Chapter -IV RESULTS AND ANALYSIS

4.1 DATA FROM TEST METHODS FOR ASSESSMENT OF BIODEGRADATION:

Based on the methodology of experimentations described under section 3.2 in the preceding chapter- Experimental Techniques, the initial strength of the specimens were obtained as follows

4.1.1. RESULTS FOR SPECIMEN TESTING:

The nomenclature of specimens produced by process described in 3.2.1 were as per table 4.1

Table 4.1 KEY TO THE SPECIMEN NUMBER

Sr. No.	Specimen	Polymer	Plasticizer	Percent (w/w)
1.	LD00	LDPE	Groundnut Oil	0%
2.	LDG5	LDPE	Groundnut Oil	5%
3.	LDG10	LDPE	Groundnut Oil	10%
4.	LDG15	LDPE	Groundnut Oil	15%
5.	LDG20	LDPE	Groundnut Oil	20%
6.	LDG25	LDPE	Groundnut Oil	25%
7.	LDS5	LDPE	Soybean Oil	5%
8.	LDS10	LDPE	Soybean Oil	10%
9.	LDS15	LDPE	Soybean Oil	15%
10.	LDS20	LDPE	Soybean Oil	20%
11.	LDS25	LDPE	Soybean Oil	25%
12.	HD00	HDPE	Groundnut Oil	0%
13.	HDG5	HDPE	Groundnut Oil	5%
14.	HDG10	HDPE	Groundnut Oil	10%
15.	HDG15	HDPE	Groundnut Oil	15%
16.	HDG20	HDPE	Groundnut Oil	20%
17.	HDG25	HDPE	Groundnut Oil	25%
18.	HDS5	HDPE	Soybean Oil	5%
19.	HDS10	HDPE	Soybean Oil	10%
20.	HDS15	HDPE	Soybean Oil	15%

21.	HDS20	HDPE	Soybean Oil	20%
22.	HDS25	HDPE	Soybean Oil	25%
23.	PS00	PS	Groundnut Oil	0%
24.	PSG5	PS	Groundnut Oil	5%
25.	PSG10	PS	Groundnut Oil	10%
26.	PSG15	PS	Groundnut Oil	15%
27.	PSG20	PS	Groundnut Oil	20%
28.	PSG25	PS	Groundnut Oil	25%
29.	PSS5	PS	Soybean Oil	5%
30.	PSS10	PS	Soybean Oil	10%
31.	PSS15	PS	Soybean Oil	15%
32.	PSS20	PS	Soybean Oil	20%
33.	PSS25	PS	Soybean Oil	25%
34.	PP00	PP	Groundnut Oil	0%
35.	PPG5	PP	Groundnut Oil	5%
36.	PPG10	PP	Groundnut Oil	10%
37.	PPG15	PP	Groundnut Oil	15%
38.	PPG20	PP	Groundnut Oil	20%
39.	PPG25	PP	Groundnut Oil	25%
40.	PPS5	PP	Soybean Oil	5%
41.	PPS10	PP	Soybean Oil	10%
42.	PPS15	PP	Soybean Oil	15%
43.	PPS20	PP	Soybean Oil	20%
44.	PPS25	PP	Soybean Oil	25%

The specimens were tested for:

◊Tensile impact strength

◊Tensile strength

◊Tensile elongation

◊Viscosity

The test results for the properties 1-3 are obtained from Department of Chemistry, Sardar Patel University, Vallabh Vidyanagar-388120. The report is produced using NEXYGEN from Lloyd LR 30 K plus UTM. The viscosity results are measured by Red Wood Viscometer.

TABLE 4.2 TENSILE STRENGTH DATA

Sr.No.	Specimen	Tensile Impact KJ/Cm	Tensile Strength Kgf/Cm²(50mm/Min)	Percent Elongation
1.	LD00	4.65	56.131	100
2.	LDG5	1.06	249.760	175
3.	LDG10	14.67	81.089	160
4.	LDG15	8.28	56.162	240
5.	LDG20	4.87	70.462	290
6.	LDG25	4.17	69.229	210
7.	LDS5	8.45	67.869	145
8.	LDS10	5.85	82.545	540
9.	LDS15	7.77	46.844	87
10.	LDS20	5.8	44.403	160
11.	LDS25	5.2	71.119	722
12.	HD00	3.65	142.710	407
13.	HDG5	4.6	134.430	635.31
14.	HDG10	5.95	155.060	472
15.	HDG15	5.4	130.080	516
16.	HDG20	4.5	134.990	99
17.	HDG25	5.51	153.830	630
18.	HDS5	6.19	90.169	50
19.	HDS10	7.5	101.190	64
20.	HDS15	8	120.870	460
21.	HDS20	7.1	139.290	620
22.	HDS25	10.26	118.760	168
23.	PS00	3.18	105.530	1.007
24.	PSG5	3.47	77.060	2.116

25.	PSG10	4.11	116.870	1.396
26.	PSG15	2.96	89.645	2.019
27.	PSG20	3.13	76.495	1.480
28.	PSG25	3.06	114.520	2.284
29.	PSS5	3.9	83.625	1.973
30.	PSS10	3.42	126.210	3.428
31.	PSS15	3.34	126.950	2.168
32.	PSS20	4.88	120.750	1.878
33.	PSS25	3.5	76.963	1.142
34.	PP00	4.97	121.780	226.786
35.	PPG5	5.25	128.205	650
36.	PPG10	5.95	142.650	540
37.	PPG15	6.8	132.020	776.5
38.	PPG20	5.08	114.910	370
39.	PPG25	4.75	97.430	1075
40.	PPS5	4.43	75.225	536.36
41.	PPS10	3.61	109.100	1076.9
42.	PPS15	4.03	145.810	1327.6
43.	PPS20	5.65	126.010	1058.33
44.	PPS25	3.65	131.400	1285.4

FIGURE 4.1: TENSILE IMPACT VS POLYMER WITH GROUNDNUT OIL

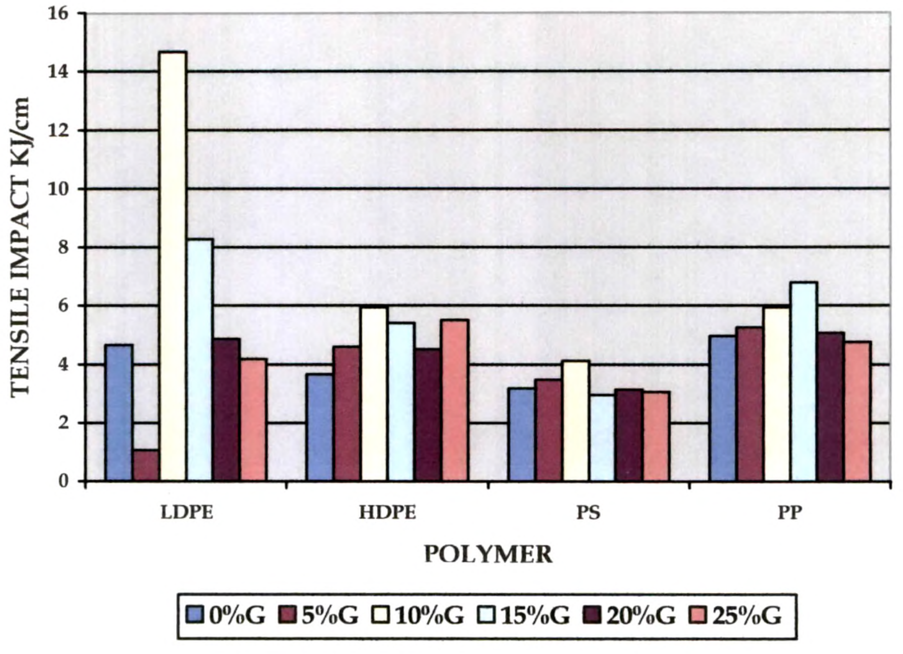


FIGURE 4.2: TENSILE IMPACT VS POLYMER WITH SOYBEAN OIL

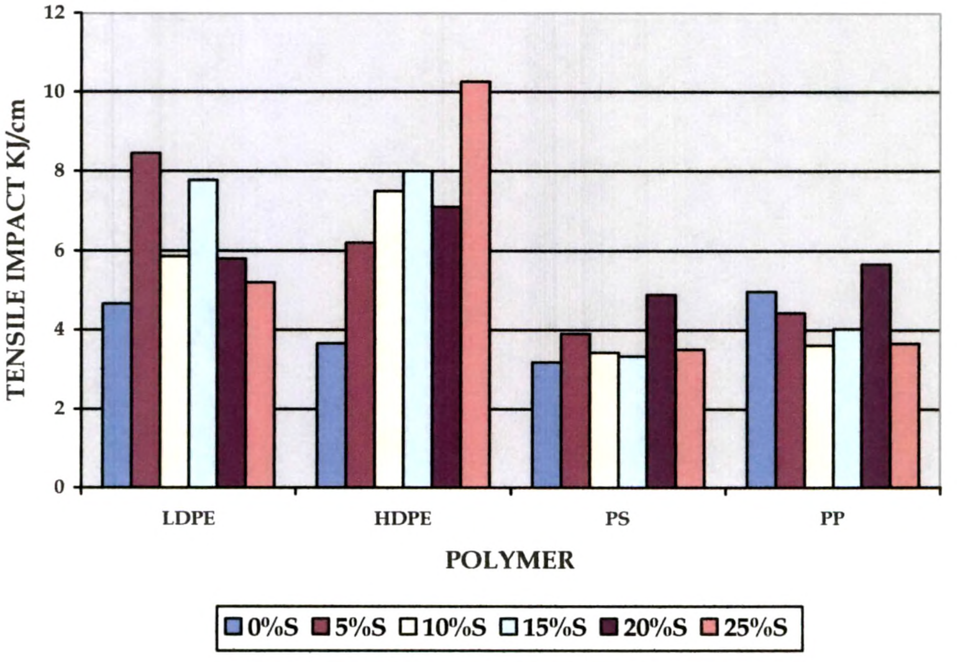


FIGURE 4.3: TENSILE STRENGTH VS POLYMER WITH GROUNDNUT OIL

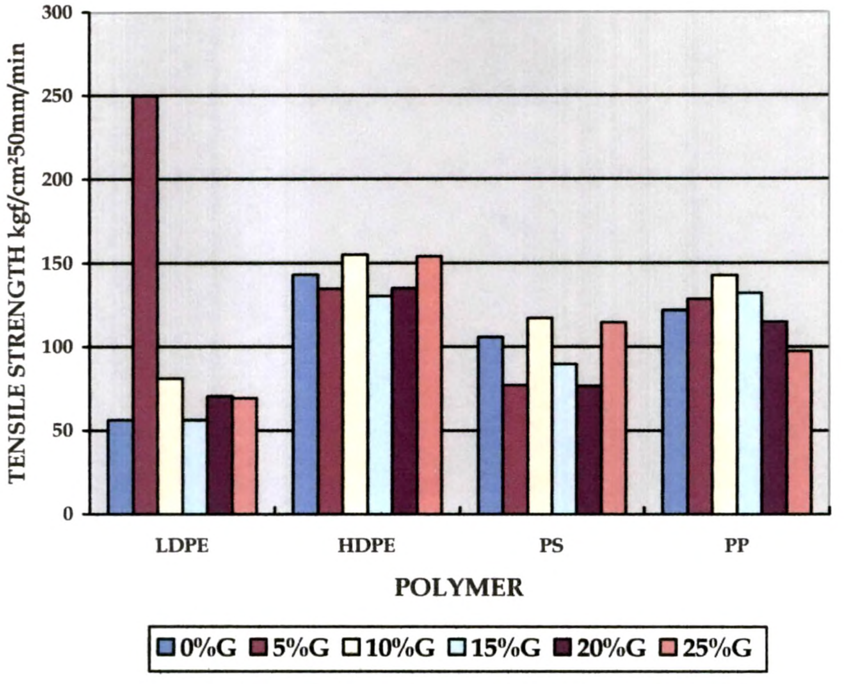


FIGURE 4.4: TENSILE STRENGTH VS POLYMER WITH SOYBEAN OIL

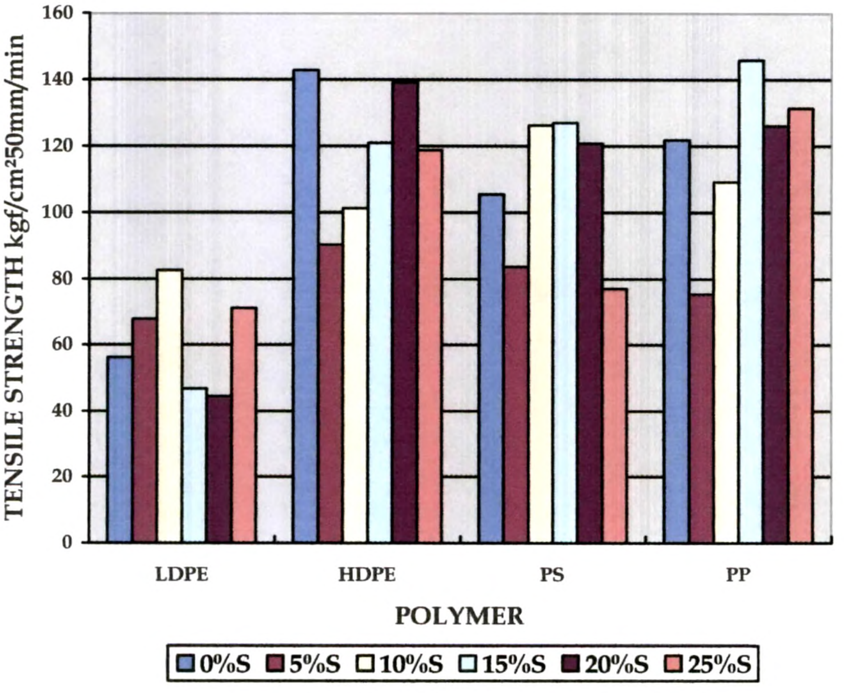


FIGURE 4.5: PERCENT ELONGATION VS POLYMER WITH GROUNDNUT OIL

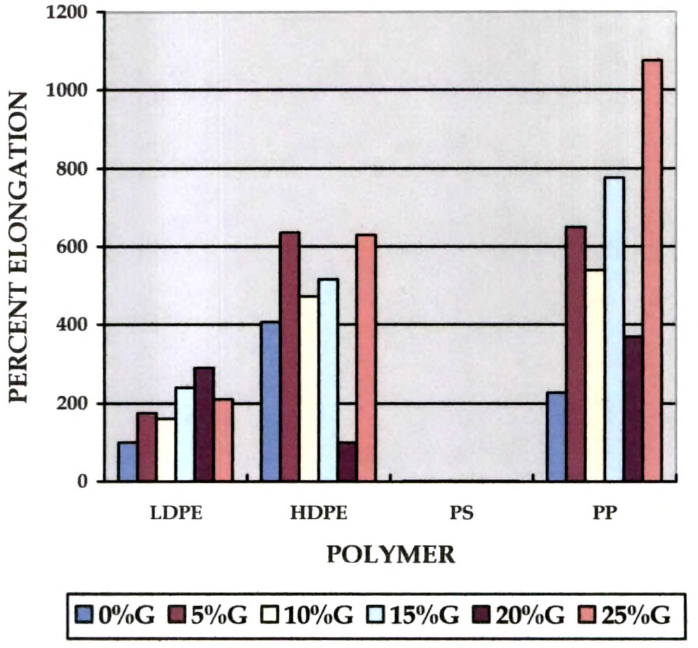
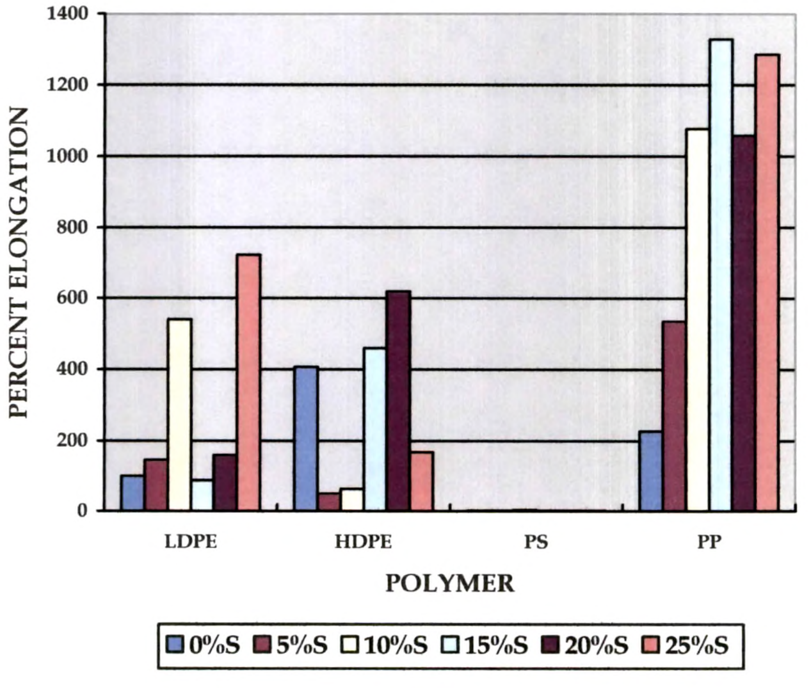


FIGURE 4.6: PERCENT ELONGATION VS POLYMER WITH SOYBEAN OIL



4.1.2 ANALYSIS AND DISCUSSION FOR INITIAL STRENGTH OF SPECIMEN:

◊The tensile impact, strength and percent elongation of polymer increases with the increase in plasticizer content up to 15% of plasticizer content and then gradually decreases with plasticizer content because the plasticizer cause the properties of elongation and softness of the polymer to be increased. It lowers the glass transition temperature, T_g, and reduces crystallinity by disrupting physical interactions between the chains. (Ch. II 2.1.3)

◊Up to 25% concentration of plasticizer, the tensile impact strength remains comparable to that of unmodified polymer. The tensile impact of LDS5 and HDS25 is increased to a greater extent as compared to the unmodified ones. For small additions of plasticizer, the plasticizer molecules may be totally immobilized by attachment to the resin by various forces. These tend to restrict the freedom of small portions of the polymer molecule so necessary for the absorption of mechanical energy. Therefore it results in a more rigid resin with a higher tensile strength and base modulus than the base polymer itself. This phenomenon is therefore termed anti plasticization.

◊The tensile impact of specimen with 15% soybean oil concentration is highly improved with LDPE and HDPE with PS and PP 20% concentration shows higher strength. Then the tensile impact of specimen reduces as the soybean oil concentration increases. (with HDPE as an exception) Thus it follows parabolic curve with respect to concentration.

◊Up to 25% concentration of plasticizer, the tensile impact strength remains comparable and higher than that of unmodified polymer.

◊The specimens were prepared by an intermittent extruder having no internal mixing device. The plasticizer was mixed manually by heating the polymer. Hence the precise mixing of plasticizer in the polymer matrix was not achieved. Plasticized HDPE, PS and PP do not retain the plasticizer in their bulk because of their higher crystallinity, molecular weight and low plasticizer compatibility. The non uniform mixing of plasticizer and low compatibility exhibits uneven loses in the strength.

◊ An exchange/equilibrium mechanism exists between the plasticizer and polymer due to which migration of plasticizer from plasticized polymer was observed. Hence it can be presumed that at least some of the plasticizer molecules are not permanently bound to the polymer.

◊ The percent elongation of modified specimen was improved which shows improved workability (ease of processing) of polymer with the addition of plasticizer.(Ch. II 2.1.3)

4.1.3 RESULTS FOR VISCOSITY:

The solution viscosities of specimens are obtained using redwood viscometer. Xylene HPLC grade is used as the solvent.

TABLE 4.3 VISCOSITY DATA

Sr. No.	Specimen	Time Sec.	Concentration g/ml	Reduced Viscosity
1.	LD00	23.52	0.005	584.000
2.	LDG5	23.34	0.005	578.000
3.	LDG10	12.5	0.01	108.333
4.	LDG15	13.58	0.01	126.333
5.	LDG20	18.04	0.01	200.667
6.	LDG25	12.78	0.01	113.000
7.	LDS5	16.41	0.01	173.500
8.	LDS10	13.14	0.01	119.000
9.	LDS15	15.26	0.01	154.333
10.	LDS20	15.43	0.01	157.167

11.	LDS25	14.28	0.01	138.000
12.	HD00	42.46	0.005	1215.333
13.	HDG5	20.63	0.005	487.667
14.	HDG10	22.88	0.005	562.667
15.	HDG15	39.54	0.005	1118.000
16.	HDG20	18.38	0.005	412.667
17.	HDG25	28	0.005	733.333
18.	HDS5	55.92	0.005	1664.000
19.	HDS10	49.27	0.005	1442.333
20.	HDS15	33.24	0.005	908.000
21.	HDS20	47.01	0.005	1367.000
22.	HDS25	47.97	0.005	1399.000
23.	PS00	31.18	0.01	419.667
24.	PSG5	18.15	0.01	202.500
25.	PSG10	12.7	0.015	74.444
26.	PSG15	9.48	0.01	58.000
27.	PSG20	11.04	0.01	84.000
28.	PSG25	9.2	0.01	53.333
29.	PSS5	9.56	0.01	59.333
30.	PSS10	9.05	0.01	50.833
31.	PSS15	10.18	0.01	69.667
32.	PSS20	12.05	0.01	100.833
33.	PSS25	8.84	0.01	47.333
34.	PP00	21.34	0.005	511.333
35.	PPG5	12.1	0.005	203.333
36.	PPG10	13.32	0.005	244.000
37.	PPG15	13.17	0.005	239.000
38.	PPG20	20.07	0.01	234.500
39.	PPG25	25.25	0.01	320.833
40.	PPS5	41.83	0.01	597.167

41.	PPS10	35.15	0.01	485.833
42.	PPS15	34.5	0.01	475.000
43.	PPS20	52.96	0.01	782.667
44.	PPS25	33.3	0.01	455.000

4.1.4 ANALYSIS AND DISCUSSION FOR INITIAL VISCOSITY:

◊The viscosity of unplasticized polymer was high because of the higher molecular weight of the polymer. Also the rigidity of the polymer arises from intermolecular friction binding the chains together in a rigid network. On heating these frictional forces become weak so that the plasticizer molecules penetrate between the chains. Once incorporated into the polymer bulk the plasticizer molecules shield the chains from each other, thus preventing the re-formation of the rigid network. (Ch. II 2.1.3)

◊Viscosity of polymer decreases as the plasticizer concentration increases. Thus the molecular weight of the polymer reduces as compared to that of the unmodified polymer. Plasticizer when incorporated in the polymer matrix is absorbed in the space between the polymer chains. They increase the free volume between the polymer chains. Thus the porosity of the polymer matrix is increased

◊The significant reduction in viscosity owes to the theory that the plasticizer reduces the friction between the chains. The reduction of viscosity with HDPE and PP was not significant because of their higher crystallinity, molecular weight and low compatibility with plasticizer. They exhibit the theory of anti plasticization.

◊The reduction of viscosity can be one of the factors affecting the increased rate of biodegradability. Because the lower molecular weight polymers- oligomers of any polymers are biodegradable.

◊The non uniformity in mixing of plasticizer in polymer mixing, the solvation-desolvation equilibrium and the phenomenon of anti plasticization adversely affect the test results. (Janet L. Lane et al 2004).

4.2 RESULTS FROM TESTING FOR BIODEGRADABILITY:

Based on the methodology of experimentations described under section 3.3 in the preceding chapter- Experimental Techniques, The following results were obtained.

4.2.1 RESULTS FROM SCREENING OF BIODEGRADATION OF SPECIMEN TO ASSESS THE PROPERTY LOSS:

◊Out of seven chains of microfilms placed in seven different bowls, the results up to 12 weeks were available.

◊The specimens and the plastic monofilament were shattered into pieces after 12 weeks. Hence the numbering and corresponding test results measurement was not possible.

◊Adopted culture had increased the biodegradability of polymers and that of nylon monofilament.

◊ All specimens were broken into fragments. This implies tremendous loss of tensile strength, percent elongation and perhaps viscosity.

◊The fragmentation may be helpful in solving the environmental problem created by the non degradable film to some extent.

4.2.1.a RESULT FOR WEIGHT LOSS:

The specimens were removed from the bowl after six, eight, ten and twelve weeks. They were separated from the nylon filament, washed and allowed to dry for one day. Then the specimens were weighed up to .01 mg precision. The weight loss was calculated for each specimen and the loss was recorded.

