	Land (Ri)	Farm	Paddy	Bush
PHBV	**1.00**	2.06	2.92	0.30
Mater-Bi	**1.00**	1.15	1.70	0.57
PLLA	**1.00**	1.09	0.82	1.09
PBSA	**1.00**	1.38	0.16	0.10
PCL alloy	**1.00**	1.55	0.24	0.15
PEC	**1.00**	1.60	0.06	0.20

Precipitation

ex. PBSA: Y=6.83X-22.3 (X: precipitation (mm), Y: weight loss (%))

pH

	< 5	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	7.0-7.4	> 7.5
PHBV	0.28	0.96	0.82	**1.00**	1.25	0.53	1.10
Mater-Bi	0.64	1.20	1.06	**1.00**	1.51	1.20	1.31
PLLA	1.00	1.00	1.00	**1.00**	1.00	1.00	1.00
PBSA	0.11	0.66	1.26	**1.00**	1.25	0.59	1.21
PCL alloy	0.29	1.14	1.33	**1.00**	2.37	1.20	1.87
PEC	0.04	0.85	1.79	**1.00**	1.97	0.96	1.41

Microorganisms in soil

Biodegradation Index (BI) = -74.4 + 14.3·Log_{10}Y (Y < 6×10^6)
BI = -738 + 113·Log_{10}Y (Y > 6×10^6)
Y: amount of microorganisms in soil (cell/g-soil)

Air Temperature

	<12℃	12-13℃	13-14℃	14-15℃	15-16℃	16-17℃	17-18℃	> 18℃
PHBV	0.94	0.88	0.50	1.40	**1.00**	1.09	0.74	0.91
Mater-Bi	0.88	0.75	0.79	1.06	**1.00**	1.02	0.95	0.77
PLLA	1.00	1.00	1.00	1.00	**1.00**	1.00	1.00	1.00
PBSA	1.41	0.66	0.45	1.15	**1.00**	1.48	1.34	1.77
PCL alloy	0.88	0.54	0.38	1.09	**1.00**	1.10	1.10	0.36
PEC	0.94	0.38	0.21	0.83	**1.00**	1.33	0.54	0.46

Seasonary (PBSA)

	May-Sep.	Sep.-Jan.	Jan.-May	May-Sep.	Sep.-Jan.
<12℃	0.69	0.55	0.46	1.57	1.20
12-13℃	0.30	0.15	0.18	0.52	0.96
13-14℃	0.48	0.00	0.39	0.40	0.14
14-15℃	0.91	0.55	0.47	1.45	0.25
15-16℃	**1.00**	0.31	0.49	1.02	0.35
16-17℃	1.13	0.88	0.40	1.74	0.73
17-18℃	0.98	1.20	0.23	1.16	0.65
> 18℃	0.56	1.36	0.63	0.84	2.21

Input parameter

Example of Output