TABLE 4.4: WEIGHT LOSS AFTER 6 WEEKS:

Sr.no.	Specimen	Initial Weight g	Weight g	Weight loss	Percent loss
1.	LD00	0.4	0.34	0.06	15
2.	LDG5	0.3	0.2943	0.0057	1.900
3.	LDG10	0.3	0.2588	0.0412	13.733
4.	LDG15	0.2	0.1992	0.0008	0.400

5.	LDG20	0.3	0.2907	0.0093	3.100
6.	LDG25	0.3	0.27	0.03	10.000
7.	LDS5	0.4	0.3639	0.0361	9.025
8.	LDS10	0.3	0.2965	0.0035	1.167
9.	LDS15	0.45	0.4144	0.0356	7.911
10.	LDS20	0.25	0.2381	0.0001	0.040
11.	LDS25	0.4	0.3311	0.0689	17.225
12.	HD00	0.7	0.6682	0.0318	4.543
13.	HDG5	0.5	0.4869	0.0131	2.620
14.	HDG10	0.6	0.5908	0.0092	1.533
15.	HDG15	1.05	1.0452	0.0048	0.457
16.	HDG20	0.6	0.5529	0.0471	7.850
17.	HDG25	0.6	0.5786	0.0214	3.567
18.	HDS5	0.4	0.3728	0.0272	6.800
19.	HDS10	0.3	0.2994	0.0006	0.200
20.	HDS15	0.5	0.4789	0.0211	4.220
21.	HDS20	0.25	0.2359	0.0141	5.640
22.	HDS25	0.1	0.09	0.01	10.000
23.	PS00	0.35	0.3369	0.0131	3.743
24.	PSG5	0.3	0.2875	0.0125	4.167
25.	PSG10	0.4	0.3887	0.0113	2.825
26.	PSG15	0.4	0.3737	0.0263	6.575
27.	PSG20	0.65	0.6468	0.0032	0.492
28.	PSG25	0.4	0.3918	0.0082	2.050
29.	PSS5	0.7	0.6509	0.0491	7.014
30.	PSS10	0.35	0.3308	0.0192	5.486
31.	PSS15	0.2	0.1636	0.0364	18.200
32.	PSS20	0.3	0.2722	0.0278	9.267
33.	PSS25	0.25	0.2	0.05	20.000
34.	PP00	0.7	0.6545	0.0455	6.500

35.	PPG5	0.5	0.4644	0.0356	7.120
36.	PPG10	0.2	0.1939	0.0061	3.050
37.	PPG15	0.3	0.2551	0.0449	14.967
38.	PPG20	0.1	0.0914	0.0086	8.600
39.	PPG25	0.2	0.1908	0.0092	4.600
40.	PPS5	0.3	0.2546	0.0454	15.133
41.	PPS10	0.3	0.2923	0.0077	2.567
42.	PPS15	0.2	0.1977	0.0023	1.150
43.	PPS20	0.3	0.25	0.05	16.667
44.	PPS25	0.4	0.3839	0.0161	4.025

TABLE 4.5: WEIGHT LOSS AFTER 8 WEEKS:

Sr.no.	Specimen	Initial Weight g	Weight g	Weight loss	Percent loss
1.	LD00	0.5	0.49	0.0100	2
2.	LDG5	0.3	0.2851	0.0149	4.967
3.	LDG10	0.3	0.2924	0.0076	2.533
4.	LDG15	0.5	0.4877	0.0123	2.460
5.	LDG20	0.5	0.4769	0.0231	4.620
6.	LDG25	0.3	0.2944	0.0056	1.867
7.	LDS5	0.25	0.2149	0.0351	14.040
8.	LDS10	0.4	0.34	0.0600	15.000
9.	LDS15	0.6	0.5777	0.0223	3.717
10.	LDS20	0.3	0.2709	0.0291	9.700
11.	LDS25	0.3	0.2337	0.0663	22.100
12.	HD00	0.7	0.6437	0.0563	8.043
13.	HDG5	0.6	0.5641	0.0359	5.983
14.	HDG10	0.75	0.7108	0.0392	5.227
15.	HDG15	0.4	0.3523	0.0477	11.925
16.	HDG20	0.7	0.6556	0.0444	6.343
17.	HDG25	0.4	0.3923	0.0077	1.925
18.	HDS5	0.5	0.4559	0.0441	8.820
19.	HDS10	0.3	0.2787	0.0213	7.100
20.	HDS15	0.7	0.6451	0.0549	7.843
21.	HDS20	0.2	0.1808	0.0192	9.600
22.	HDS25	0.15	0.1207	0.0293	19.533
23.	PS00	0.6	0.5871	0.0129	2.150
24.	PSG5	0.3	0.2648	0.0352	11.733
25.	PSG10	0.35	0.3183	0.0317	9.057
26.	PSG15	0.6	0.5956	0.0044	0.733

27.	PSG20	0.8	0.59	0.2100	26.250
28.	PSG25	0.5	0.4553	0.0447	8.940
29.	PSS5	0.65	0.65	0.0000	0.000
30.	PSS10	0.35	0.3248	0.0252	7.200
31.	PSS15	0.2	0.1807	0.0193	9.650
32.	PSS20	0.2	0.1919	0.0081	4.050
33.	PSS25	0.25	0.2409	0.0091	3.640
34.	PP00	0.8	0.7832	0.0168	2.100
35.	PPG5	0.65	0.6318	0.0182	2.800
36.	PPG10	0.2	0.19208	0.0079	3.960
37.	PPG15	0.2	0.1867	0.0133	6.650
38.	PPG20	0.15	0.1313	0.0187	12.467
39.	PPG25	0.2	0.1544	0.0456	22.800
40.	PPS5	0.1	0.0921	0.0079	7.900
41.	PPS10	0.4	0.3555	0.0445	11.125
42.	PPS15	0.3	0.2458	0.0542	18.067
43.	PPS20	0.3	0.2744	0.0256	8.533
44.	PPS25	0.3	0.2434	0.0566	18.867

TABLE 4.6: WEIGHT LOSS AFTER 10 WEEKS:

Sr.no.	Specimen	Initial Weight g	Weight g	Weight loss	Percent loss
1.	LD00	0.45	0.4392	0.0108	2.4
2.	LDG5	0.35	0.3254	0.0246	7.029
3.	LDG10	0.3	0.2608	0.0392	13.067
4.	LDG15	0.45	0.4152	0.0348	7.733
5.	LDG20	0.3	0.2711	0.0289	9.633
6.	LDG25	0.35	0.32	0.0300	8.571
7.	LDS5	0.35	0.3178	0.0322	9.200
8.	LDS10	0.35	0.33	0.0200	5.714
9.	LDS15	0.6	0.5325	0.0675	11.250
10.	LDS20	0.3	0.2609	0.0391	13.033
11.	LDS25	0.35	0.2912	0.0588	16.800
12.	HD00	0.4	0.3917	0.0083	2.075
13.	HDG5	0.5	0.4654	0.0346	6.920
14.	HDG10	0.75	0.6942	0.0558	7.440
15.	HDG15	0.6	0.5534	0.0466	7.767
16.	HDG20	0.65	0.5934	0.0566	8.708
17.	HDG25	0.4	0.3534	0.0466	11.650
18.	HDS5	0.7	0.6688	0.0312	4.457
19.	HDS10	0.3	0.2937	0.0063	2.100
20.	HDS15	0.6	0.558	0.0420	7.000
21.	HDS20	0.2	0.1544	0.0456	22.800
22.	HDS25	0.1	0.0853	0.0147	14.700
23.	PS00	0.5	0.4753	0.0247	4.940
24.	PSG5	0.5	0.3937	0.1063	21.260
25.	PSG10	0.4	0.3906	0.0094	2.350
26.	PSG15	0.4	0.348	0.0520	13.000

27.	PSG20	0.5	0.4556	0.0444	8.880
28.	PSG25	0.5	0.2237	0.2763	55.260
29.	PSS5	0.3	0.2409	0.0591	19.700
30.	PSS10	0.3	0.0524	0.2476	82.533
31.	PSS15	0.25	0.2387	0.0113	4.520
32.	PSS20	0.3	0.2359	0.0641	21.367
33.	PSS25	0.2	0.1604	0.0396	19.800
34.	PP00	0.6	0.5554	0.0446	7.433
35.	PPG5	0.4	0.3622	0.0378	9.450
36.	PPG10	0.25	0.1983	0.0517	20.680
37.	PPG15	0.2	0.1623	0.0377	18.850
38.	PPG20	0.1	0.0951	0.0049	4.900
39.	PPG25	0.25	0.2288	0.0212	8.480
40.	PPS5	0.3	0.29	0.0100	3.333
41.	PPS10	0.3	0.2261	0.0739	24.633
42.	PPS15	0.2	0.1965	0.0035	1.750
43.	PPS20	0.4	0.351	0.0490	12.250
44.	PPS25	0.3	0.2907	0.0093	3.100

TABLE 4.7: WEIGHT LOSS AFTER 12 WEEKS:

Sr.no.	Specimen	Initial Weight g	Weight g	Weight loss	Percent loss
1.	LD00	0.35	0.3257	0.0243	6.943
2.	LDG5	0.35	0.3424	0.0076	2.171
3.	LDG10	0.3	0.2574	0.0426	14.200
4.	LDG15	0.3	0.2917	0.0083	2.767
5.	LDG20	0.35	0.3148	0.0352	10.057
6.	LDG25	0.3	0.2952	0.0048	1.600
7.	LDS5	0.2	0.2	0.0000	0.000
8.	LDS10	0.4	0.3685	0.0315	7.875
9.	LDS15	0.5	0.4633	0.0367	7.340
10.	LDS20	0.3	0.2609	0.0391	13.033
11.	LDS25	0.3	0.2647	0.0353	11.767
12.	HD00	0.4	0.3813	0.0187	4.675
13.	HDG5	0.5	0.4646	0.0354	7.080
14.	HDG10	0.7	0.6585	0.0415	5.929
15.	HDG15	0.6	0.5582	0.0418	6.967
16.	HDG20	0.6	0.5866	0.0134	2.233
17.	HDG25	0.45	0.4272	0.0228	5.067
18.	HDS5	0.4	0.3862	0.0138	3.450
19.	HDS10	0.3	0.2723	0.0277	9.233
20.	HDS15	0.6	0.5615	0.0385	6.417
21.	HDS20	0.2	0.1965	0.0035	1.750
22.	HDS25	0.15	0.1427	0.0073	4.867
23.	PS00	0.55	0.5489	0.0011	0.200
24.	PSG5	0.1	0.0674	0.0326	32.600
25.	PSG10	0.4	0.3955	0.0045	1.125
26.	PSG15	0.45	0.4455	0.0045	1.000
27.	PSG20	0.5	0.4937	0.0063	1.260

28.	PSG25	0.55	0.5163	0.0337	6.127
29.	PSS5	0.5	0.4923	0.0077	1.540
30.	PSS10	0.35	0.2826	0.0674	19.257
31.	PSS15	0.2	0.1942	0.0058	2.900
32.	PSS20	0.25	0.2341	0.0159	6.360
33.	PSS25	0.3	0.2652	0.0348	11.600
34.	PP00	0.2	0.1987	0.0013	0.650
35.	PPG5	0.4	0.3555	0.0445	11.125
36.	PPG10	0.2	0.1908	0.0092	4.600
37.	PPG15	0.2	0.1537	0.0463	23.150
38.	PPG20	0.1	0.0928	0.0072	7.200
39.	PPG25	0.2	0.1945	0.0055	2.750
40.	PPS5	0.2	0.1353	0.0647	32.350
41.	PPS10	0.3	0.2988	0.0012	0.400
42.	PPS15	0.35	0.3446	0.0054	1.543
43.	PPS20	0.25	0.2115	0.0385	15.400
44.	PPS25	0.35	0.3248	0.0252	7.200

4.2.2 ANALYSIS AND DISCUSSION FOR WEIGHT LOSS:

◊The exudation of plasticizer and other additives in the base polymer shows higher weight loss after six weeks. After six weeks significant weight loss was not observed up to 12 weeks. After 12 weeks sudden fragmentation was observed. This may have resulted due to the consumption of plasticizer molecules between the polymer chains. (Ch. II 2.1.3).

◊ A bio film may be formed on the plasticized polymer that could be strongly attached to the polymer surface. The presence of plasticizer increases the probability of bio film formation. The strong attachment of bio film to the polymer surface does not allow its removal simply by washing. When the polymer specimens were washed with water this bio film could not be removed hence has contributed in the total weight of the specimen.

◊ Initially the microorganisms only consume the plasticizer molecules available on the surface of the specimen. Then they reach the free space between the polymer chains and gather there. The accumulation of microorganism within the polymer matrix also contributes the total weight of the polymer specimen.

◊ When the microorganisms consume the plasticizer molecules, large free space between the polymer chains may be left. This results in break down of the polymer into small fragments of lower molecular weight. But the overall weight of the specimen may not be reduced to a greater extent.

◊A biological system comprising of a concentrated culture of specific microorganism, water, the specimen, the plasticizer and the atmospheric condition may have developed. This biological system may have supported the growth of some new flora of microorganism that could consume the unmodified polymer as the sole source of nutrition. This phenomenon is also observed in an oil contaminated rubber band which when subjected to atmospheric conditions, loses its properties and strength, and becomes tacky after certain period. (J. E. Glass et al,1989)

◊The biodegradability is inversely proportional to the molecular weight. Hence the fragments of low molecular weight can be utilized by the microorganism as a source of nutrition. (Wan Aizan et al, 2006). Also the fine fragments contribute towards the solution of environmental problem to some extent.

◊Certain migratory additives incorporated in the base polymer to improve the workability and utility of the polymer may be extracted in the medium.

4.2.1.b RESULT FOR TENSILE STRENGTH LOSS:

The specimens were removed from the bowl after six, eight, ten and twelve weeks. They were separated from the nylon filament, washed and allowed to dry for one day. The specimens were weighed up to .01 mg precision. The specimens were tested for tensile strength on semi automatic tensile testing machine wherein the initial length and the final length were measured manually. The specimens after failure were collected for further testing of viscosity.

TABLE 4.8: TENSILE STRENGTH LOSS AFTER 6 WEEKS:

Sr.No.	Specimen	Tensile Force Kgf	Width mm	Thick Ness mm	Area mm^2	Tensile Strength Kgf/cm^2	Loss Kgf/cm^2	Percent Loss
1.	LD00	1.400	0.2	18	3.6	38.889	17.242	30.718
2.	LDG5	1.133	0.17	14	2.38	47.619	202.141	80.934
3.	LDG10	1.200	0.22	13	2.86	41.958	39.131	48.257
4.	LDG15	0.767	0.19	13	2.47	31.039	25.123	44.733
5.	LDG20	1.500	0.31	16	4.96	30.242	40.220	57.081
6.	LDG25	0.867	0.21	15	3.15	27.513	41.716	60.258
7.	LDS5	0.833	0.19	13	2.47	33.738	34.131	50.289
8.	LDS10	2.233	0.27	13	3.51	63.628	18.917	22.918
9.	LDS15	2.667	0.39	15	5.85	45.584	1.260	2.690
10.	LDS20	0.967	0.2	11	2.2	43.939	0.464	1.044
11.	LDS25	0.767	0.16	13	2.08	36.859	34.260	48.173
12.	HD00	4.733	0.31	22	6.82	69.404	73.306	51.367
13.	HDG5	3.333	0.26	20	5.2	64.103	70.327	52.315
14.	HDG10	4.600	0.3	21	6.3	73.016	82.044	52.911
15.	HDG15	2.100	0.19	17	3.23	65.015	65.065	50.019
16.	HDG20	4.133	0.32	20	6.4	64.583	70.407	52.157
17.	HDG25	2.767	0.27	16	4.32	64.043	89.787	58.368
18.	HDS5	1.867	0.25	18	4.5	41.481	48.688	53.996
19.	HDS10	2.367	0.2	15	3	78.889	22.301	22.039
20.	HDS15	4.500	0.3	18	5.4	83.333	37.537	31.055
21.	HDS20	2.100	0.14	17	2.38	88.235	51.055	36.654
22.	HDS25	1.467	0.13	11	1.43	102.564	16.196	13.638
23.	PS00	3.833	0.25	15	3.75	102.222	3.308	3.134
24.	PSG5	1.467	0.15	13	1.95	75.214	1.846	2.396
25.	PSG10	0.767	0.18	11	1.98	38.721	78.149	66.869
26.	PSG15	1.767	0.36	15	5.4	32.716	56.929	63.505

27.	PSG20	2.667	0.41	14	5.74	46.458	30.037	39.267
28.	PSG25	3.133	0.35	15	5.25	59.683	54.837	47.885
29.	PSS5	2.267	0.46	19	8.74	25.934	57.691	68.987
30.	PSS10	1.567	0.28	12	3.36	46.627	79.583	63.056
31.	PSS15	2.133	0.18	11	1.98	107.744	19.206	15.129
32.	PSS20	1.167	0.39	10	3.9	29.915	90.835	75.226
33.	PSS25	1.100	0.11	13	1.43	76.923	0.040	0.052
34.	PP00	4.800	0.29	19	5.51	87.114	34.666	28.466
35.	PPG5	3.133	0.35	14	4.9	63.946	64.259	50.122
36.	PPG10	1.433	0.18	8	1.44	99.537	43.113	30.223
37.	PPG15	1.133	0.19	8	1.52	74.561	57.459	43.523
38.	PPG20	0.800	0.17	8	1.36	58.824	56.086	48.809
39.	PPG25	1.100	0.19	8	1.52	72.368	25.062	25.723
40.	PPS5	0.833	0.19	6	1.14	73.099	2.126	2.826
41.	PPS10	2.067	0.2	10	2	103.333	5.767	5.286
42.	PPS15	3.167	0.25	9	2.25	140.741	5.069	3.477
43.	PPS20	1.500	0.28	8	2.24	66.964	59.046	46.858
44.	PPS25	1.633	0.31	9	2.79	58.542	72.858	55.447

TABLE 4.9: TENSILE STRENGTH LOSS AFTER 8 WEEKS:

Sr.No.	Specimen	Tensile Force Kgf	Width mm	Thick Ness mm	Area mm^2	Tensile Strength Kgf/cm^2	Loss Kgf/cm^2	Percent Loss
1.	LD00	1.1	15	0.32	4.8	22.917	33.215	59.173
2.	LDG5	1.267	15	0.26	3.9	32.479	217.281	86.996
3.	LDG10	1.033	15	0.22	3.3	31.313	49.776	61.384
4.	LDG15	0.767	13	0.19	2.47	31.039	25.123	44.733
5.	LDG20	0.967	15	0.25	3.75	25.778	44.684	63.416
6.	LDG25	0.867	15	0.25	3.75	23.111	46.118	66.616
7.	LDS5	1.200	15	0.27	4.05	29.630	38.239	56.343

8.	LDS10	2.233	13	0.27	3.51	63.628	18.917	22.918
9.	LDS15	1.400	13	0.29	3.77	37.135	9.709	20.726
10.	LDS20	0.833	15	0.13	1.95	42.735	1.668	3.756
11.	LDS25	1.100	13	0.23	2.99	36.789	34.330	48.271
12.	HD00	4.767	21	0.33	6.93	68.783	73.927	51.802
13.	HDG5	2.933	19	0.25	4.75	61.754	72.676	54.062
14.	HDG10	3.733	20	0,27	5.4	69.136	85.924	55.414
15.	HDG15	2.100	23	0.45	10.35	20.290	109.790	84.402
16.	HDG20	3.233	19	0.27	5.13	63.028	71.962	53.309
17.	HDG25	3.200	18	0.31	5.58	57.348	96.482	62.720
18.	HDS5	1.867	18	0.25	4.5	41.481	48.688	53.996
19.	HDS10	1.933	15	0.17	2.55	75.817	25.373	25.075
20.	HDS15	2.633	18	0.18	3.24	81.276	39.594	32.758
21.	HDS20	1.533	15	0.13	1.95	78.632	60.658	43.548
22.	HDS25	0.633	10	0.7	7	9.048	109.712	92.382
23.	PS00	3.333	17	0.2	3.4	98.039	7.491	7.098
24.	PSG5	1.533	13	0.16	2.08	73.718	3.342	4.337
25.	PSG10	1.667	16	0.27	4.32	38.580	78.290	66.989
26.	PSG15	0.533	13	0.21	2.73	19.536	70.109	78.207
27.	PSG20	2.433	16	0.33	5.28	46.086	30.409	39.753
28.	PSG25	1.900	15	0.23	3.45	55.072	59.448	51.910
29.	PSS5	1.900	20	0.4	8	23.750	59.875	71.599
30.	PSS10	0.867	16	0.2	3.2	27.083	99.127	78.541
31.	PSS15	1.400	10	0.13	1.3	107.692	19.258	15.170
32.	PSS20	0.567	12	0.24	2.88	19.676	101.074	83.705
33.	PSS25	1.100	13	0.11	1.43	76.923	0.040	0.052
34.	PP00	2.000	9	0.26	2.34	85.470	36.310	29.816
35.	PPG5	2.833	14	0.33	4.62	61.328	66.877	52.164
36.	PPG10	1.433	8	0.18	1.44	99.537	43.113	30.223
37.	PPG15	1.233	10	0.18	1.8	68.519	63.501	48.100

38.	PPG20	0.600	7	0.4	2.8	21.429	93.481	81.352
39.	PPG25	0.800	9	0.14	1.26	63.492	33.938	34.833
40.	PPS5	1.667	10	0.24	2.4	69.444	5.781	7.684
41.	PPS10	1.733	9	0.19	1.71	101.365	7.735	7.090
42.	PPS15	2.667	10	0.2	2	133.333	12.477	8.557
43.	PPS20	1.067	9	0.18	1.62	65.844	60.166	47.747
44.	PPS25	1.833	11	0.29	3.19	57.471	73.929	56.262

TABLE 4.10: TENSILE STRENGTH LOSS AFTER10 WEEKS:

Sr.No.	Specimen	Tensile Force Kgf	Width mm	Thick Ness mm	Area mm²	Tensile Strength Kgf/cm²	Loss Kgf/cm²	Percent Loss
1.	LD00	1	21	0.21	4.41	22.676	33.456	59.602
2.	LDG5	1.100	14	0.25	3.5	31.429	218.331	87.416
3.	LDG10	0.933	14	0.24	3.36	27.778	53.311	65.744
4.	LDG15	1.767	17	0.34	5.78	30.565	25.597	45.577
5.	LDG20	0.733	15	0.22	3.3	22.222	48.240	68.462
6.	LDG25	0.933	17	0.25	4.25	21.961	47.268	68.278
7.	LDS5	1.033	15	0.24	3.6	28.704	39.165	57.707
8.	LDS10	1.100	13	0.25	3.25	33.846	48.699	58.997
9.	LDS15	1.633	15	0.38	5.7	28.655	18.189	38.829
10.	LDS20	0.867	13	0.22	2.86	30.303	14.100	31.755
11.	LDS25	0.933	14	0.19	2.66	35.088	36.031	50.663
12.	HD00	2.800	18	0.26	4.68	59.829	82.881	58.076
13.	HDG5	2.433	18	0.28	5.04	48.280	86.150	64.085
14.	HDG10	4.300	22	0.34	7.48	57.487	97.573	62.926
15.	HDG15	1.933	24	0.4	9.6	20.139	109.941	84.518
16.	HDG20	3.200	18	0.36	6.48	49.383	85.607	63.418
17.	HDG25	1.733	15	0.32	4.8	36.111	117.719	76.525
18.	HDS5	2.633	18	0.36	6.48	40.638	49.531	54.931

19.	HDS10	1.933	16	0.22	3.52	54.924	46.266	45.722
20.	HDS15	2.667	19	0.31	5.89	45.274	75.596	62.543
21.	HDS20	2.100	17	0.16	2.72	77.206	62.084	44.572
22.	HDS25	0.500	22	0.27	5.94	8.418	110.342	92.912
23.	PS00	0.267	17	0.28	4.76	5.602	99.928	94.691
24.	PSG5	0.667	11	0.31	3.41	19.550	57.510	74.630
25.	PSG10	0.400	13	0.31	4.03	9.926	106.944	91.507
26.	PSG15	1.600	23	0.36	8.28	19.324	70.321	78.444
27.	PSG20	2.800	22	0.31	6.82	41.056	35.439	46.329
28.	PSG25	0.100	19	0.27	5.13	1.949	112.571	98.298
29.	PSS5	0.533	13	0.22	2.86	18.648	64.977	77.700
30.	PSS10	0.367	11	0.13	1.43	25.641	100.569	79.684
31.	PSS15	1.833	12	0.25	3	61.111	65.839	51.862
32.	PSS20	0.100	11	0.33	3.63	2.755	117.995	97.719
33.	PSS25	0.333	14	0.17	2.38	14.006	62.957	81.802
34.	PP00	3.367	20	0.41	8.2	41.057	80.723	66.286
35.	PPG5	2.033	10	0.38	3.8	53.509	74.696	58.263
36.	PPG10	1.900	8	0.27	2.16	87.963	54.687	38.337
37.	PPG15	2.067	12	0.26	3.12	66.239	65.781	49.826
38.	PPG20	1.067	23	0.22	5.06	21.080	93.830	81.655
39.	PPG25	0.967	9	0.26	2.34	41.311	56.119	57.600
40.	PPS5	1.500	8	0.29	2.32	64.655	10.570	14.051
41.	PPS10	1.967	9	0.3	2.7	72.840	36.260	33.236
42.	PPS15	1.800	7	0.35	2.45	73.469	72.341	49.613
43.	PPS20	1.700	11	0.36	3.96	42.929	83.081	65.932
44.	PPS25	1.533	11	0.38	4.18	36.683	94.717	72.083

TABLE 4.11: TENSILE STRENGTH LOSS AFTER 12 WEEKS:

Sr.No.	Specimen	Tensile Force Kgf	Width mm	Thick Ness mm	Area mm²	Tensile Strength Kgf/cm²	Loss Kgf/cm²	Percent Loss
1.	LD00	0.733	19	0.2	3.8	19.298	36.833	65.619
2.	LDG5	1.300	20	0.21	4.2	30.952	218.808	87.607
3.	LDG10	1.033	18	0.22	3.96	26.094	54.995	67.820
4.	LDG15	1.067	15	0.24	3.6	29.630	26.532	47.242
5.	LDG20	0.867	19	0.21	3.99	21.721	48.741	69.173
6.	LDG25	1.200	19	0.29	5.51	21.779	47.450	68.541
7.	LDS5	1.500	19	0.29	5.51	27.223	40.646	59.889
8.	LDS10	1.300	14	0.34	4.76	27.311	55.234	66.914
9.	LDS15	1.233	22	0.2	4.4	28.030	18.814	40.162
10.	LDS20	0.767	15	0.19	2.85	26.901	17.502	39.417
11.	LDS25	0.733	13	0.26	3.38	21.696	49.423	69.493
12.	HD00	2.100	19	0.25	4.75	44.211	98.499	69.021
13.	HDG5	0.900	19	0.29	5.51	16.334	118.096	87.849
14.	HDG10	3.500	22	0.28	6.16	56.818	98.242	63.357
15.	HDG15	1.167	20	0.29	5.8	20.115	109.965	84.536
16.	HDG20	2.433	19	0.26	4.94	49.258	85.732	63.510
17.	HDG25	1.700	17	0.28	4.76	35.714	118.116	76.783
18.	HDS5	1.900	21	0.23	4.83	39.337	50.832	56.374
19.	HDS10	1.400	14	0.28	3.92	35.714	65.476	64.706
20.	HDS15	2.067	21	0.22	4.62	44.733	76.137	62.991
21.	HDS20	2.067	19	0.15	2.85	72.515	66.775	47.940
22.	HDS25	0.767	27	0.34	9.18	8.351	110.409	92.968
23.	PS00	1.867	18	19	342	0.546	104.984	99.483
24.	PSG5	0.867	19	0.26	4.94	17.544	59.516	77.234
25.	PSG10	0.867	25	0.35	8.75	9.905	106.965	91.525
26.	PSG15	0.700	15	0.39	5.85	11.966	77.679	86.652

27.	PSG20	1.867	15	0.38	5.7	32.749	43.746	57.189
28.	PSG25	0.300	35	0.48	16.8	1.786	112.734	98.441
29.	PSS5	1.233	21	0.34	7.14	17.274	66.351	79.344
30.	PSS10	0.233	15	0.22	3.3	7.071	119.139	94.398
31.	PSS15	1.700	13	0.22	2.86	59.441	67.509	53.178
32.	PSS20	0.367	31	0.45	13.95	2.628	118.122	97.823
33.	PSS25	0.433	15	0.22	3.3	13.131	63.832	82.938
34.	PP00	0.733	10	0.46	4.6	15.942	105.838	86.909
35.	PPG5	1.633	12	0.26	3.12	52.350	75.855	59.167
36.	PPG10	1.033	8	0.26	2.08	49.679	92.971	65.174
37.	PPG15	0.833	9	0.19	1.71	48.733	83.287	63.087
38.	PPG20	0.567	12	0.27	3.24	17.490	97.420	84.780
39.	PPG25	1.733	21	0.22	4.62	37.518	59.912	61.492
40.	PPS5	0.833	5	0.36	1.8	46.296	28.929	38.456
41.	PPS10	1.367	8	0.36	2.88	47.454	61.646	56.504
42.	PPS15	1.733	10	0.26	2.6	66.667	79.143	54.278
43.	PPS20	1.033	8	0.33	2.64	39.141	86.869	68.938
44.	PPS25	1.567	15	0.29	4.35	36.015	95.385	72.591

FIGURE 4.17: TENSILE STRENGTH LOSS FOR LDPE WITH GROUNDNUT OIL

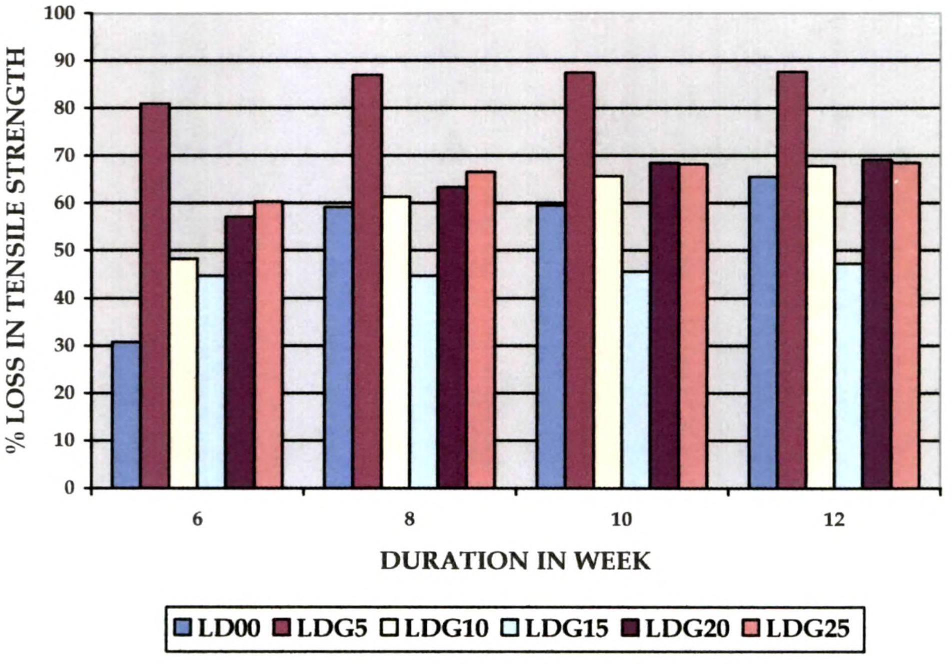
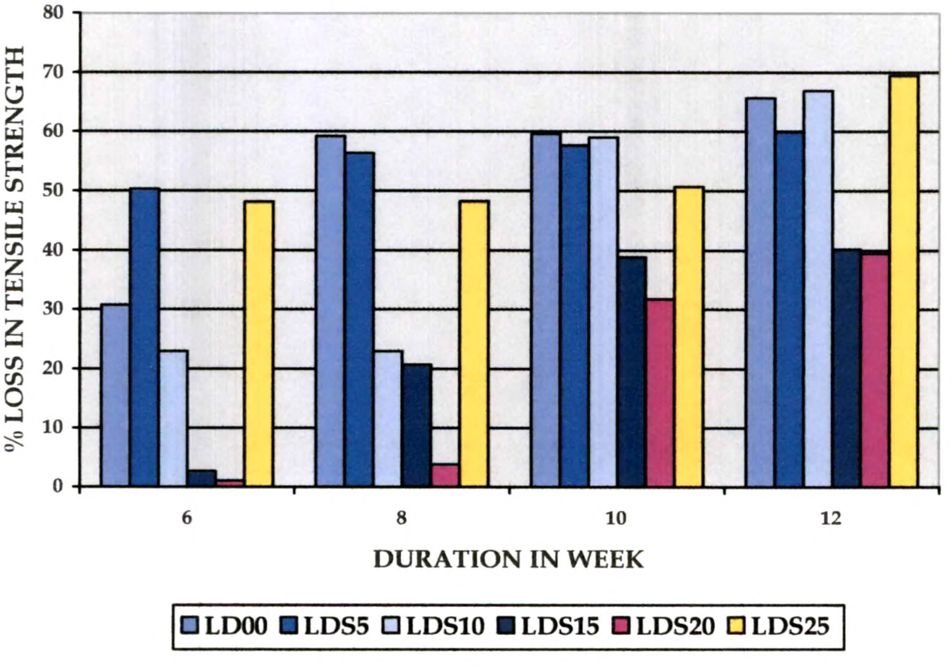
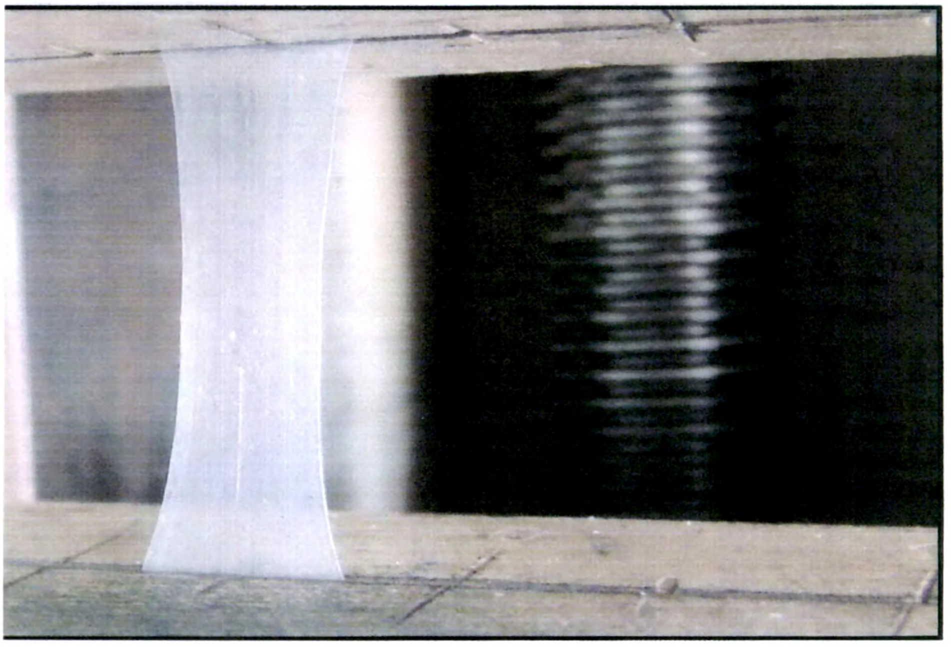


FIGURE 4.18: TENSILE STRENGTH LOSS FOR LDPE WITH SOYBEAN OIL



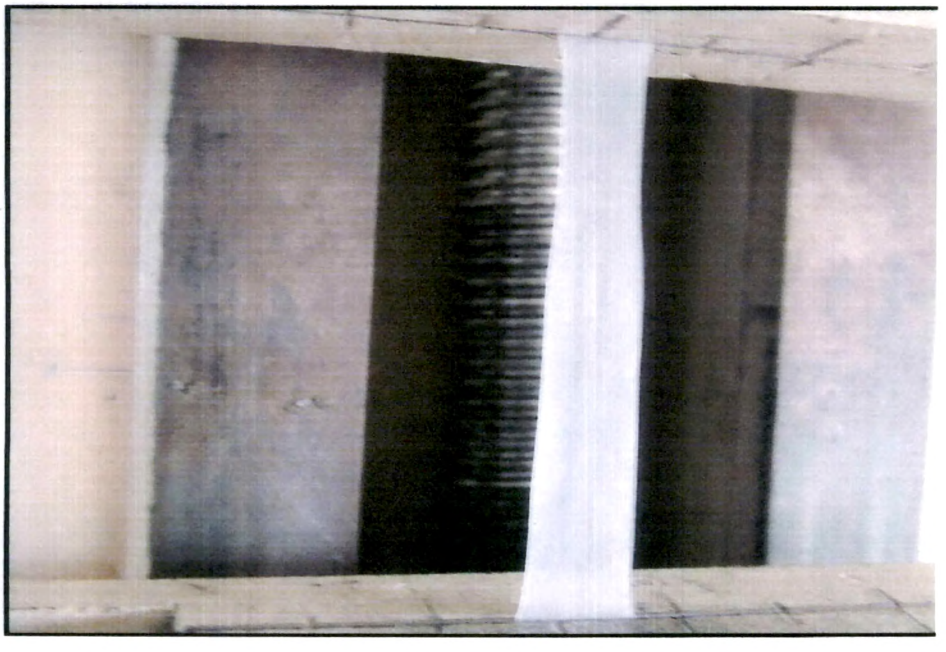
Photograph 4.1:

Failure pattern of LDG25 before being subjected to microorganism: Regular elongation was observed in specimen.



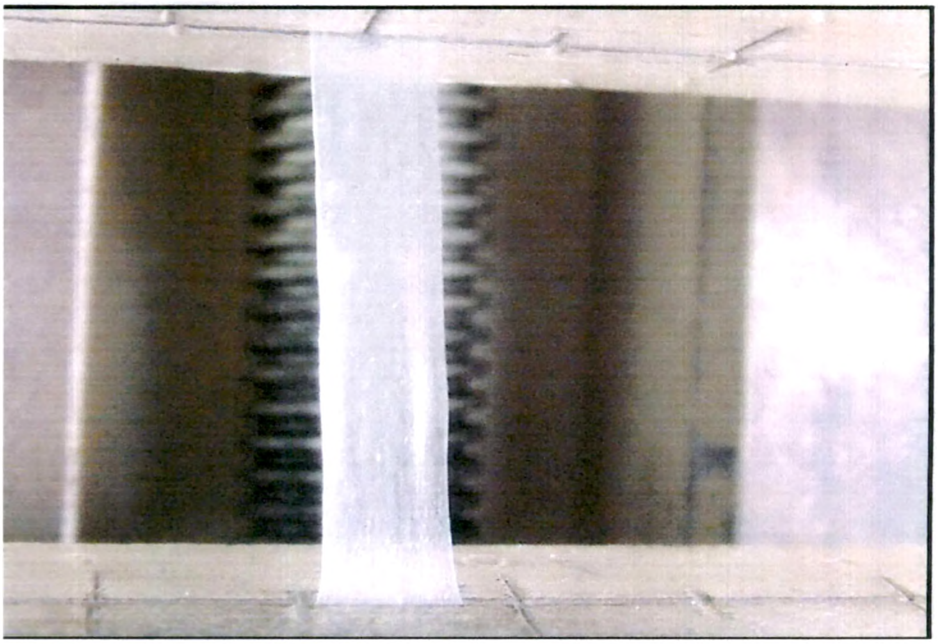
Photograph 4.2:

Failure pattern of LDG25 after 12 weeks of exposure to microorganism: The specimen was elongated near the grip and the middle of the specimen remained un extended. This shows the change in the orientation of polymer chains.



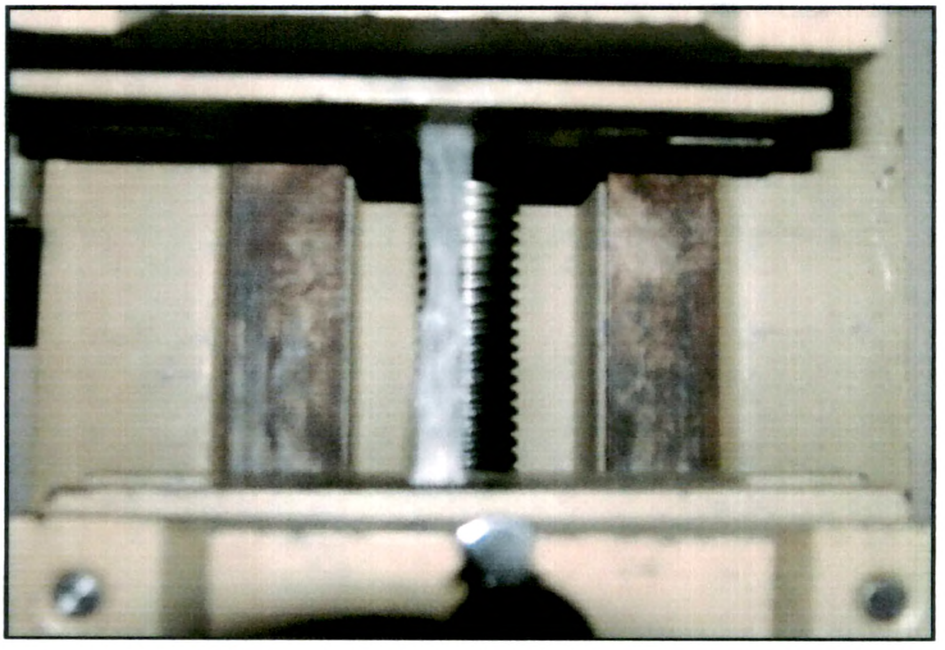
Photograph 4.3:

Failure pattern of LDS10 before being subjected to microorganism: Regular elongation and sag in the middle of specimen shows non uniform thickness in the specimen.



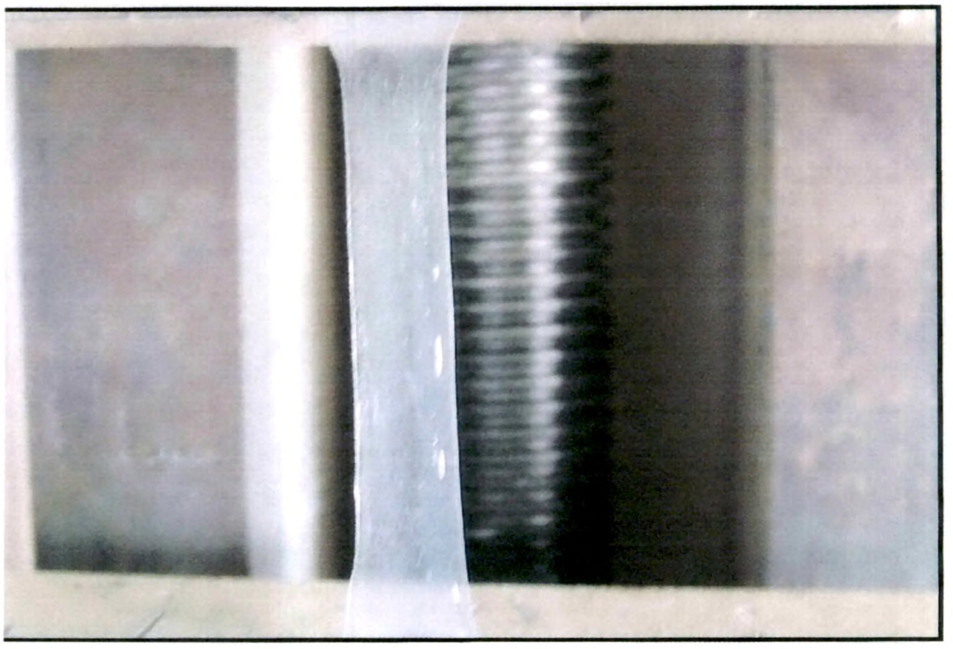
Photograph 4.4:

Failure pattern of LDS10 after 12 weeks of exposure to microorganism: The specimen was elongated from two different portions showing the weak area where the polymer chains were broken.



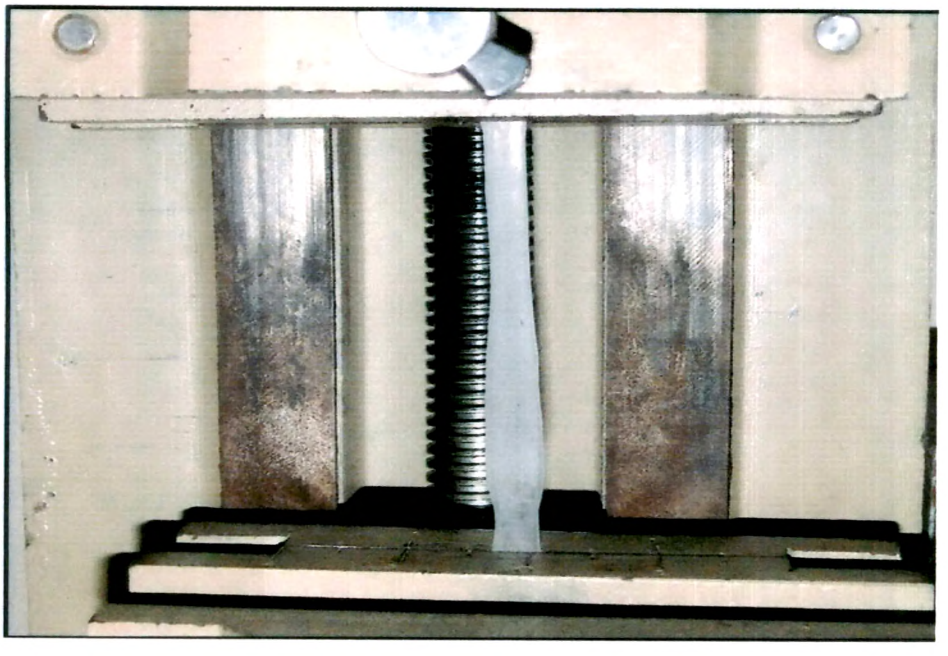
Photograph 4.5:

Failure pattern of LDS15 before being subjected to microorganism



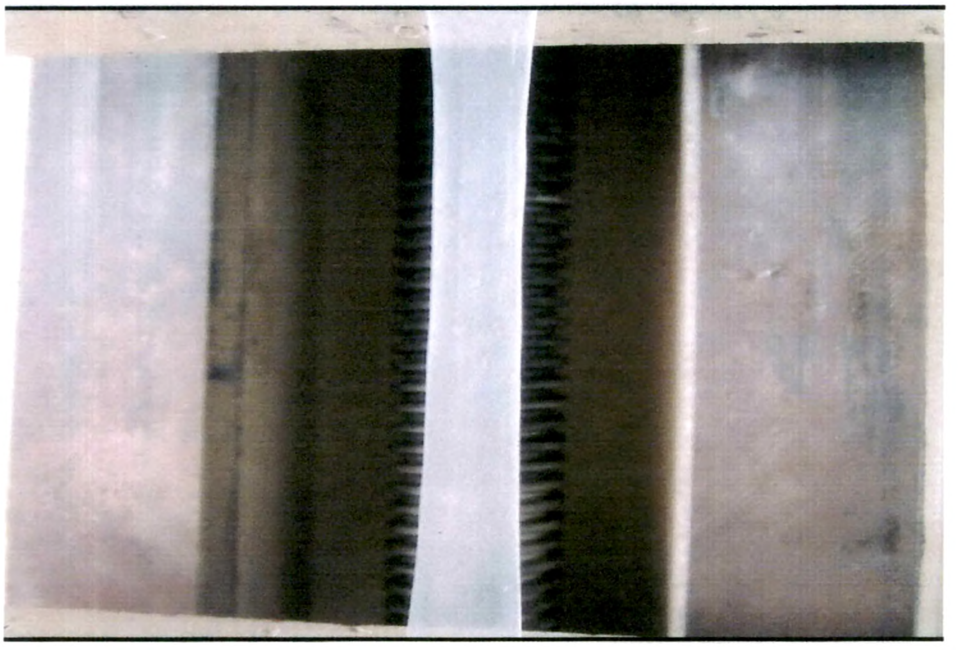
Photograph 4.6:

Failure pattern of LDS15 after 12 weeks of exposure to microorganism: Specific un affected area was clearly seen and the specimen was elongated near the grip. The concentrated effect of microorganism was observed.



Photograph 4.7:

Failure pattern of LDS25 before being subjected to microorganism



Photograph 4.8:

Failure pattern of LDS25 after 12 weeks of exposure to microorganism: A clear line of polymer chain separation due to the consumption of plasticizer was observed.

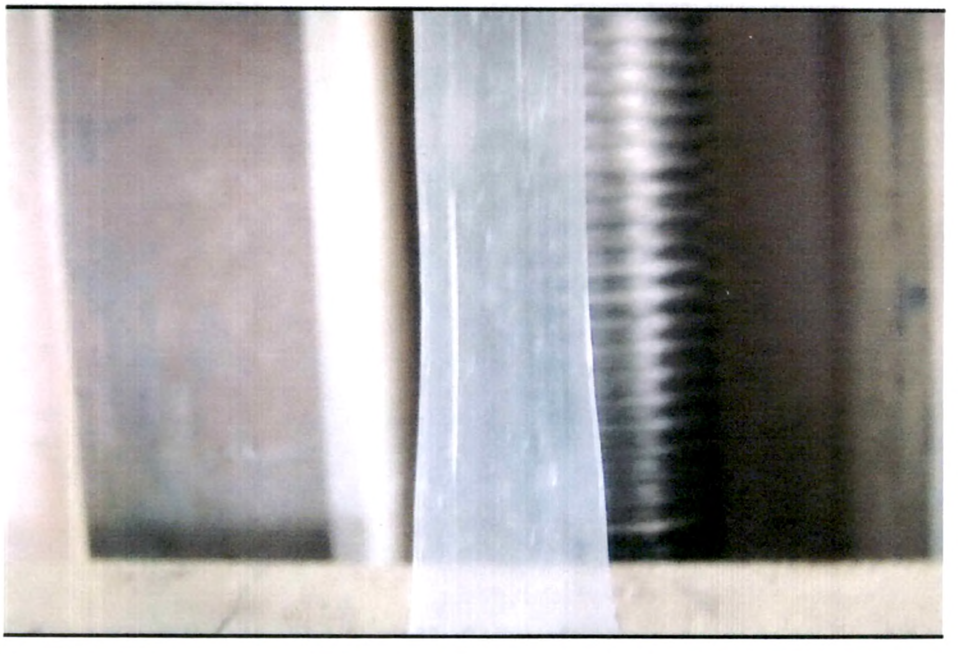


FIGURE 4.19: TENSILE STRENGTH LOSS FOR HDPE WITH GROUNDNUT OIL

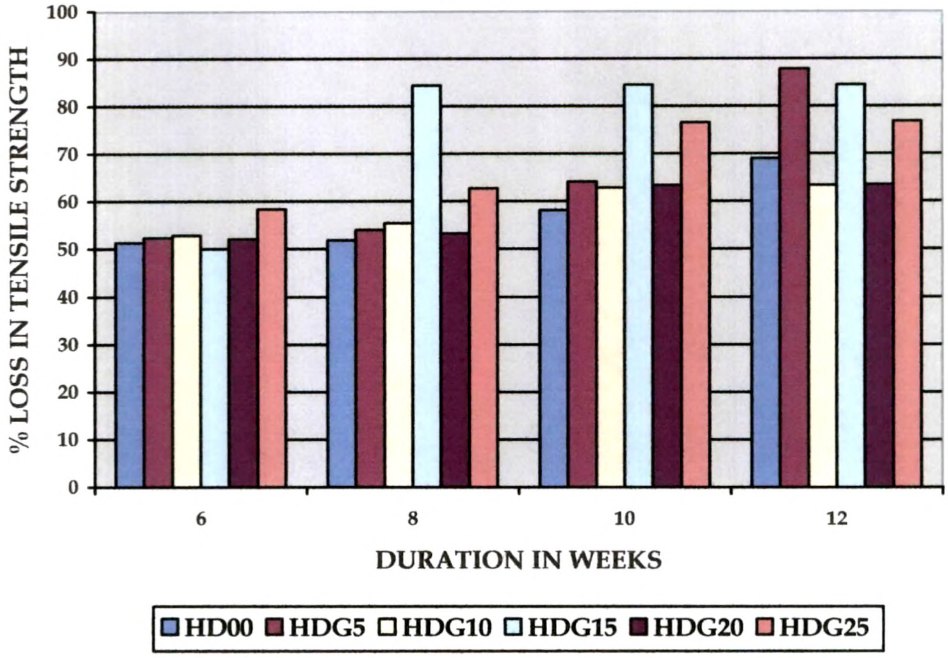
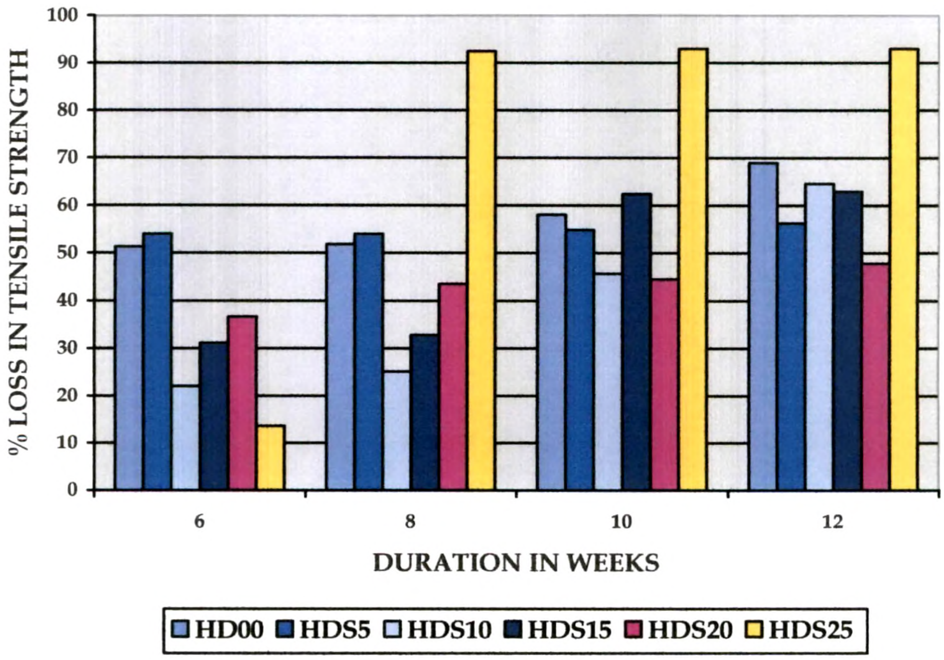
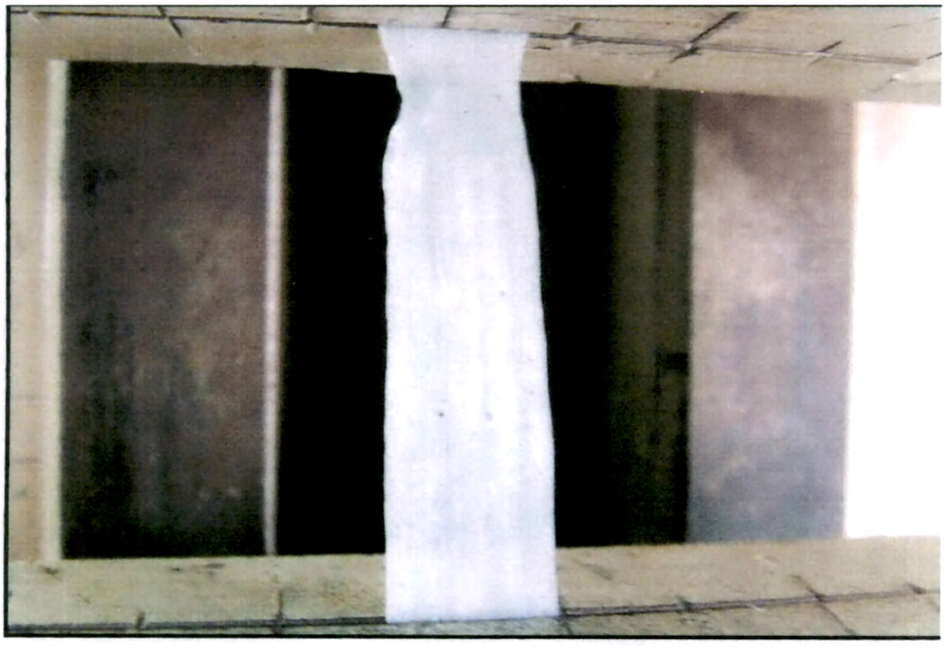


FIGURE 4.20: TENSILE STRENGTH LOSS FOR HDPE WITH SOYBEAN OIL



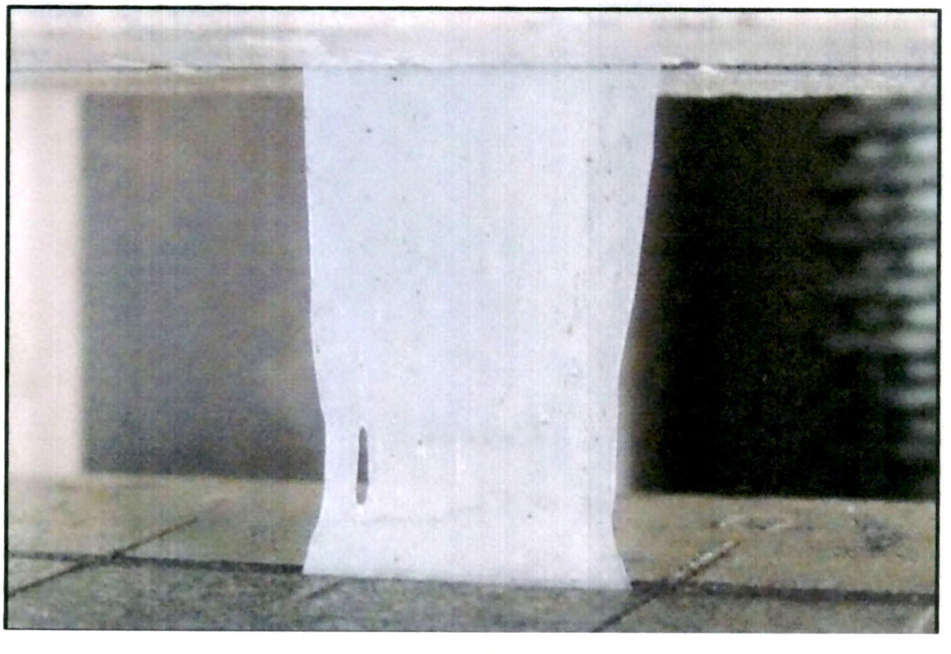
Photograph 4.9:

Failure pattern of HDG25 before being subjected to microorganism



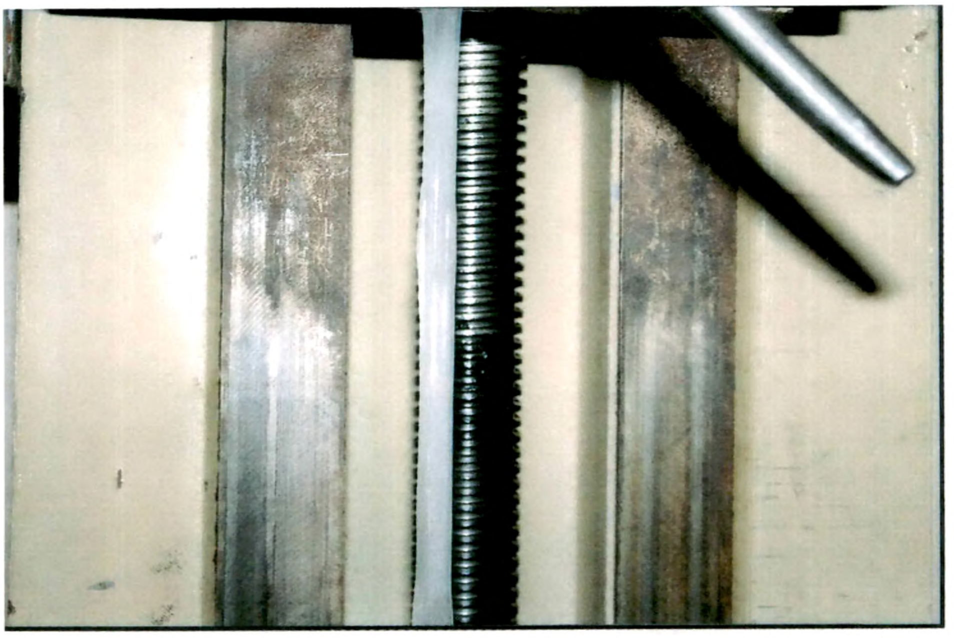
Photograph 4.10:

Failure pattern of HDG25 after 12 weeks of exposure to microorganism: A clear hole showing the concentrated attack of microorganism and an area of elongation was observed.



Photograph 4.11:

Failure pattern of HDS25 before being subjected to microorganism



Photograph 4.12:

Failure pattern of HDS25 after 12 weeks of exposure to microorganism: Thinning of specimen was observed in the specimen. Also the elongation was observed in the thinner transparent portion of the specimen showing the broken polymer chains.

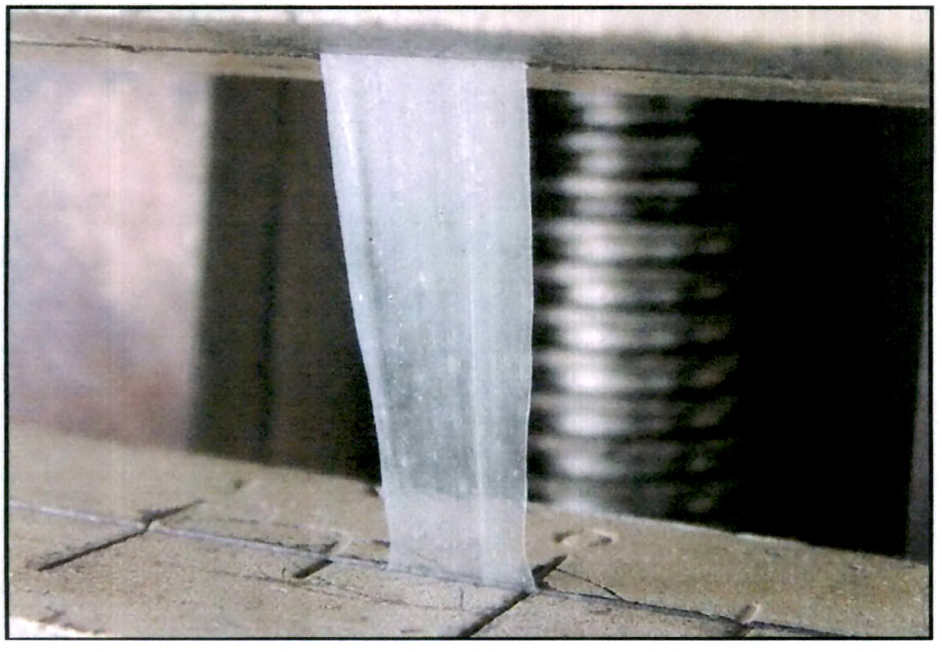


FIGURE 4.21: TENSILE STRENGTH LOSS FOR PS WITH GROUNDNUT OIL

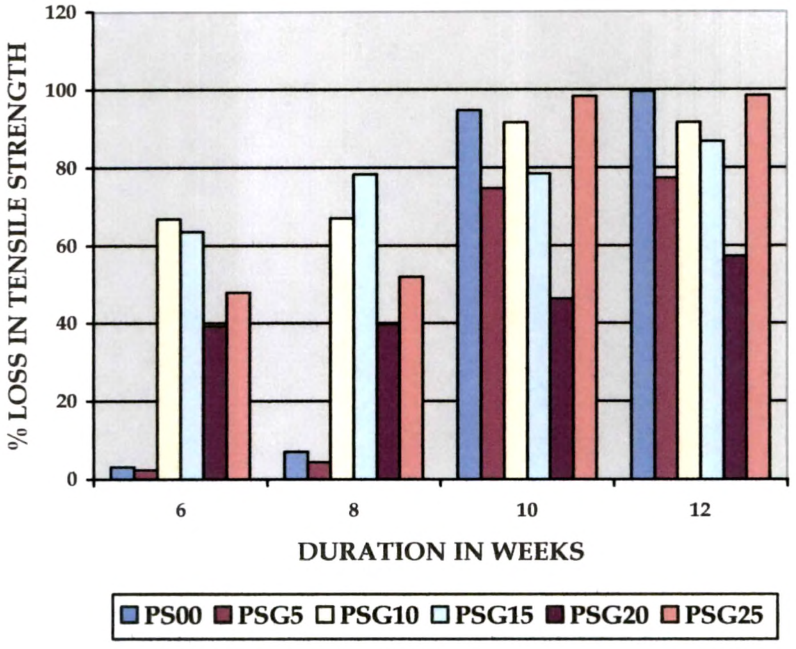
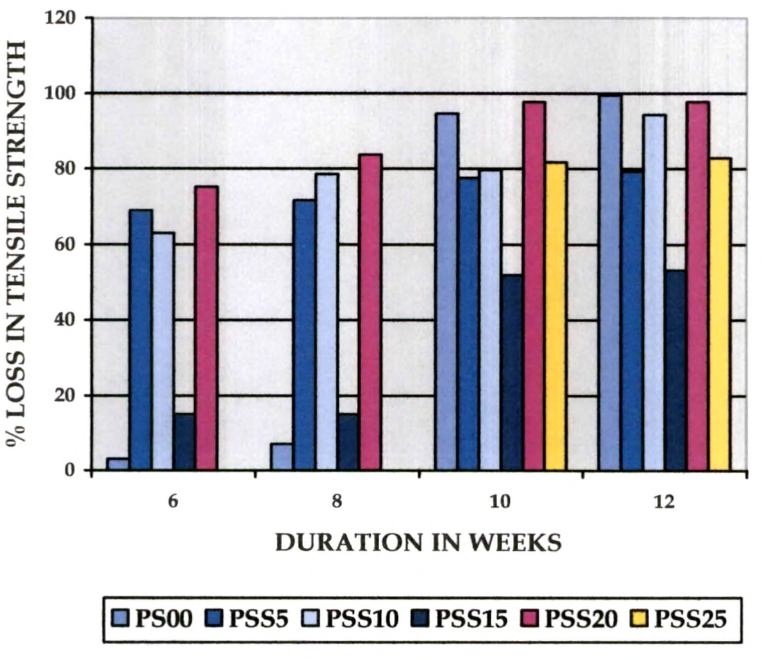
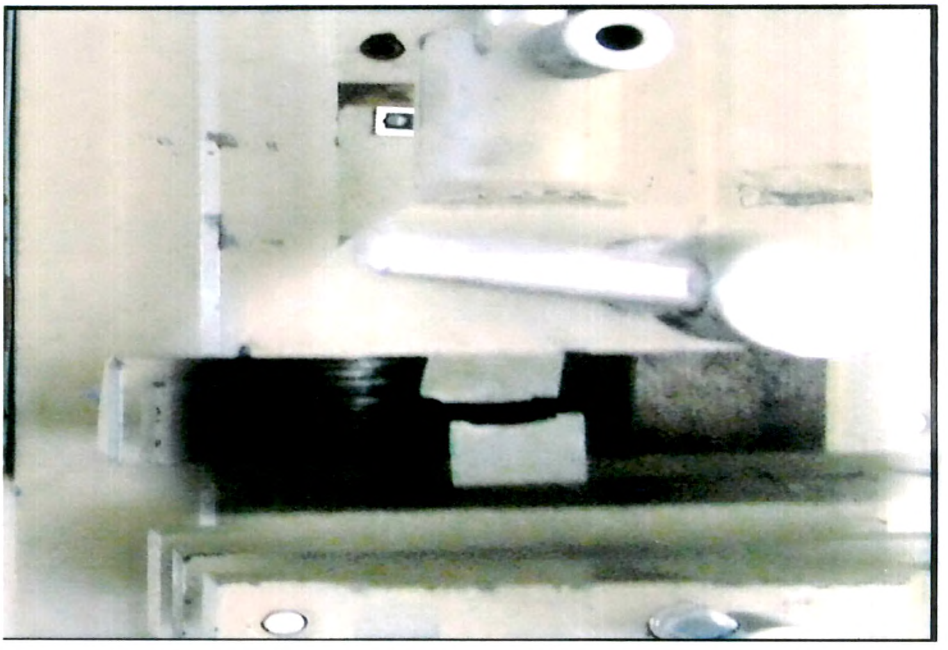


FIGURE 4.22: TENSILE STRENGTH LOSS FOR PS WITH SOYBEAN OIL



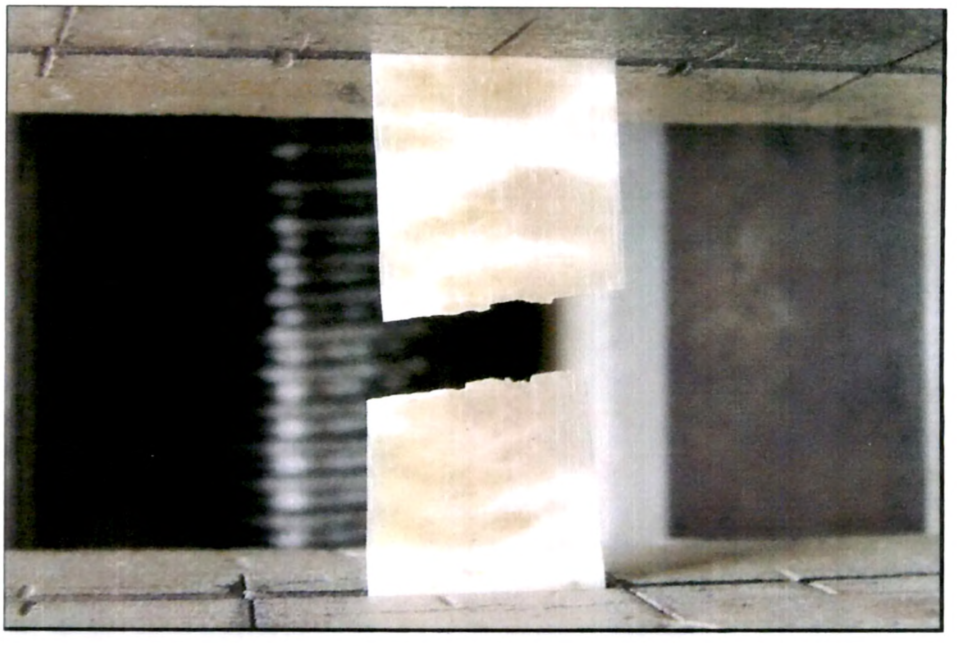
Photograph 4.13:

Failure pattern of PSG15 before being subjected to microorganism: The specimen exhibits lower elongation due to its crystalline structure.



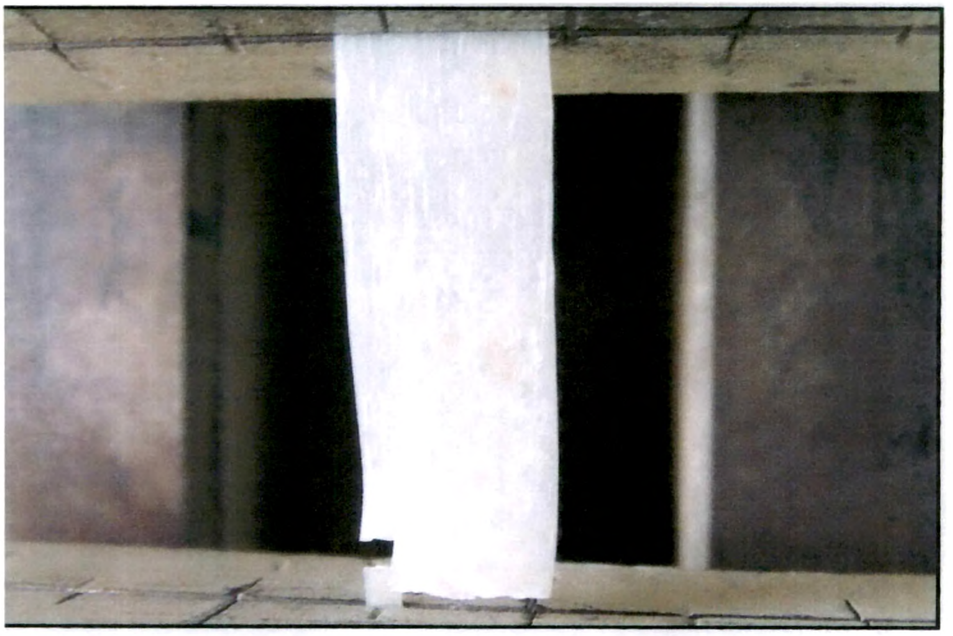
Photograph 4.14:

Failure pattern of PSG15 after 12 weeks of exposure to microorganism: Areas of elongation were clearly seen showing the effect of temperature, moisture and *uv* radiation.



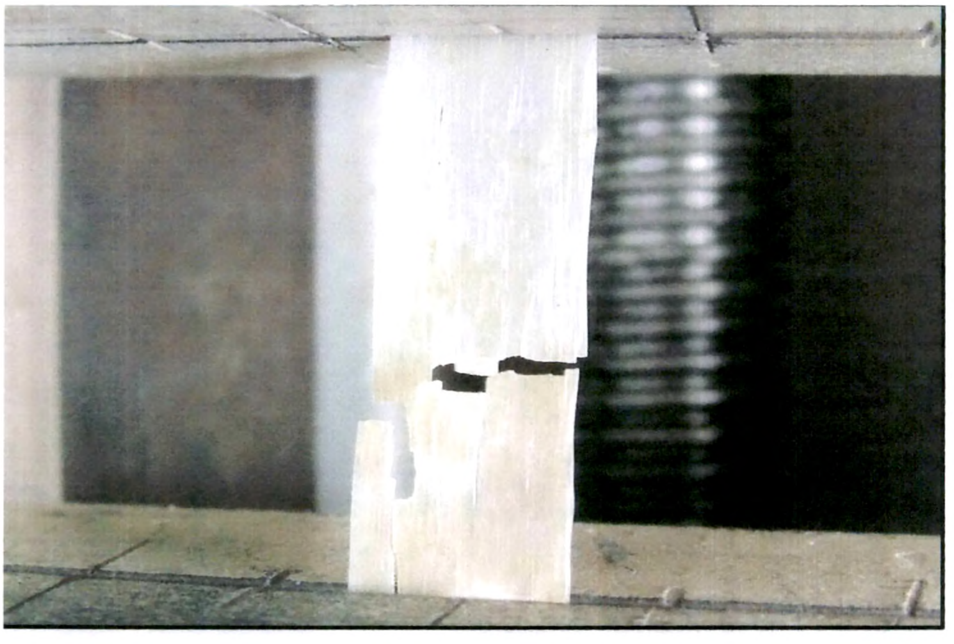
Photograph 4.15:

Failure pattern of PSG25 before being subjected to microorganism



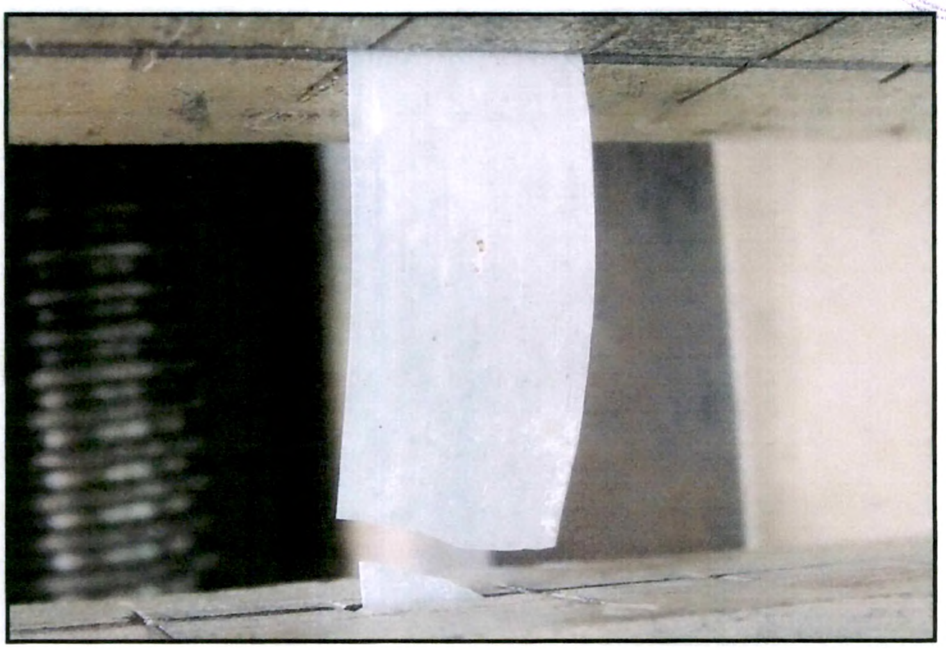
Photograph 4.16:

Failure pattern of PSG25 after 12 weeks of exposure to microorganism: The areas of elongation are not prominent. Crazing in the specimen was observed.



Photograph 4.17:

Failure pattern of PSS25 before being subjected to microorganism



Photograph 4.18:

Failure pattern of PSS25 after 12 weeks of exposure to microorganism: The change in color and thinning of specimen was seen.

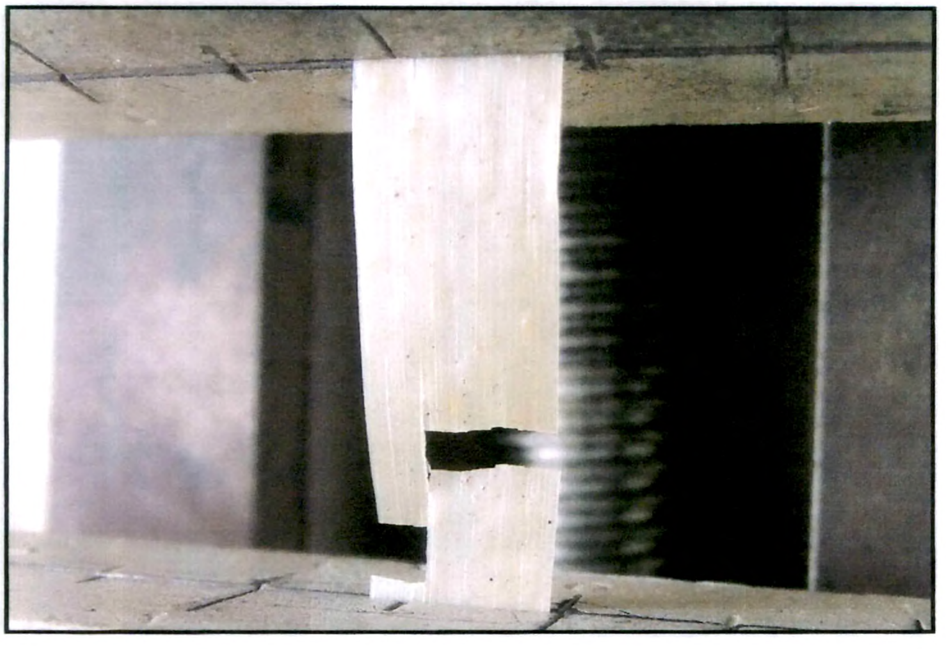


FIGURE 4.23: TENSILE STRENGTH LOSS FOR PP WITH GROUNDNUT OIL

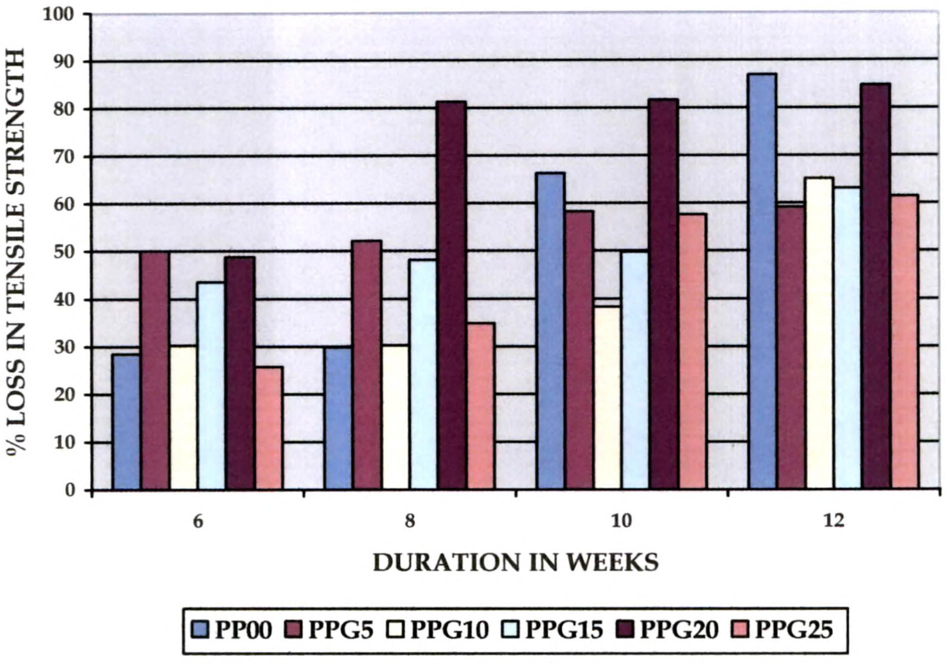
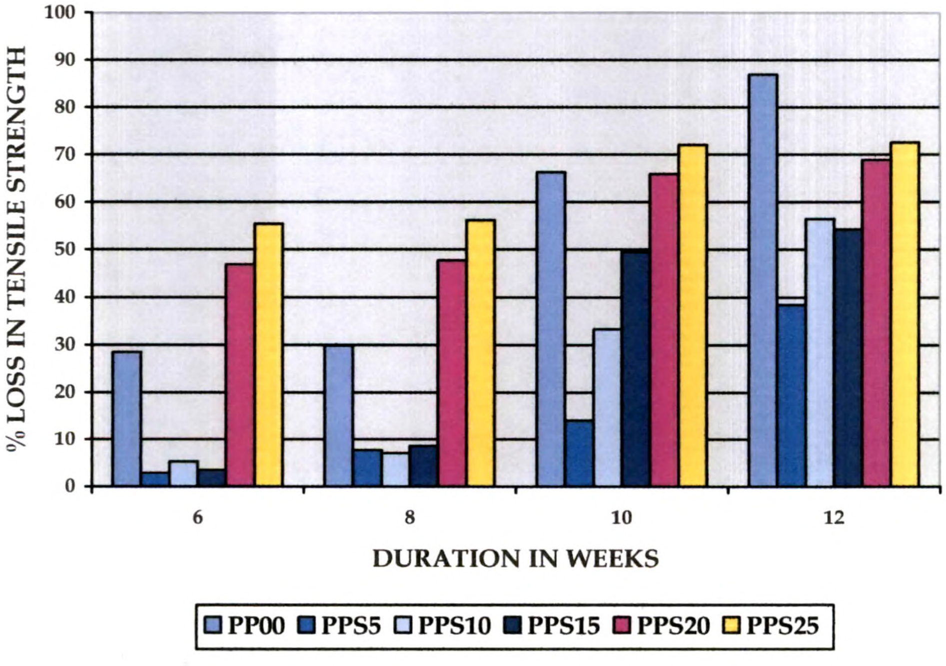
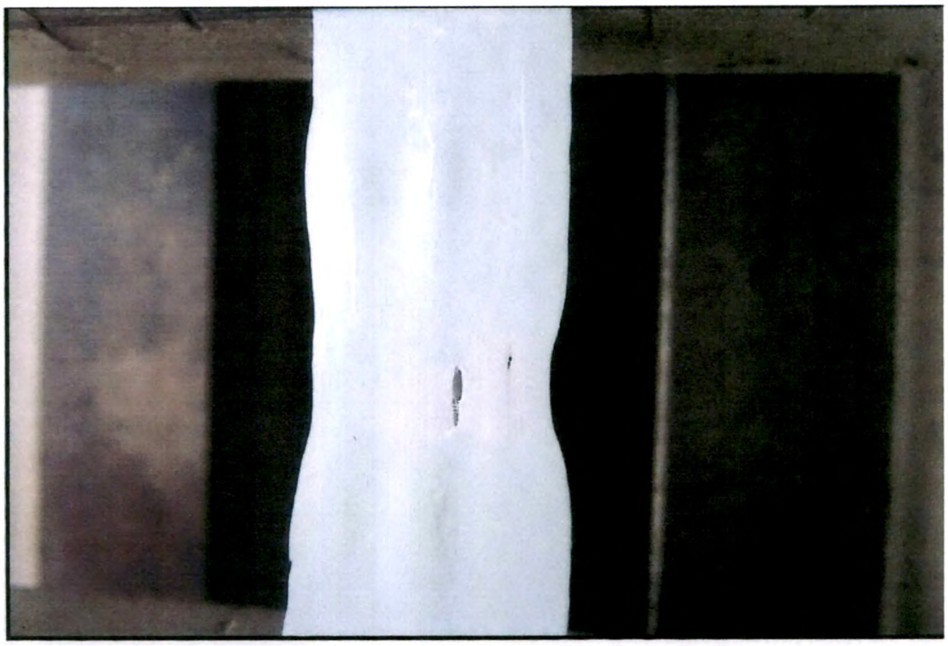


FIGURE 4.24: TENSILE STRENGTH LOSS FOR PP WITH SOYBEAN OIL



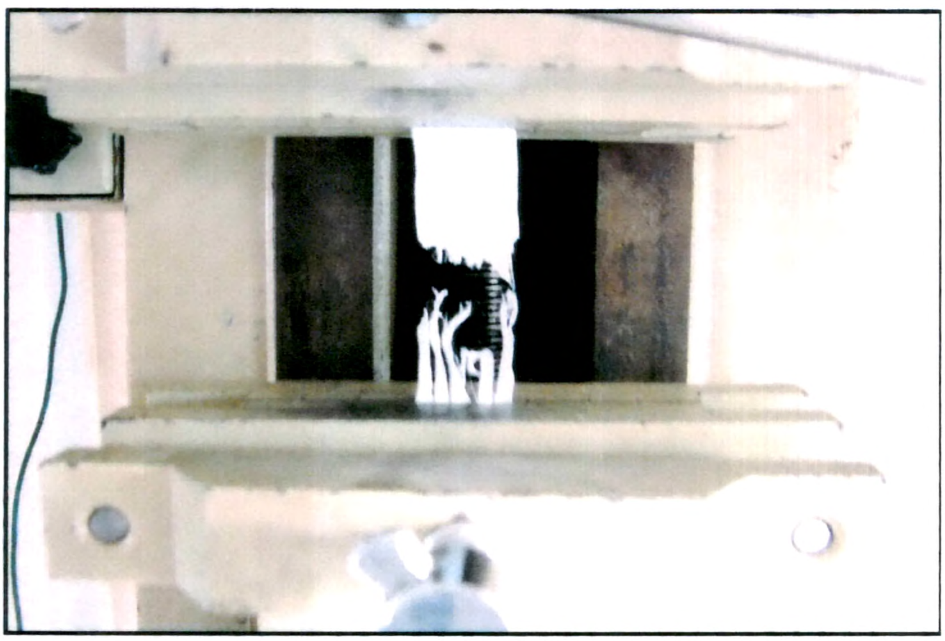
Photograph 4.19:

Failure pattern of PP00 before being subjected to microorganism



Photograph 4.20:

Failure pattern of PP00 after 12 weeks of exposure to microorganism: The adopted microorganism affects the biodegradation of un modified polymer. The chain separation was clearly seen.

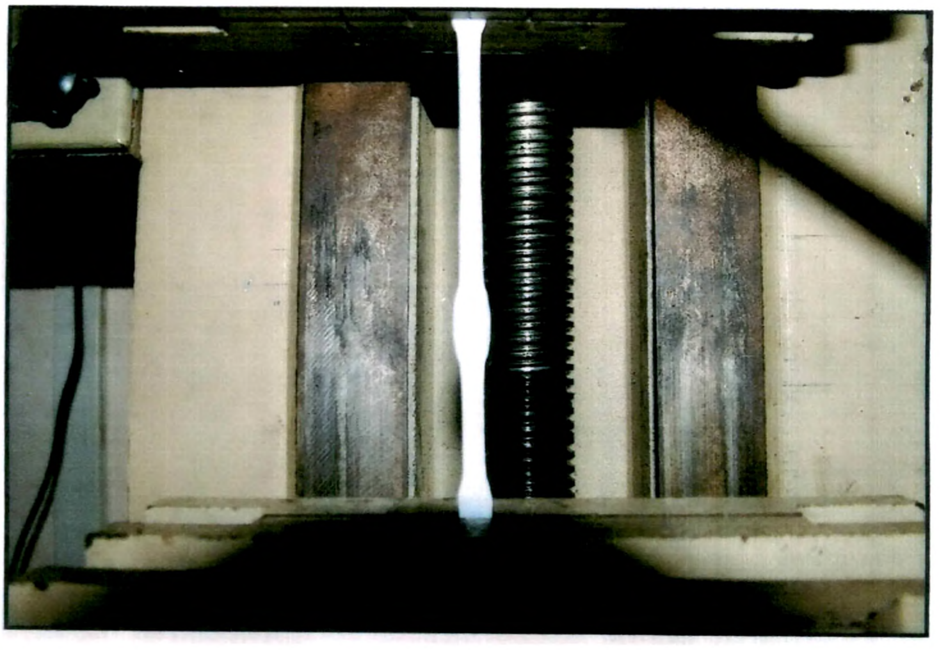


Photograph 4.21:

Failure pattern of PPG15 before being subjected to microorganism

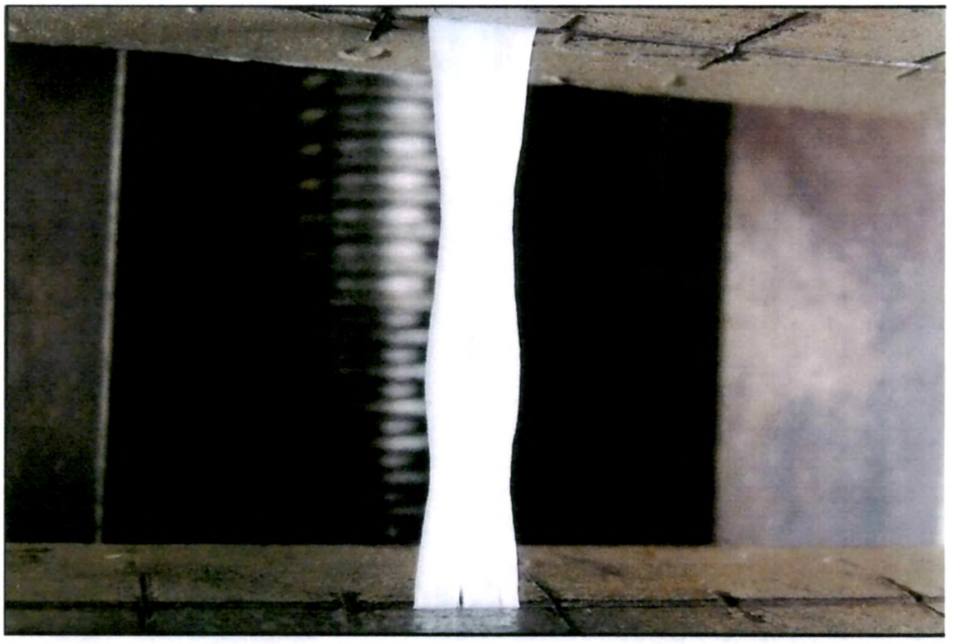
Photograph 4.22:

Failure pattern of PPG15 after 12 weeks of exposure to microorganism: The accumulation of microorganism was clearly seen by area where no elongation was observed.



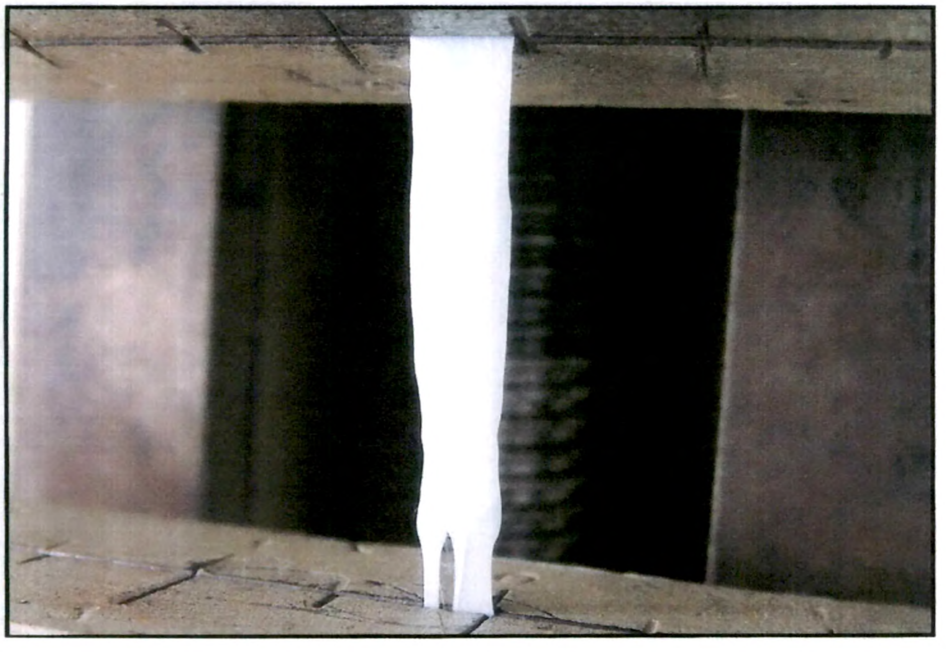
Photograph 4.23:

Failure pattern of PPG25 before being subjected to microorganism



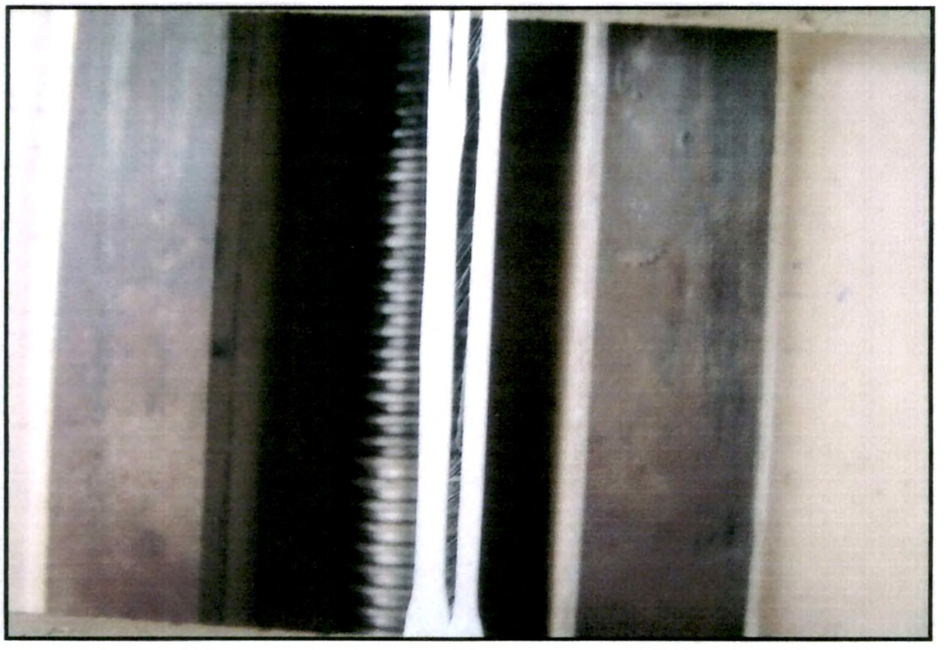
Photograph 4.24:

Failure pattern of PPG25 after 12 weeks of exposure to microorganism: Prominent hole was seen. The chain separation was clearly seen.



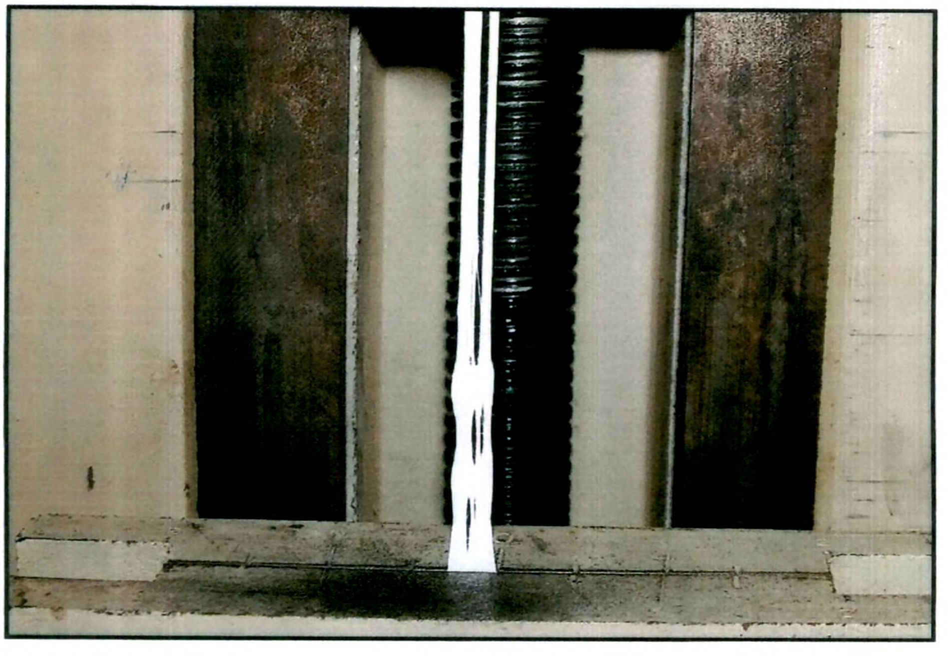
Photograph 4.25:

Failure pattern of PPS20 before being subjected to microorganism



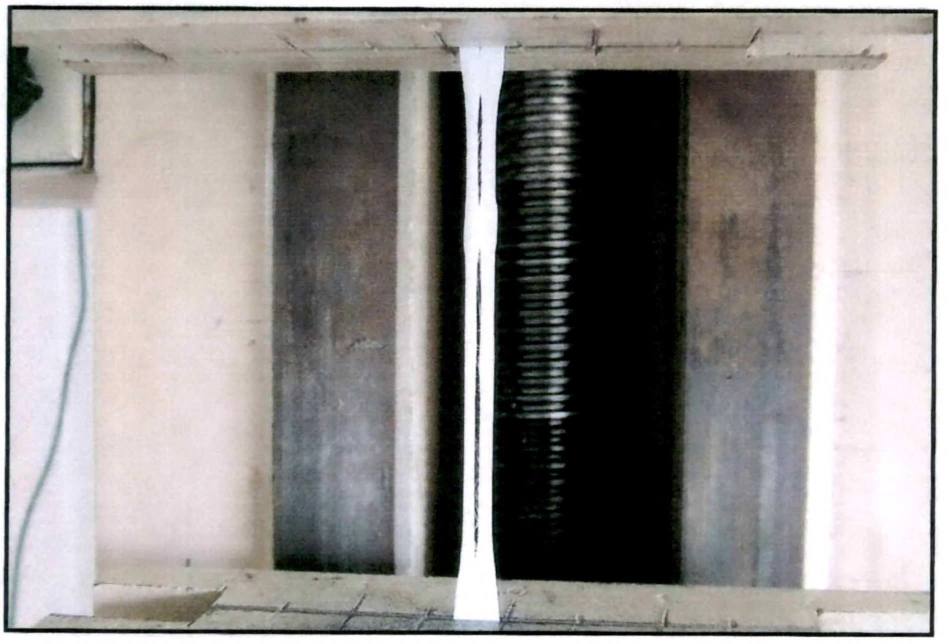
Photograph 4.26:

Failure pattern of PPS20 after 12 weeks of exposure to microorganism: The accumulation of microorganism was clearly seen by area where no elongation was observed. The chain separation was clearly seen.



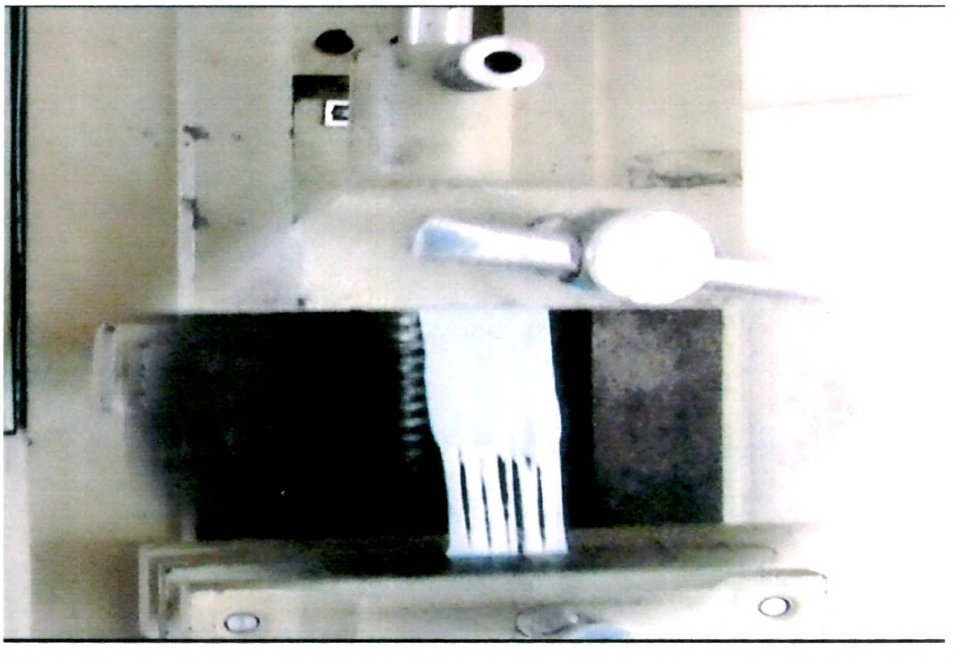
Photograph 4.27:

Failure pattern of PPS25 before being subjected to microorganism



Photograph 4.28:

Failure pattern of PPS25 after 12 weeks of exposure to microorganism: The chain separation was clearly seen.



4.2.3 ANALYSIS AND DISCUSSION FOR LOSS IN TENSILE STRENGTH:

◊The exudation of plasticizer and other addition in the base polymer shows higher loss in tensile strength after six weeks. This loss remains almost constant up to 12 weeks. Thus up to 12 weeks the microorganism consumes the plasticizer molecules from the surface and those between the polymer chains.

◊When the plasticizer between the polymers chains get consumed the polymer chains gets separated exhibiting the loss in tensile strength.

◊The loss in tensile strength observed with un modified specimen after 10/12 weeks was observed with modified specimen after six weeks. This shows that the plasticizer helps the microorganism to reach within the polymer chain/matrix.

◊After consumption of plasticizer the microorganism approaches/reaches the polymer chain and a sudden fragmentation/loss in tensile strength was observed after 12 weeks.

◊The fragmentation of the un modified specimen and the breakage of nylon filament was also observed. Thus it can be inferred that the microorganism gets adopted within 12 weeks and can affect the degradability of the un modified polymers also.

◊It would be interesting to identify the specie and structure of the microorganism affecting the biodegradation of the polymer.

4.2.1.c RESULT FOR PERCENT ELONGATION LOSS:

The specimens were removed from the bowl after six, eight, ten and twelve weeks. They were separated from the nylon filament, washed and allowed to dry for one day. The specimens were weighed up to .01 mg precision. The specimens were tested for tensile strength on semi automatic tensile testing machine wherein the initial length and the final length were measured manually. The ratio of difference in length and initial length was recorded as loss in tensile elongation. The specimens after failure were collected for further testing of viscosity.

TABLE 4.12: PERCENT ELONGATION LOSS AFTER 6 WEEKS:

Sr.no.	Specimen	Initial Elongation mm	L2 mm	L1 mm	Percent Elongation (L2-L1)*100/L1	Loss
1.	LD00	100	79	50	58	42
2.	LDG5	175	126	50	152	23
3.	LDG10	160	114	50	128	32
4.	LDG15	240	142	50	184	56
5.	LDG20	290	140	50	180	110
6.	LDG25	210	120	50	140	70
7.	LDS5	145	115	50	130	15
8.	LDS10	540	281	50	462	78
9.	LDS15	87	87	50	74	13
10.	LDS20	160	126	50	152	8
11.	LDS25	722	305	50	510	212
12.	HD00	407	115	50	130	277
13.	HDG5	635.31	86	50	72	563.31
14.	HDG10	472	91	50	82	390
15.	HDG15	516	65	50	30	486
16.	HDG20	99	96	50	92	7
17.	HDG25	630	92	50	84	546
18.	HDS5	50	74	50	48	2
19.	HDS10	64	78	50	56	8
20.	HDS15	460	123	50	146	314
21.	HDS20	620	90	50	80	540
22.	HDS25	168	111	50	122	46
23.	PS00	1.007	42	30	40	-38.993
24.	PSG5	2.116	53	50	6	-3.884
25.	PSG10	1.396	53	50	6	-4.605
26.	PSG15	2.019	52	50	4	-1.982

27.	PSG20	1.480	54	50	8	-6.520
28.	PSG25	2.284	53	50	6	-3.716
29.	PSS5	1.973	53	50	6	-4.027
30.	PSS10	3.428	26	25	4	-0.572
31.	PSS15	2.168	51	50	2	0.168
32.	PSS20	1.878	51	50	2	-0.122
33.	PSS25	1.142	51	50	2	-0.858
34.	PP00	226.786	90	50	80	146.786
35.	PPG5	650	113	50	126	524
36.	PPG10	540	280	50	460	80
37.	PPG15	776.5	320	50	540	236.5
38.	PPG20	370	235	50	370	0
39.	PPG25	1075	510	50	920	155
40.	PPS5	536.36	263	50	426	110.36
41.	PPS10	1076.9	551	50	1002	74.9
42.	PPS15	1327.6	583	50	1066	261.6
43.	PPS20	1058.33	545	50	990	68.33
44.	PPS25	1285.4	440	50	780	505.4

TABLE 4.13: PERCENT ELONGATION LOSS AFTER 8 WEEKS:

Sr.no.	Specimen	Initial Elongation mm	L2 mm	L1 mm	Percent Elongation (L2-L1)*100/L1	Loss
1.	LD00	100	79	50	58	42
2.	LDG5	175	120	50	140.000	35.000
3.	LDG10	160	113	50	126.000	34.000
4.	LDG15	240	140	50	180.000	60.000
5.	LDG20	290	92	42	119.048	170.952
6.	LDG25	210	75	40	87.500	122.500
7.	LDS5	145	95	50	90.000	55.000

8.	LDS10	540	242	50	384.000	156.000
9.	LDS15	87	86	50	72.000	15.000
10.	LDS20	160	125	50	150.000	10.000
11.	LDS25	722	81	32	153.125	568.875
12.	HD00	407	41	31	32.258	374.742
13.	HDG5	635.31	55	32	71.875	563.435
14.	HDG10	472	68	38	78.947	393.053
15.	HDG15	516	58	45	28.889	487.111
16.	HDG20	99	50	45	11.111	87.889
17.	HDG25	630	55	30	83.333	546.667
18.	HDS5	50	65	50	30.000	20.000
19.	HDS10	64	74	50	48.000	16.000
20.	HDS15	460	84	41	104.878	355.122
21.	HDS20	620	60	35	71.429	548.571
22.	HDS25	168	109	50	118.000	50.000
23.	PS00	1.007	31	25	24.000	-22.993
24.	PSG5	2.116	18	17	5.882	-3.766
25.	PSG10	1.396	22	21	4.762	-3.366
26.	PSG15	2.019	27	26	3.846	-1.828
27.	PSG20	1.480	30	29	3.448	-1.968
28.	PSG25	2.284	35	34	2.941	-0.657
29.	PSS5	1.973	38	36	5.556	-3.583
30.	PSS10	3.428	20	18	11.111	-7.684
31.	PSS15	2.168	34	32	6.250	-4.082
32.	PSS20	1.878	36	34	5.882	-4.004
33.	PSS25	1.142	31	28	10.714	-9.573
34.	PP00	226.786	70	30	133.333	93.452
35.	PPG5	650	47	35	34.286	615.714
36.	PPG10	540	274	50	448.000	92.000
37.	PPG15	776.5	318	50	536.000	240.500

161

38.	PPG20	370	177	50	254.000	116.000
39.	PPG25	1075	509	50	918.000	157.000
40.	PPS5	536.36	261	50	422.000	114.360
41.	PPS10	1076.9	545	50	990.000	86.900
42.	PPS15	1327.6	581	50	1062.000	265.600
43.	PPS20	1058.33	544	50	988.000	70.330
44.	PPS25	1285.4	435	50	770.000	515.400

TABLE 4.14: PERCENT ELONGATION LOSS AFTER10 WEEKS:

Sr.no.	Specimen	Initial Elongation mm	L2 mm	L1 mm	Percent Elongation (L2-L1)*100/L1	Loss
1.	LD00	100	38	35	8.571	91.429
2.	LDG5	175	50	21	138.095	36.905
3.	LDG10	160	78	35	122.857	37.143
4.	LDG15	240	100	36	177.778	62.222
5.	LDG20	290	71	33	115.152	174.848
6.	LDG25	210	58	32	81.25	128.75
7.	LDS5	145	56	30	86.66667	58.333
8.	LDS10	540	191	40	377.5	162.5
9.	LDS15	87	43	26	65.385	21.615
10.	LDS20	160	73	30	143.333	16.667
11.	LDS25	722	87	35	148.571	573.429
12.	HD00	407	39	30	30.000	377.000
13.	HDG5	635.31	44	38	15.789	619.521
14.	HDG10	472	58	34	70.588	401.412
15.	HDG15	516	48	38	26.316	489.684
16.	HDG20	99	28	26	7.692	91.308
17.	HDG25	630	55	31	77.419	552.581
18.	HDS5	50	50	39	28.205	21.795

19.	HDS10	64	34	23	47.826	16.174
20.	HDS15	460	77	38	102.632	357.368
21.	HDS20	620	50	35	42.857	577.143
22.	HDS25	168	40	25	60	108
23.	PS00	1.007	35	32	9.375	-8.368
24.	PSG5	2.116	39	37	5.405	-3.289
25.	PSG10	1.396	42	40	5	-3.605
26.	PSG15	2.019	42	40	5	-2.982
27.	PSG20	1.480	38	34	11.765	-10.285
28.	PSG25	2.284	25	24	4.167	-1.883
29.	PSS5	1.973	20	18	11.111	-9.138
30.	PSS10	3.428	23	20	15	-11.572
31.	PSS15	2.168	34	31	9.677	-7.509
32.	PSS20	1.878	19	17	11.765	-9.886
33.	PSS25	1.142	19	18	5.556	-4.41386
34.	PP00	226.786	42	21	100	126.786
35.	PPG5	650	56	44	27.273	622.727
36.	PPG10	540	168	31	441.935	98.065
37.	PPG15	776.5	139	22	531.818	244.682
38.	PPG20	370	66	22	200	170
39.	PPG25	1075	223	22	913.6364	161.3636
40.	PPS5	536.36	108	21	414.2857	122.0743
41.	PPS10	1076.9	71	15	373.333	703.567
42.	PPS15	1327.6	289	25	1056	271.6
43.	PPS20	1058.33	430	40	975	83.33
44.	PPS25	1285.4	195	23	747.8261	537.5739

TABLE 4.15: PERCENT ELONGATION LOSS AFTER 12 WEEKS:

Sr.no.	Specimen	Initial Elongation mm	L2 mm	L1 mm	Percent Elongation (L2-L1)*100/L1	Loss
1.	LD00	100	50	48	4.167	95.833
2.	LDG5	175	91	39	133.333	41.667
3.	LDG10	160	65	30	116.6667	43.333
4.	LDG15	240	111	40	177.5	62.5
5.	LDG20	290	95	45	111.111	178.889
6.	LDG25	210	69	40	72.5	137.5
7.	LDS5	145	72	40	80	65
8.	LDS10	540	171	36	375.000	165.000
9.	LDS15	87	64	40	60	27
10.	LDS20	160	90	37	143.243	16.757
11.	LDS25	722	98	40	145	577
12.	HD00	407	46	36	27.778	379.222
13.	HDG5	635.31	64	56	14.286	621.024
14.	HDG10	472	81	48	68.750	403.250
15.	HDG15	516	54	43	25.581	490.418
16.	HDG20	99	53	50	6	93
17.	HDG25	630	70	40	75	555
18.	HDS5	50	57	45	26.667	23.333
19.	HDS10	64	58	40	45	19
20.	HDS15	460	86	55	56.364	403.636
21.	HDS20	620	65	46	41.304	578.696
22.	HDS25	168	74	39	89.744	78.256
23.	PS00	1.007	48	42	14.286	-13.278
24.	PSG5	2.116	36	30	20	-17.884
25.	PSG10	1.396	41	36	13.889	-12.493
26.	PSG15	2.019	45	41	9.756	-7.738

27.	PSG20	1.480	49	45	8.889	-7.409
28.	PSG25	2.284	52	49	6.122	-3.839
29.	PSS5	1.973	54	52	3.846	-1.873
30.	PSS10	3.428	21	19	10.526	-7.099
31.	PSS15	2.168	32	30	6.667	-4.498
32.	PSS20	1.878	35	32	9.375	-7.497
33.	PSS25	1.142	36	35	2.857	-1.715
34.	PP00	226.786	73	37	97.297	129.488
35.	PPG5	650	36	29	24.138	625.862
36.	PPG10	540	161	30	436.667	103.333
37.	PPG15	776.5	157	25	528	248.5
38.	PPG20	370	80	27	196.296	173.704
39.	PPG25	1075	260	28	828.571	246.429
40.	PPS5	536.36	143	28	410.7143	125.646
41.	PPS10	1076.9	151	32	371.875	705.025
42.	PPS15	1327.6	231	20	1055	272.6
43.	PPS20	1058.33	279	26	973.0769	85.25308
44.	PPS25	1285.4	219	26	742.3077	543.092

4.2.4 ANALYSIS AND DISCUSSION FOR PERCENT ELONGATION LOSS:

◊The loss in percent elongation with most of the specimen was remarkable. Due to biodegradation the chains have broken in to small pieces.

◊The loss in percent elongation was significant and range from above 500 to 700 during the span of 12 weeks. Hence the initial reduction of elongation was observed after 6 weeks and then after 12 weeks sudden fragmentation was observed due to the consumption of plasticizer from the polymer matrix. This was observed as in PPG25 where the loss in percent elongation remains almost constant at @ 150 up to 10 weeks and than it increases to @250.

◊Plasticizer had increased the polymer's flexibility, elongation or ease of processing (workability). The chains could move more freely relative to one another, and the stiffness of the polymer is reduced.(Ch. II 2.1.3)

◊Due to the consumption of plasticizer within the chains the space between the chains was increased hence the elongation was increased with PS. Then the fragmentation of polymer was sudden.

◊With other polymers viz. LDPE, HDPE and PP the consumption of plasticizer resulted in breakage of chain. Hence the elongation was reduced.

◊The initial percent elongation was measured by automatic tensile testing machine. The subsequent results were measured on semi automatic tensile testing machine wherein the initial length and the final length were measured manually. Since the PS material itself is brittle in nature, the measurement in change in elongation requires very precise tensile testing machine. Hence the measurement error could be possible with the results of PS.

FIGURE 4.25:LOSS IN PERCENT ELONGATION FOR LDPE WITH GROUNDNUT OIL

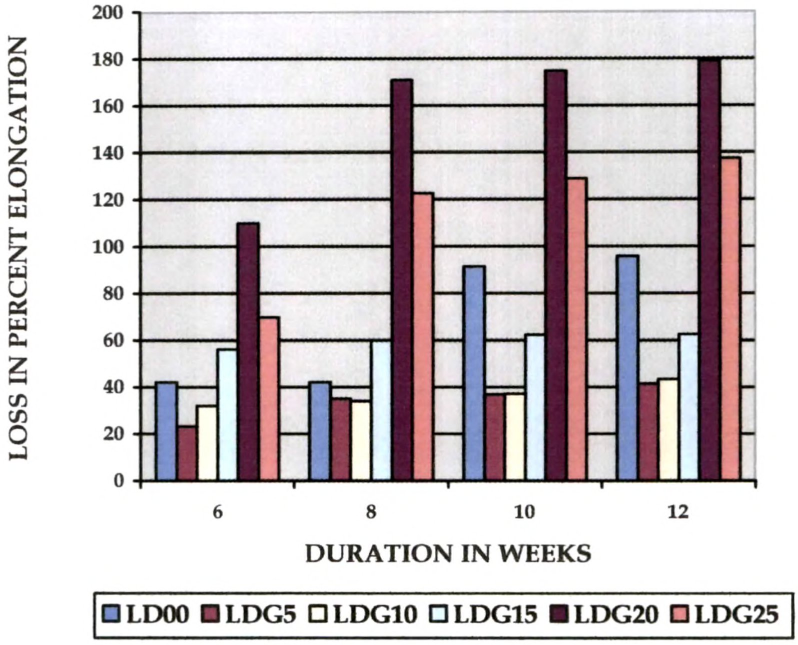


FIGURE 4.26:LOSS IN PERCENT ELONGATION FOR LDPE WITH SOYBEAN OIL

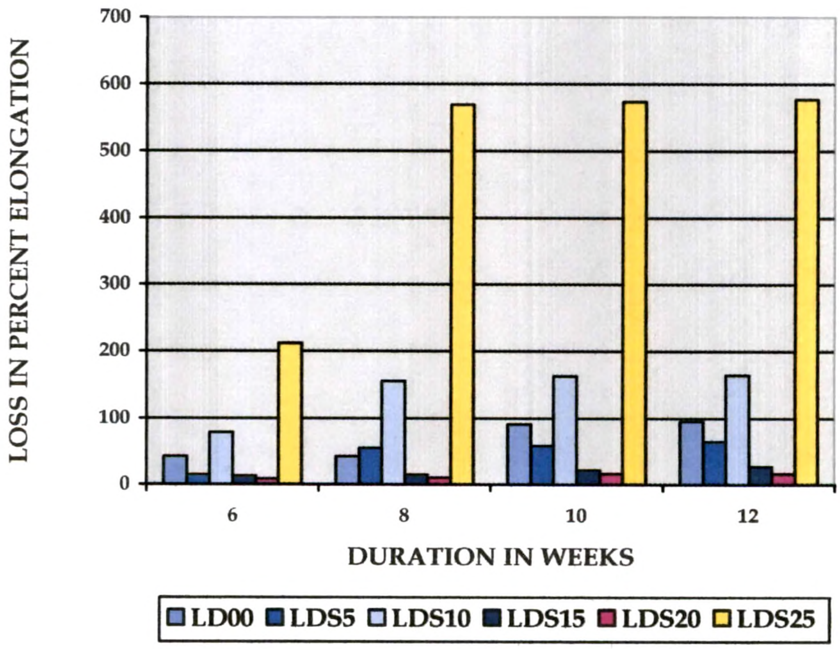


FIGURE 4.27: LOSS INPERCENT ELONGATION FOR HDPE WITH GROUNDNUT OIL

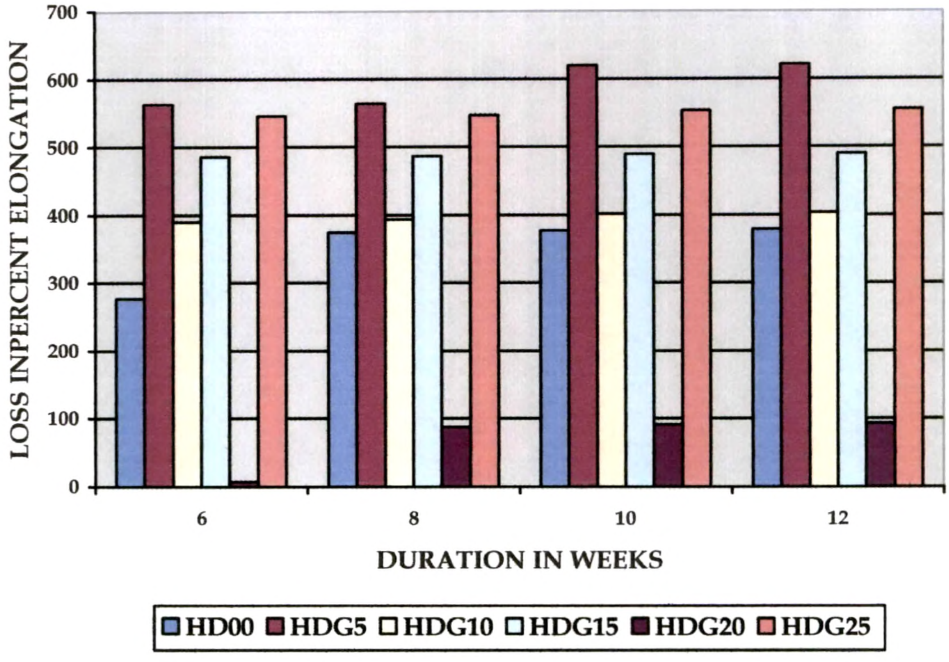


FIGURE 4.28: LOSS INPERCENT ELONGATION FOR HDPE WITH SOYBEAN OIL

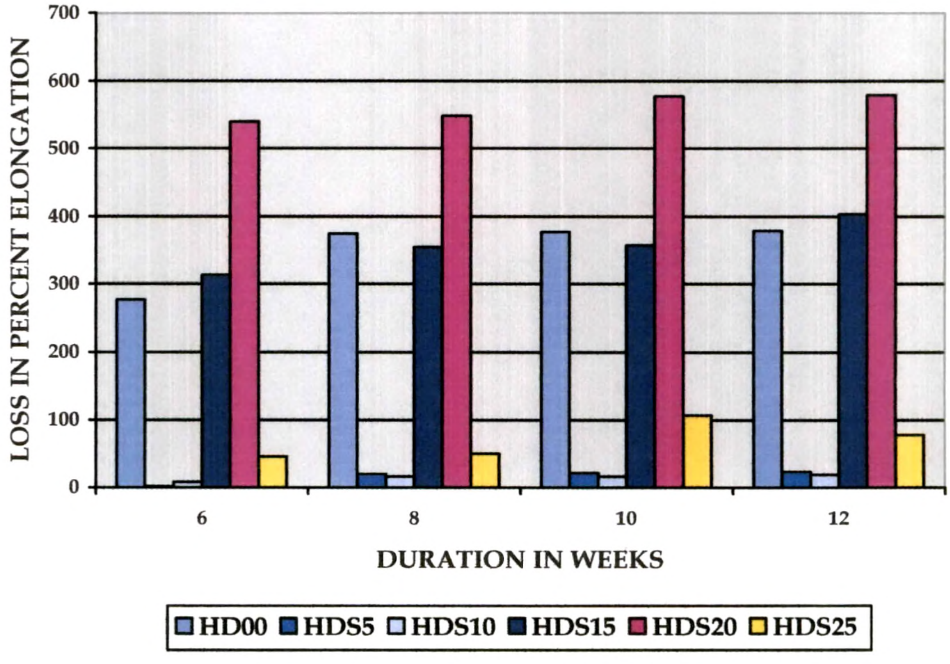


FIGURE 4.29: LOSS IN PERCENTELONGATION FOR PS WITH GROUNDNUT OIL

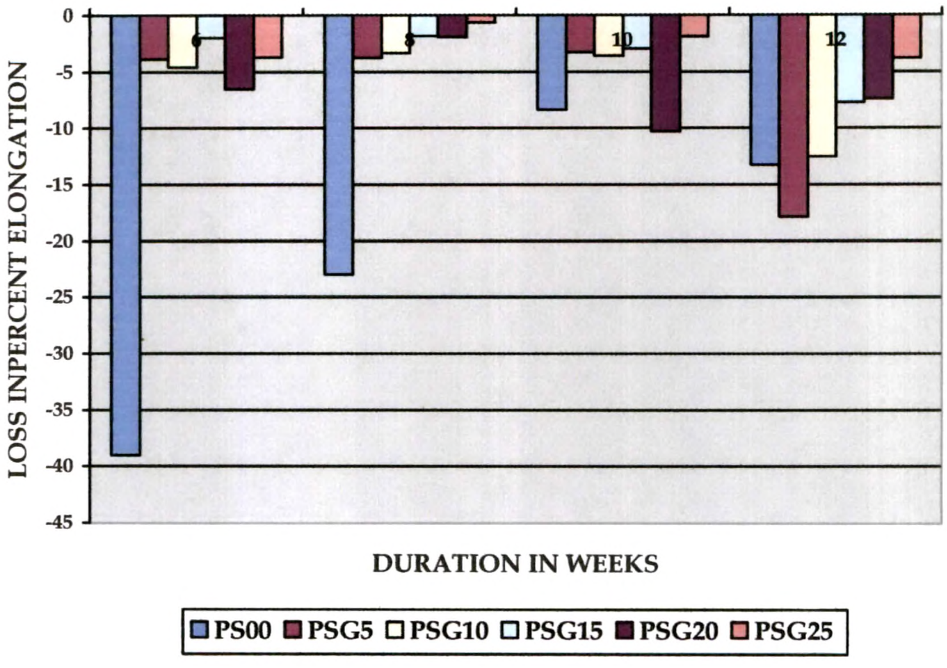


FIGURE 4.30: LOSS IN PERCENTELONGATION FOR PS WITH SOYBEAN OIL

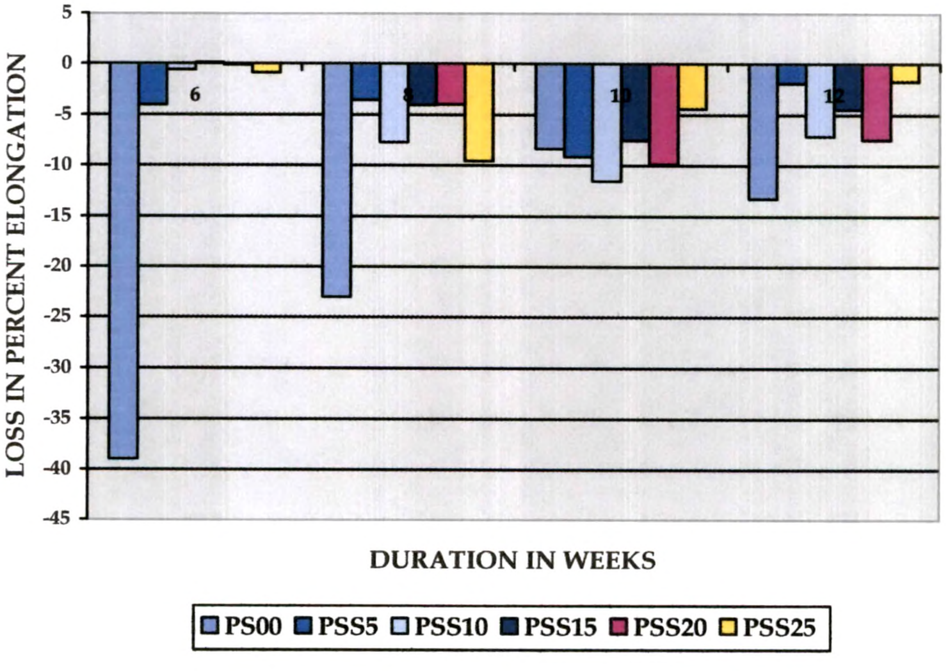


FIGURE 4.31: LOSS IN PERCENT ELONGATION FOR PP WITH GROUNDNUT OIL

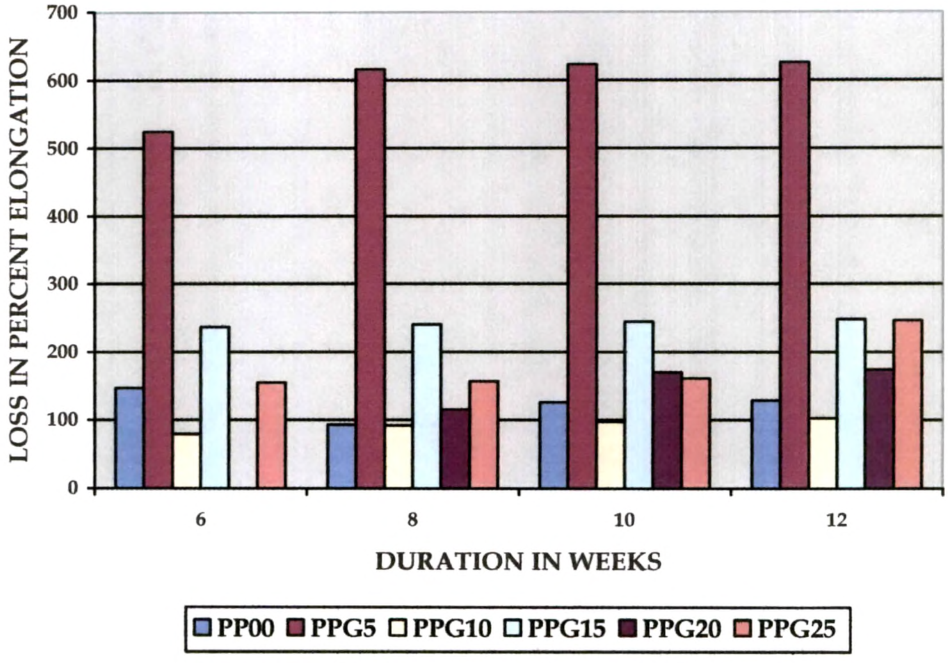
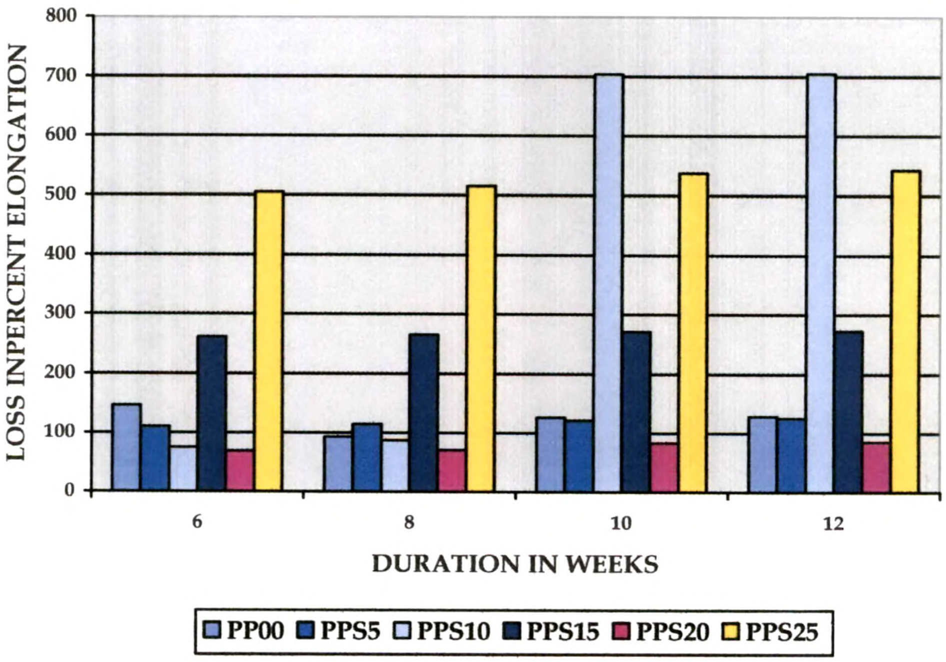


FIGURE 4.32: LOSS INPERCENT ELONGATION FOR PP WITH SOYBEAN OIL



4.2.1.d RESULT FOR VISCOSITY LOSS:

The specimens were removed from the bowl after six, eight, ten and twelve weeks. They were separated from the nylon filament, washed and allowed to dry for one day. After the measurement of weight, tensile strength and percent elongation the specimens were collected for further testing of viscosity. The specimens were further cut to small pieces and dissolved in Xylene HPLC grade at 130°C temperature. The viscosity was measured by Redwood Viscometer. Since the weight of specimens was different, the concentration of solution of specimen in Xylene was calculated and the reduced viscosity of the specimen was calculated as per the literature. (Vishu Shah 1998)

TABLE 4.16: VISCOSITY LOSS AFTER 6 WEEKS:

Sr. No.	Specimen	Specific Viscosity	Time	Weight	Concentration	Specific Viscosity
1.	LD00	584.000	120.02	0.510	0.051	372.614
2.	LDG5	578.000	19.83	0.305	0.031	75.549
3.	LDG10	108.333	17.43	0.312	0.031	60.980
4.	LDG15	126.333	14.69	0.508	0.051	28.527
5.	LDG20	200.667	10.52	0.497	0.050	15.161
6.	LDG25	113.000	10.02	0.354	0.035	18.905
7.	LDS5	173.500	22.2	0.235	0.023	114.943
8.	LDS10	119.000	19.25	0.360	0.036	61.343
9.	LDS15	154.333	23.73	0.598	0.060	49.440
10.	LDS20	157.167	24.02	0.291	0.029	103.243
11.	LDS25	138.000	24.21	0.254	0.025	119.629
12.	HD00	1215.333	190.97	0.664	0.027	1161.230
13.	HDG5	487.667	89.59	0.584	0.029	477.030
14.	HDG10	562.667	85.79	0.731	0.024	545.909
15.	HDG15	1118.000	61.34	0.372	0.012	743.218
16.	HDG20	412.667	58.34	0.676	0.023	387.359

17.	HDG25	733.333	50.92	0.412	0.014	544.749
18.	HDS5	1664.000	48.52	0.476	0.016	446.733
19.	HDS10	1442.333	89.38	0.299	0.010	1395.715
20.	HDS15	908.000	31.56	0.665	0.022	192.152
21.	HDS20	1367.000	34.64	0.221	0.007	648.551
22.	HDS25	1399.000	29.6	0.141	0.005	838.664
23.	PS00	419.667	24.32	0.607	0.061	50.294
24.	PSG5	202.500	14.07	0.285	0.028	47.226
25.	PSG10	74.444	16.92	0.338	0.034	53.798
26.	PSG15	58.000	16.53	0.616	0.062	28.509
27.	PSG20	84.000	24.12	0.610	0.061	49.508
28.	PSG25	53.333	18.42	0.475	0.048	43.551
29.	PSS5	59.333	23.23	0.670	0.067	42.861
30.	PSS10	50.833	16.03	0.345	0.034	48.482
31.	PSS15	69.667	13.72	0.201	0.020	64.109
32.	PSS20	100.833	19.59	0.232	0.023	97.671
33.	PSS25	47.333	12.72	0.261	0.026	42.928
34.	PP00	511.333	45.54	0.803	0.032	205.117
35.	PPG5	203.333	38.77	0.672	0.034	162.598
36.	PPG10	244.000	9.32	0.221	0.011	50.121
37.	PPG15	239.000	16.88	0.207	0.010	175.456
38.	PPG20	234.500	13.88	0.171	0.009	153.337
39.	PPG25	320.833	20.61	0.174	0.009	279.243
40.	PPS5	597.167	20.95	0.122	0.006	408.135
41.	PPS10	485.833	10.72	0.376	0.019	41.900
42.	PPS15	475.000	17.21	0.266	0.013	140.582
43.	PPS20	782.667	17.1	0.294	0.015	125.679
44.	PPS25	455.000	21.75	0.263	0.013	199.317

TABLE 4.17: VISCOSITY LOSS AFTER 8 WEEKS:

Sr. No.	Specimen	Specific Viscosity	Time	Weight	Concentration	Specific Viscosity
1.	LD00	584.000	113.15	0.36	0.036	496.065
2.	LDG5	578.000	19.61	0.3343	0.033	67.853
3.	LDG10	108.333	21.83	0.2788	0.028	94.632
4.	LDG15	126.333	21.3	0.2292	0.023	111.257
5.	LDG20	200.667	22.04	0.3507	0.035	76.228
6.	LDG25	113.000	19.22	0.29	0.029	75.977
7.	LDS5	173.500	22.2	0.3839	0.038	70.331
8.	LDS10	119.000	29.81	0.3465	0.035	114.526
9.	LDS15	154.333	43.43	0.4344	0.043	143.608
10.	LDS20	157.167	30.1	0.2581	0.026	155.624
11.	LDS25	138.000	25.35	0.3511	0.035	91.854
12.	HD00	1215.333	190.97	0.6882	0.069	447.956
13.	HDG5	487.667	89.59	0.5069	0.051	274.841
14.	HDG10	562.667	85.79	0.6208	0.062	214.213
15.	HDG15	1118.000	184.54	1.0652	0.107	279.353
16.	HDG20	412.667	58.34	0.5729	0.057	152.266
17.	HDG25	733.333	50.92	0.5986	0.060	125.070
18.	HDS5	1664.000	48.52	0.3928	0.039	180.414
19.	HDS10	1442.333	89.38	0.3394	0.034	409.448
20.	HDS15	908.000	31.56	0.4989	0.050	85.388
21.	HDS20	1367.000	34.64	0.2559	0.026	186.531
22.	HDS25	1399.000	29.6	0.11	0.011	357.576
23.	PS00	419.667	23.01	0.3569	0.036	79.434
24.	PSG5	202.500	13.71	0.3075	0.031	41.789
25.	PSG10	74.444	23.83	0.4087	0.041	72.710
26.	PSG15	58.000	16.12	0.3937	0.039	42.841
27.	PSG20	84.000	17.74	0.6668	0.067	29.344

28.	PSG25	53.333	14.4	0.4218	0.042	33.191
29.	PSS5	59.333	19.39	0.6709	0.067	33.264
30.	PSS10	50.833	12.32	0.3508	0.035	30.027
31.	PSS15	69.667	13.64	0.1836	0.018	69.354
32.	PSS20	100.833	20.91	0.2922	0.029	85.044
33.	PSS25	47.333	11.98	0.22	0.022	45.303
34.	PP00	511.333	132.54	0.6745	0.067	312.676
35.	PPG5	203.333	55.73	0.4844	0.048	171.105
36.	PPG10	244.000	26.45	0.2339	0.023	145.718
37.	PPG15	239.000	23.16	0.2751	0.028	103.962
38.	PPG20	234.500	16.52	0.1314	0.013	133.435
39.	PPG25	320.833	19.88	0.2108	0.021	109.741
40.	PPS5	597.167	18.15	0.2746	0.027	73.744
41.	PPS10	485.833	23.38	0.3223	0.032	89.875
42.	PPS15	475.000	21.77	0.2177	0.022	120.732
43.	PPS20	782.667	15.88	0.27	0.027	60.988
44.	PPS25	455.000	29.97	0.4039	0.040	98.911

TABLE 4.18: VISCOSITY LOSS AFTER 10 WEEKS:

Sr. No.	Specimen	Specific Viscosity	Time	Weight	Concentration	Specific Viscosity
1.	LD00	584.000	133.06	0.4392	0.04392	482.165
2.	LDG5	578.000	19.44	0.3254	0.03254	68.838
3.	LDG10	108.333	21.81	0.2608	0.02608	101.035
4.	LDG15	126.333	26.53	0.4152	0.04152	82.410
5.	LDG20	200.667	37.31	0.2711	0.02711	192.487
6.	LDG25	113.000	18.13	0.32	0.032	63.177
7.	LDS5	173.500	36.49	0.3178	0.03178	159.901
8.	LDS10	119.000	28.23	0.33	0.033	112.273
9.	LDS15	154.333	23.69	0.5325	0.05325	55.368

10.	LDS20	157.167	22.55	0.2609	0.02609	105.724
11.	LDS25	138.000	22.42	0.2912	0.02912	93.979
12.	HD00	1215.333	65.47	0.3917	0.013057	759.127
13.	HDG5	487.667	50.39	0.4654	0.015513	476.902
14.	HDG10	562.667	74.9	0.6942	0.02314	496.255
15.	HDG15	1118.000	65.79	0.5534	0.018447	540.206
16.	HDG20	412.667	26.8	0.5934	0.01978	175.261
17.	HDG25	733.333	27.53	0.3534	0.01178	304.612
18.	HDS5	1664.000	32.53	0.6688	0.022293	198.340
19.	HDS10	1442.333	25.61	0.2937	0.00979	333.844
20.	HDS15	908.000	35.73	0.558	0.0186	266.398
21.	HDS20	1367.000	31.89	0.1544	0.005147	838.407
22.	HDS25	1399.000	28.9	0.0853	0.002843	1342.321
23.	PS00	419.667	10.51	0.4753	0.04753	15.815
24.	PSG5	202.500	10.22	0.3937	0.03937	17.865
25.	PSG10	74.444	13.08	0.3906	0.03906	30.210
26.	PSG15	58.000	17.37	0.348	0.0348	54.454
27.	PSG20	84.000	19.79	0.4556	0.04556	50.446
28.	PSG25	53.333	13.12	0.2237	0.02237	53.047
29.	PSS5	59.333	14.07	0.2409	0.02409	55.832
30.	PSS10	50.833	6.85	0.0524	0.00524	27.036
31.	PSS15	69.667	12.02	0.2387	0.02387	42.033
32.	PSS20	100.833	14.05	0.2359	0.02359	56.874
33.	PSS25	47.333	10.47	0.1604	0.01604	46.446
34.	PP00	511.333	61.92	0.5554	0.02777	335.614
35.	PPG5	203.333	26.61	0.3622	0.01811	189.674
36.	PPG10	244.000	20.05	0.1983	0.009915	236.174
37.	PPG15	239.000	14.53	0.1623	0.008115	175.190
38.	PPG20	234.500	10.49	0.0951	0.004755	157.378
39.	PPG25	320.833	14.6	0.2288	0.01144	125.291

175

40.	PPS5	597.167	19.23	0.29	0.0145	152.069
41.	PPS10	485.833	22.9	0.2261	0.011305	249.152
42.	PPS15	475.000	20.91	0.1965	0.009825	252.926
43.	PPS20	782.667	17.44	0.351	0.01755	108.642
44.	PPS25	455.000	27.25	0.2907	0.014535	243.665

TABLE 4.19: VISCOSITY LOSS AFTER 12 WEEKS:

Sr. No.	Specimen	Specific Viscosity	Time	Weight	Concentration	Specific Viscosity
1.	LD00	584.000	30.55	0.3257	0.03257	125.627
2.	LDG5	578.000	24.08	0.3424	0.03424	88.006
3.	LDG10	108.333	16.16	0.2574	0.02574	65.786
4.	LDG15	126.333	19.34	0.2917	0.02917	76.220
5.	LDG20	200.667	14.9	0.3148	0.03148	47.120
6.	LDG25	113.000	14.89	0.2952	0.02952	50.192
7.	LDS5	173.500	12.34	0.2	0.02	52.833
8.	LDS10	119.000	17.2	0.3685	0.03685	50.656
9.	LDS15	154.333	20.67	0.4633	0.04633	52.774
10.	LDS20	157.167	14.22	0.2609	0.02609	52.511
11.	LDS25	138.000	15.41	0.2647	0.02647	59.249
12.	HD00	1215.333	56.4	0.3813	0.01271	660.897
13.	HDG5	487.667	40.8	0.4646	0.015487	374.516
14.	HDG10	562.667	31.57	0.6585	0.02195	194.153
15.	HDG15	1118.000	51.91	0.5582	0.018607	411.233
16.	HDG20	412.667	44.52	0.5866	0.019553	328.333
17.	HDG25	733.333	30	0.4272	0.01424	280.899
18.	HDS5	1664.000	26.13	0.3862	0.012873	260.616
19.	HDS10	1442.333	57.6	0.2723	0.009077	947.484
20.	HDS15	908.000	45.48	0.5615	0.018717	351.558
21.	HDS20	1367.000	31.8	0.1965	0.00655	656.489

22.	HDS25	1399.000	28.59	0.1427	0.004757	791.521
23.	PS00	419.667	46.33	0.5489	0.05489	122.457
24.	PSG5	202.500	10.55	0.0674	0.00674	112.512
25.	PSG10	74.444	19.19	0.3955	0.03955	55.584
26.	PSG15	58.000	15.06	0.4455	0.04455	33.895
27.	PSG20	84.000	13.13	0.4937	0.04937	24.070
28.	PSG25	53.333	13.73	0.5163	0.05163	24.953
29.	PSS5	59.333	17.07	0.4923	0.04923	37.477
30.	PSS10	50.833	11.35	0.2826	0.02826	31.552
31.	PSS15	69.667	13.9	0.1942	0.01942	67.800
32.	PSS20	100.833	12.21	0.2341	0.02341	44.212
33.	PSS25	47.333	13.2	0.2652	0.02652	45.249
34.	PP00	511.333	29.85	0.1987	0.009935	400.101
35.	PPG5	203.333	26.68	0.3555	0.017775	193.905
36.	PPG10	244.000	18.53	0.1908	0.00954	218.903
37.	PPG15	239.000	16.88	0.1537	0.007685	235.957
38.	PPG20	234.500	12.5	0.0928	0.00464	233.477
39.	PPG25	320.833	23.1	0.1945	0.009725	293.059
40.	PPS5	597.167	19.91	0.1353	0.006765	342.695
41.	PPS10	485.833	36.3	0.2988	0.01494	338.019
42.	PPS15	475.000	26.53	0.3446	0.01723	198.588
43.	PPS20	782.667	22.34	0.2115	0.010575	257.526
44.	PPS25	455.000	23.7	0.3248	0.01624	181.650

FIGURE 4.33: LOSS IN VISCOSITY FOR LDPE WITH GROUNDNUT OIL

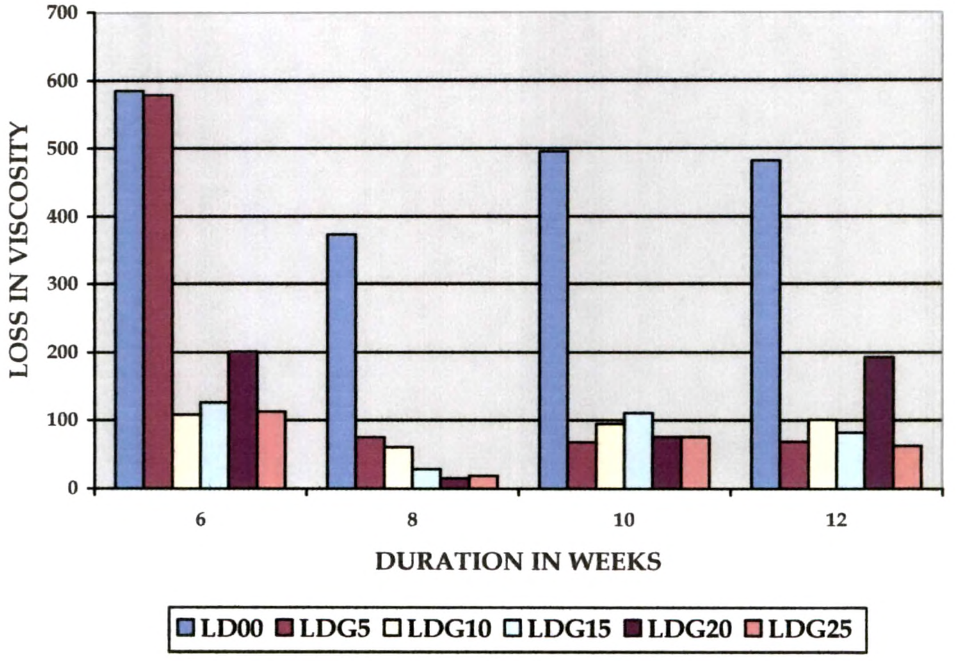


FIGURE 4.34: LOSS IN VISCOSITY FOR LDPE WITH SOYBEAN OIL

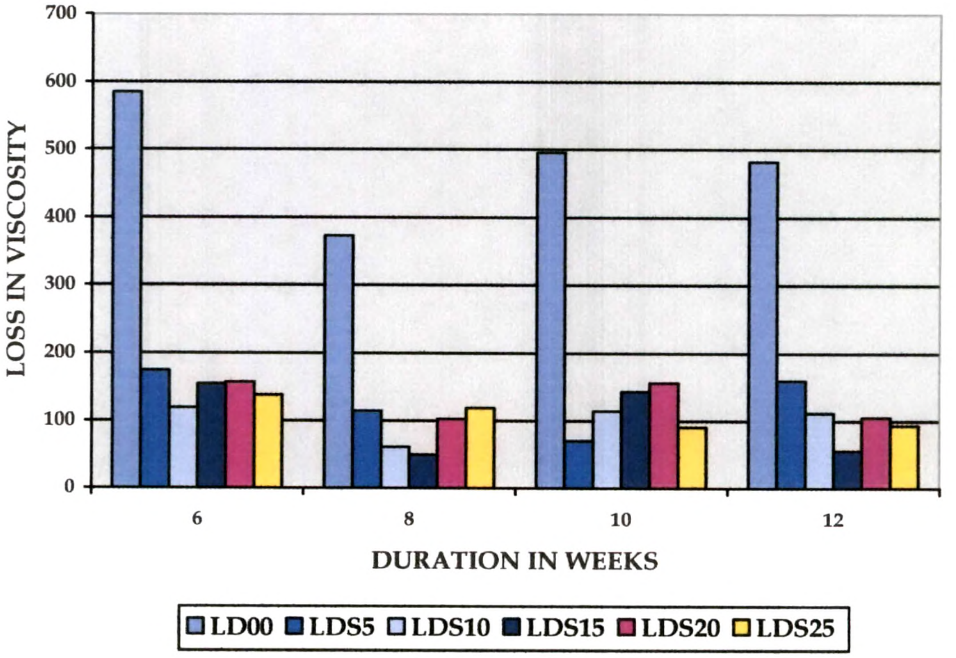


FIGURE 4.35: LOSS IN VISCOSITY FOR HDPE GROUNDNUT OIL

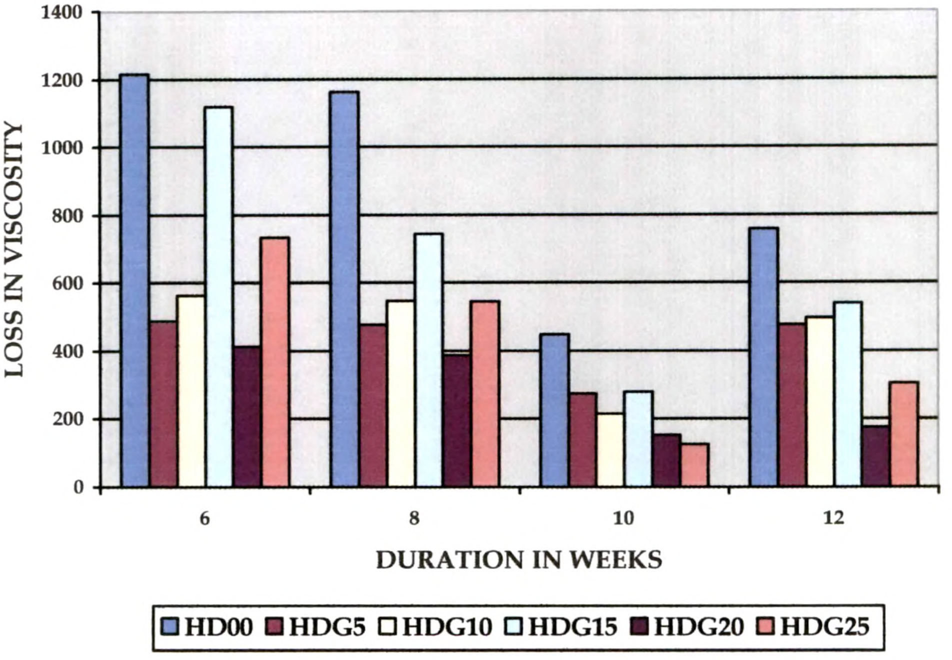


FIGURE 4.36: LOSS IN VISCOSITY FOR HDPE WITH SOYBEAN OIL

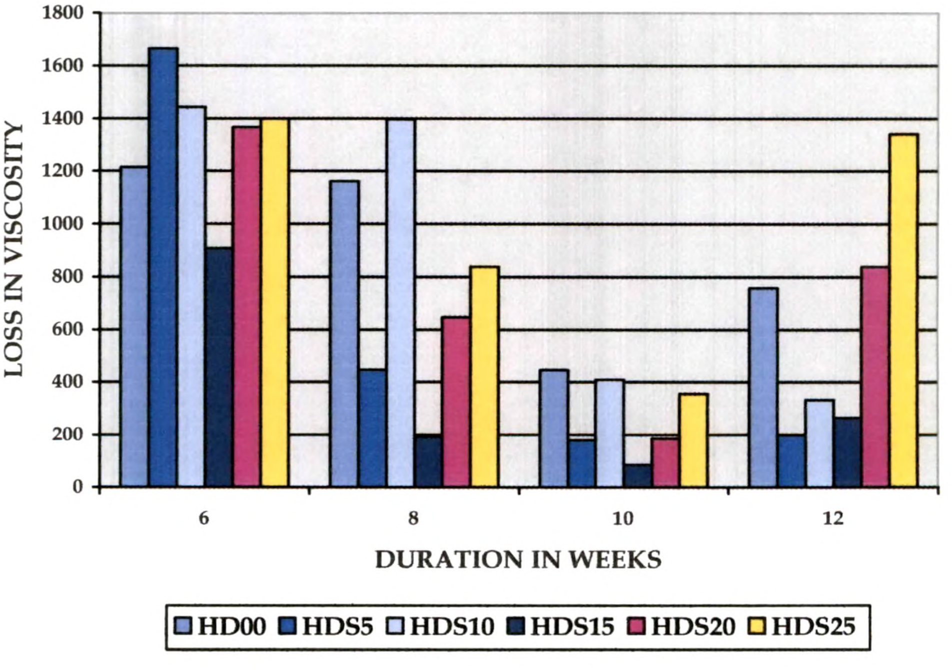


FIGURE 4.37: LOSS IN VISCOSITY FOR PS WITH GROUNDNUT OIL

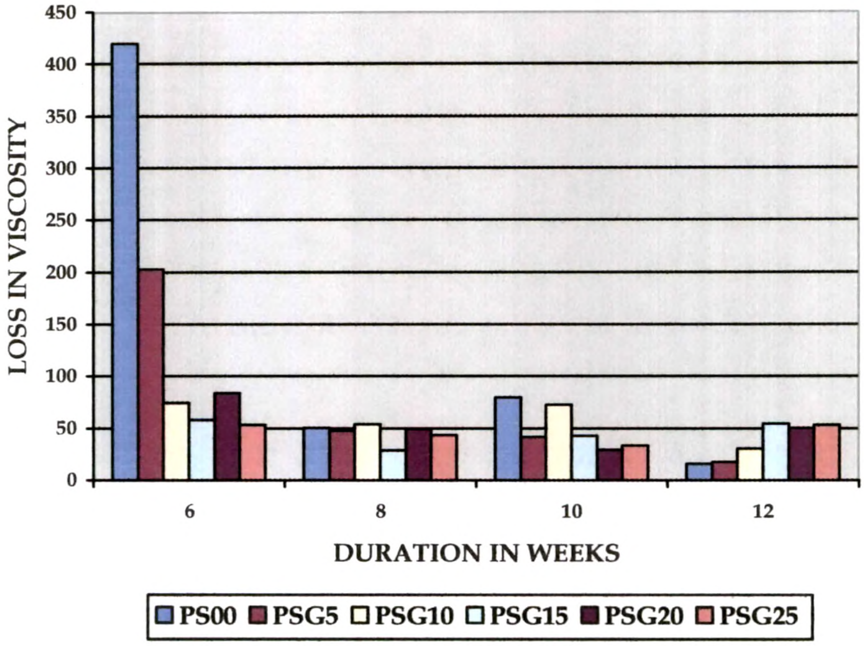


FIGURE 4.38: LOSS IN VISCOSITY FOR PS WITH SOYBEAN OIL

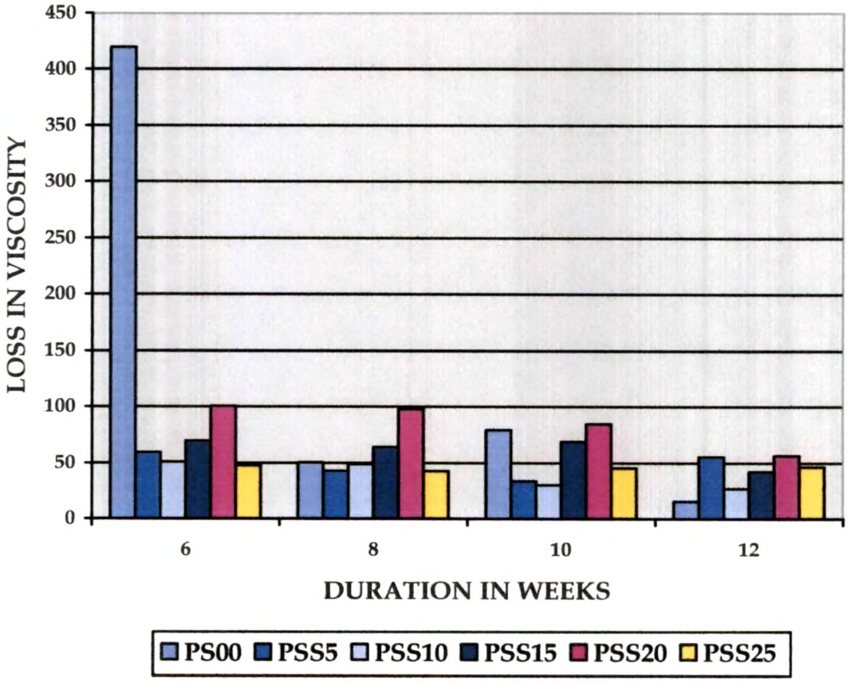


FIGURE 4.39: LOSS IN VISCOSITY FOR PP WITH GROUNDNUT OIL

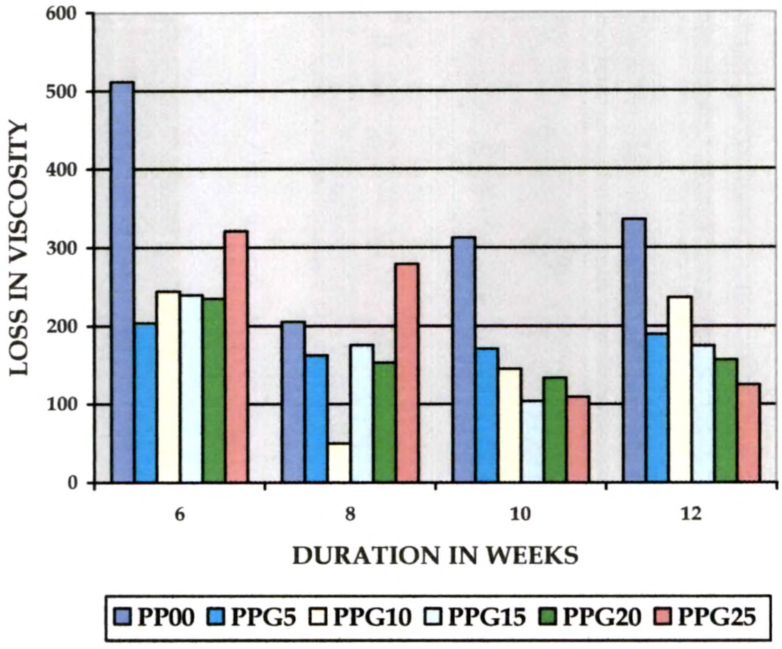
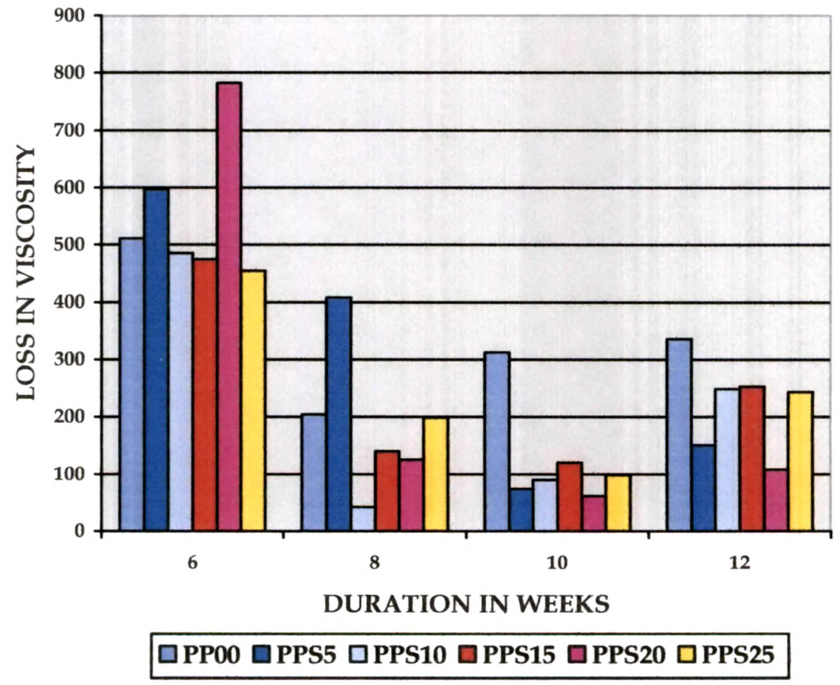


FIGURE 4.40: LOSS IN VISCOSITY FOR PP WITH SOYBEAN OIL



4.2.5 ANALYSIS AND DISCUSSION FOR VISCOSITY LOSS:

◊ As per the theory that the microorganism attacks only if polymers could be degraded to extremely short chain lengths. The viscosity of polymer and hence the polymer chain length was reduced due to the addition of plasticizer.

◊ This reduction of viscosity and the corresponding chain length was observed gradually during the span of 12 weeks.

◊ The physical change on the specimen was observed after 12 weeks in the way of fragmentation of the entire specimens and the breakage of nylon filament in which the specimens were tied up.

◊ As per the theory that synthetic polymers can also be metabolized at relatively high molecular weights the reduction of viscosity of the un modified polymer was observed. (Ch. II 2.7)

◊ A variety of environmental factors such as oxygen, temperature, sunlight, water, stress, living organisms and pollutants may affect the reduction of viscosity of polymer.

4.2.6 OBSERVATIONS FOR THE SCREENING OF BIODEGRADATION OF SPECIMEN TO ASSESS THE PROPERTY LOSS RESULTS:

◊ Screening of biodegradation of specimen in open air to assess the property loss test reveals great loss in viscosity and mechanical strength which in turn assures the biodegradability of the films.

◊ @ 70-99% loss in tensile strength within 12 weeks was observed with plasticized LDPE, HDPE, PS and PP.

◊ The loss in percent elongation within 12 weeks of almost all specimens is between 140- 580 during the span of 12 weeks.

◊ Loss in specific Viscosity within 12 weeks ranges from 60-600 after 12weeks. The viscosity is reduced gradually.

◊ This loss was observed after initial six weeks for the plasticized polymer and the n it remained almost constant. For unplasticized polymer the loss was observed after ten to twelve weeks duration.

Hence it may be inferred that the incorporation of plasticizer increases the rate of biodegradation.

◊After 12 weeks fragmentation into extremely small pieces of the specimens was observed and all the specimens were mixed up. Hence the loss in mechanical strength and viscosity could not be measured.

◊But from the loss in mechanical properties and viscosity it could be inferred that the polymer chains with high molecular weight were converted into small chains with low molecular weight.

◊The weight loss was not significant and of regular pattern. The biofilm formation on the specimen, the biomass of the microorganism within the polymer matrix and the leaching of additives, plasticizers from the specimen may be responsible for the irregular results.

◊The presence of a biological system influencing the rate of biodegradation was also revealed. The biological system consists of environmental factors, microorganisms, polymer composition and structure, plasticizer: composition, structure and concentration.

◊To identify the specific specie of the microorganism affecting the biodegradability the specimen were subjected to the concentrated culture of six microorganism that exhibit the highest susceptibility towards the biodegradation i.e. Pseudomonas (Bacteria), Staphylococcus (Bacteria), E- Coli (Bacteria), Aspergillus Niger (Fungi), Rhizopus (Fungi) and Consortium - Mixed Culture of above microorganisms were selected.

◊The specimens were placed in open air so that other environmental factors and microorganism can also affect the biodegradability.

◊After 16 weeks typical color change and higher growth was observed in some specimen.

4.3 RESULTS FROM SCREENING OF BIODEGRADATION OF SPECIMEN IN OPEN AIR:

The fragments of specimen were isolated from the biomass and the medium in the container. Very fine fragments of the specimen that were not possible to isolate were recorded as weight loss. The supernatant from the container was collected for further testing. The fragments of specimen were washed with water and allowed to dry for one day. The weight of specimen up to 0.01 mg precision was recorded. The percentage weight loss was calculated from the initial weight.

TABLE 4.20 WEIGHT LOSS AFTER 16 WEEKS WITH PSEUDOMONAS AERUGINOSA (BACTERIA)

Sr.No.	Specimen	Initial Weight g	Weight g	Weight Loss g	Percent Weight Loss
1.	LD00	0.100	0.079	0.021	20.820
2.	LDG5	0.100	0.079	0.021	20.650
3.	LDG10	0.100	0.084	0.016	16.220
4.	LDG15	0.150	0.082	0.068	45.340
5.	LDG20	0.100	0.081	0.019	19.100
6.	LDG25	0.100	0.075	0.025	25.150
7.	LDS5	0.100	0.075	0.025	24.620
8.	LDS10	0.100	0.077	0.023	23.150
9.	LDS15	0.100	0.082	0.018	18.420
10.	LDS20	0.100	0.078	0.022	21.930
11.	LDS25	0.100	0.077	0.023	22.690
12.	HD00	0.250	0.084	0.166	66.300
13.	HDG5	0.100	0.077	0.023	23.260
14.	HDG10	0.100	0.074	0.026	26.110
15.	HDG15	0.100	0.080	0.020	19.740
16.	HDG20	0.100	0.076	0.024	23.730

17.	HDG25	0.100	0.078	0.022	21.640
18.	HDS5	0.200	0.079	0.121	60.610
19.	HDS10	0.100	0.076	0.024	23.930
20.	HDS15	0.100	0.080	0.020	19.820
21.	HDS20	0.100	0.077	0.023	22.710
22.	HDS25	0.100	0.074	0.026	26.140
23.	PS00	0.100	0.075	0.025	25.250
24.	PSG5	0.100	0.072	0.028	27.620
25.	PSG10	0.100	0.070	0.030	30.210
26.	PSG15	0.150	0.074	0.076	50.507
27.	PSG20	0.100	0.077	0.023	22.790
28.	PSG25	0.100	0.076	0.024	23.820
29.	PSS5	0.100	0.070	0.030	29.870
30.	PSS10	0.100	0.069	0.031	30.710
31.	PSS15	0.100	0.069	0.031	30.670
32.	PSS20	0.100	0.066	0.034	33.860
33.	PSS25	0.100	0.069	0.031	31.300
34.	PP00	0.300	0.088	0.212	70.597
35.	PPG5	0.100	0.081	0.019	18.910
36.	PPG10	0.100	0.072	0.028	28.230
37.	PPG15	0.100	0.076	0.024	24.170
38.	PPG20	0.150	0.078	0.072	48.253
39.	PPG25	0.200	0.088	0.112	56.000
40.	PPS5	0.100	0.079	0.021	21.110
41.	PPS10	0.150	0.084	0.066	43.740
42.	PPS15	0.100	0.075	0.025	25.410
43.	PPS20	0.300	0.099	0.201	67.137
44.	PPS25	0.200	0.086	0.114	56.945

TABLE 4.21 WEIGHT LOSS AFTER 16 WEEKS WITH STAPHYLOCOCCUS (BACTERIA)

Sr.No.	Specimen	Initial Weight g	Weight g	Weight Loss g	Percent Weight Loss
1.	LD00	0.100	0.077	0.023	23.000
2.	LDG5	0.100	0.077	0.023	23.390
3.	LDG10	0.100	0.077	0.023	23.170
4.	LDG15	0.150	0.072	0.078	51.793
5.	LDG20	0.100	0.073	0.027	27.410
6.	LDG25	0.100	0.074	0.026	25.990
7.	LDS5	0.100	0.073	0.027	27.410
8.	LDS10	0.100	0.071	0.029	29.000
9.	LDS15	0.100	0.070	0.030	29.850
10.	LDS20	0.100	0.075	0.025	24.840
11.	LDS25	0.100	0.077	0.023	23.120
12.	HD00	0.200	0.084	0.116	58.175
13.	HDG5	0.100	0.074	0.026	25.530
14.	HDG10	0.100	0.081	0.019	19.320
15.	HDG15	0.100	0.082	0.018	18.240
16.	HDG20	0.100	0.078	0.022	22.430
17.	HDG25	0.200	0.084	0.116	57.955
18.	HDS5	0.100	0.081	0.019	18.650
19.	HDS10	0.100	0.081	0.019	18.850
20.	HDS15	0.100	0.083	0.017	16.640
21.	HDS20	0.200	0.079	0.121	60.270
22.	HDS25	0.100	0.080	0.020	19.860
23.	PS00	0.150	0.080	0.070	46.940
24.	PSG5	0.100	0.079	0.021	20.710
25.	PSG10	0.100	0.079	0.021	21.260

26.	PSG15	0.100	0.077	0.023	23.260
27.	PSG20	0.100	0.082	0.018	18.140
28.	PSG25	0.150	0.078	0.072	47.720
29.	PSS5	0.100	0.081	0.019	19.350
30.	PSS10	0.100	0.081	0.019	19.250
31.	PSS15	0.100	0.079	0.021	20.560
32.	PSS20	0.100	0.081	0.019	19.190
33.	PSS25	0.100	0.073	0.027	27.000
34.	PP00	0.300	0.096	0.204	67.930
35.	PPG5	0.200	0.088	0.112	55.860
36.	PPG10	0.100	0.075	0.025	24.630
37.	PPG15	0.100	0.076	0.024	24.320
38.	PPG20	0.200	0.088	0.112	55.870
39.	PPG25	0.200	0.089	0.111	55.645
40.	PPS5	0.100	0.080	0.020	20.180
41.	PPS10	0.100	0.083	0.017	16.580
42.	PPS15	0.100	0.076	0.024	24.120
43.	PPS20	0.200	0.091	0.109	54.680
44.	PPS25	0.100	0.080	0.020	20.290

TABLE 4.22 WEIGHT LOSS AFTER 16 WEEKS WITH E-COLI (BACTERIA)

Sr.No.	Specimen	Initial Weight g	Weight g	Weight Loss g	Percent Weight Loss
1.	LD00	0.100	0.076	0.024	23.790
2.	LDG5	0.100	0.078	0.022	21.910
3.	LDG10	0.100	0.077	0.023	23.380
4.	LDG15	0.200	0.090	0.110	54.930
5.	LDG20	0.100	0.080	0.020	20.420

6.	LDG25	0.100	0.078	0.022	21.780
7.	LDS5	0.100	0.078	0.022	22.440
8.	LDS10	0.200	0.079	0.121	60.555
9.	LDS15	0.100	0.074	0.026	26.290
10.	LDS20	0.100	0.073	0.027	26.770
11.	LDS25	0.100	0.075	0.025	24.980
12.	HD00	0.200	0.084	0.116	58.130
13.	HDG5	0.100	0.079	0.021	21.140
14.	HDG10	0.100	0.080	0.020	19.930
15.	HDG15	0.100	0.083	0.017	16.670
16.	HDG20	0.100	0.078	0.022	22.220
17.	HDG25	0.200	0.089	0.111	55.610
18.	HDS5	0.150	0.080	0.070	46.753
19.	HDS10	0.100	0.084	0.016	15.640
20.	HDS15	0.100	0.075	0.025	25.250
21.	HDS20	0.200	0.086	0.114	57.075
22.	HDS25	0.100	0.080	0.020	19.630
23.	PS00	0.200	0.090	0.110	54.935
24.	PSG5	0.100	0.077	0.023	22.520
25.	PSG10	0.100	0.076	0.024	24.430
26.	PSG15	0.100	0.082	0.018	18.190
27.	PSG20	0.100	0.075	0.025	24.580
28.	PSG25	0.100	0.081	0.019	18.930
29.	PSS5	0.100	0.078	0.022	22.180
30.	PSS10	0.100	0.081	0.019	18.870
31.	PSS15	0.100	0.079	0.021	20.750
32.	PSS20	0.100	0.074	0.026	25.750
33.	PSS25	0.100	0.075	0.025	25.380
34.	PP00	0.200	0.089	0.111	55.340
35.	PPG5	0.150	0.085	0.065	43.653

36.	PPG10	0.100	0.072	0.028	28.480
37.	PPG15	0.100	0.076	0.024	24.440
38.	PPG20	0.200	0.090	0.110	54.835
39.	PPG25	0.100	0.081	0.019	19.280
40.	PPS5	0.100	0.076	0.024	24.380
41.	PPS10	0.300	0.100	0.200	66.697
42.	PPS15	0.100	0.077	0.023	23.250
43.	PPS20	0.200	0.092	0.108	54.170
44.	PPS25	0.100	0.078	0.022	21.520

TABLE 4.23 WEIGHT LOSS AFTER 16 WEEKS WITH ASPERGILLUS NIGER (FUNGI)

Sr.No.	Specimen	Initial Weight g	Weight g	Weight Loss g	Percent Weight Loss
1.	LD00	0.100	0.074	0.026	25.770
2.	LDG5	0.100	0.075	0.025	25.240
3.	LDG10	0.150	0.083	0.067	44.567
4.	LDG15	0.200	0.089	0.111	55.535
5.	LDG20	0.150	0.082	0.068	45.533
6.	LDG25	0.100	0.074	0.026	25.950
7.	LDS5	0.100	0.072	0.028	27.830
8.	LDS10	0.100	0.073	0.027	26.630
9.	LDS15	0.100	0.080	0.020	20.140
10.	LDS20	0.100	0.080	0.020	19.820
11.	LDS25	0.100	0.074	0.026	25.570
12.	HD00	0.200	0.092	0.108	54.045
13.	HDG5	0.100	0.077	0.023	22.550
14.	HDG10	0.100	0.081	0.019	19.250
15.	HDG15	0.100	0.082	0.018	18.210

16.	HDG20	0.100	0.074	0.026	26.430
17.	HDG25	0.100	0.084	0.016	15.670
18.	HDS5	0.150	0.081	0.069	45.680
19.	HDS10	0.200	0.095	0.105	52.735
20.	HDS15	0.100	0.076	0.024	24.290
21.	HDS20	0.100	0.080	0.020	19.690
22.	HDS25	0.100	0.079	0.021	21.420
23.	PS00	0.100	0.079	0.021	20.510
24.	PSG5	0.100	0.080	0.020	20.170
25.	PSG10	0.100	0.078	0.022	21.630
26.	PSG15	0.100	0.074	0.026	25.780
27.	PSG20	0.100	0.073	0.027	26.760
28.	PSG25	0.100	0.080	0.020	20.490
29.	PSS5	0.100	0.080	0.020	20.180
30.	PSS10	0.100	0.079	0.021	20.840
31.	PSS15	0.100	0.080	0.020	19.710
32.	PSS20	0.100	0.076	0.024	23.750
33.	PSS25	0.100	0.075	0.025	24.560
34.	PP00	0.200	0.093	0.107	53.330
35.	PPG5	0.150	0.086	0.064	42.547
36.	PPG10	0.100	0.100	0.000	100.00
37.	PPG15	0.100	0.071	0.029	29.270
38.	PPG20	0.100	0.087	0.013	13.220
39.	PPG25	0.100	0.076	0.024	24.170
40.	PPS5	0.150	0.089	0.061	40.860
41.	PPS10	0.100	0.100	0.000	100.00
42.	PPS15	0.200	0.089	0.111	55.610
43.	PPS20	0.100	0.079	0.021	21.320
44.	PPS25	0.150	0.079	0.071	47.093

TABLE 4.24 WEIGHT LOSS AFTER 16 WEEKS WITH RHIZOPUS (FUNGI)

Sr.No.	Specimen	Initial Weight g	Weight g	Weight Loss g	Percent Weight Loss
1.	LD00	0.100	0.077	0.005	4.970
2.	LDG5	0.100	0.078	0.103	51.405
3.	LDG10	0.100	0.077	0.028	18.860
4.	LDG15	0.100	0.081	0.014	14.460
5.	LDG20	0.100	0.079	0.007	7.410
6.	LDG25	0.100	0.075	0.007	6.620
7.	LDS5	0.100	0.074	0.010	10.210
8.	LDS10	0.100	0.080	0.012	11.520
9.	LDS15	0.100	0.080	0.089	44.405
10.	LDS20	0.100	0.073	0.044	29.507
11.	LDS25	0.100	0.075	0.046	30.920
12.	HD00	0.200	0.089	0.043	28.767
13.	HDG5	0.100	0.076	0.040	26.773
14.	HDG10	0.100	0.077	0.042	27.780
15.	HDG15	0.100	0.081	0.001	0.790
16.	HDG20	0.100	0.080	0.040	26.980
17.	HDG25	0.150	0.087	0.008	7.930
18.	HDS5	0.100	0.080	0.054	35.700
19.	HDS10	0.150	0.083	0.103	51.330
20.	HDS15	0.150	0.083	0.005	4.970
21.	HDS20	0.150	0.134	0.103	51.405
22.	HDS25	0.100	0.088	0.028	18.860
23.	PS00	0.150	0.137	0.014	14.460
24.	PSG5	0.100	0.096	0.007	7.410
25.	PSG10	0.150	0.133	0.007	6.620

26.	PSG15	0.100	0.095	0.010	10.210
27.	PSG20	0.200	0.097	0.012	11.520
28.	PSG25	0.150	0.122	0.089	44.405
29.	PSS5	0.100	0.086	0.044	29.507
30.	PSS10	0.100	0.093	0.046	30.920
31.	PSS15	0.100	0.093	0.043	28.767
32.	PSS20	0.100	0.090	0.040	26.773
33.	PSS25	0.100	0.088	0.042	27.780
34.	PP00	0.200	0.111	0.001	0.790
35.	PPG5	0.150	0.106	0.040	26.980
36.	PPG10	0.150	0.104	0.008	7.930
37.	PPG15	0.150	0.107	0.054	35.700
38.	PPG20	0.150	0.110	0.103	51.330
39.	PPG25	0.150	0.108	0.005	4.970
40.	PPS5	0.100	0.099	0.103	51.405
41.	PPS10	0.150	0.110	0.028	18.860
42.	PPS15	0.100	0.092	0.014	14.460
43.	PPS20	0.150	0.096	0.007	7.410
44.	PPS25	0.200	0.097	0.007	6.620

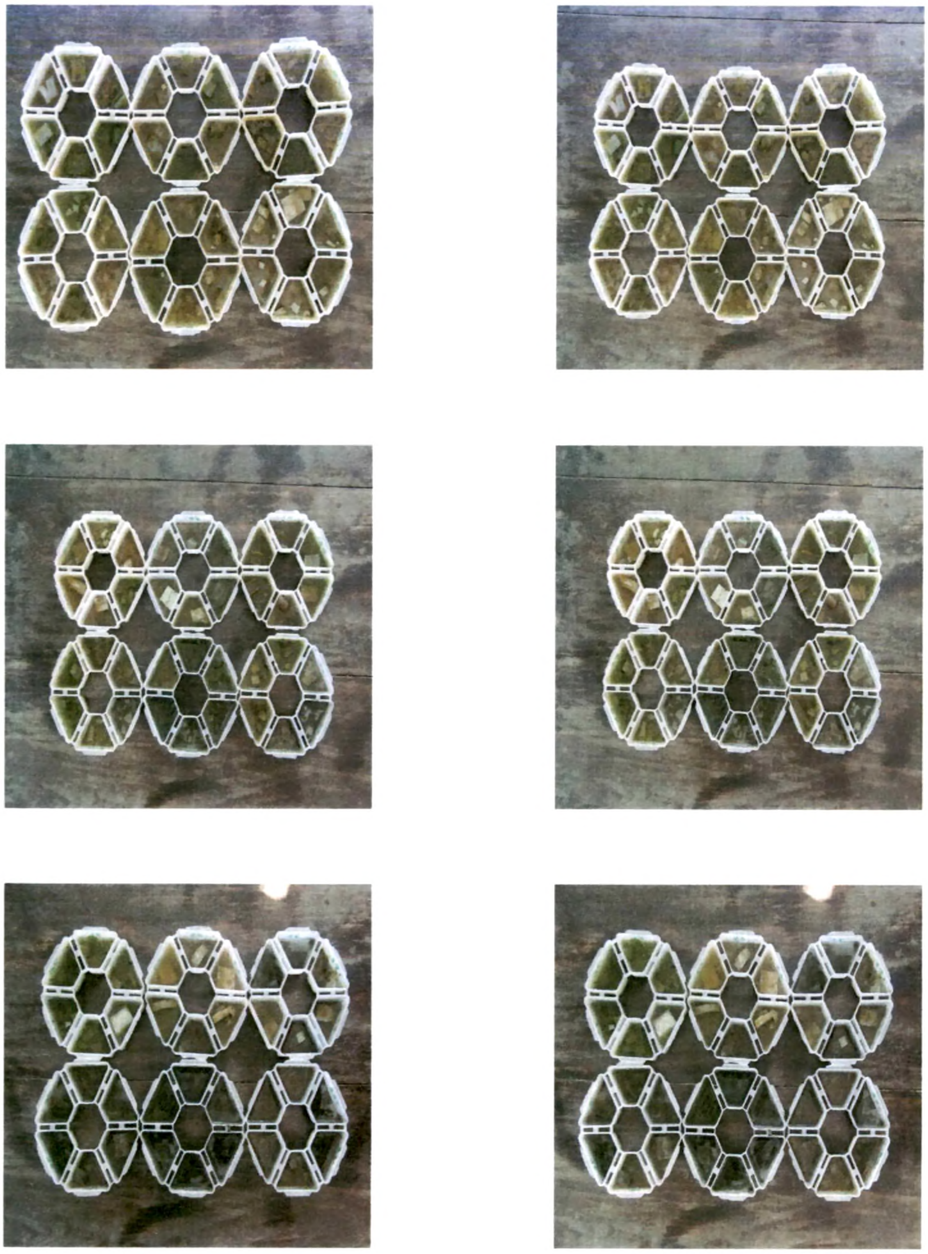
TABLE 4.25 WEIGHT LOSS AFTER 16 WEEKS WITH CONSORTIUM - mixed culture

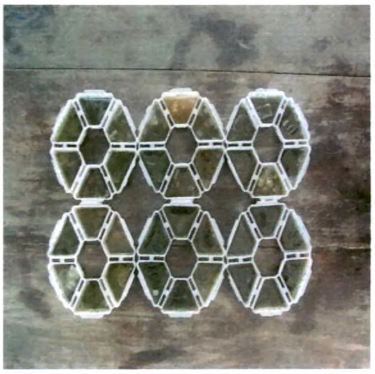
Sr.No.	Specimen	Initial Weight g	Weight g	Weight Loss g	Percent Weight Loss
1.	LD00	0.150	0.117	0.033	22.300
2.	LDG5	0.100	0.091	0.009	9.450
3.	LDG10	0.150	0.121	0.029	19.547
4.	LDG15	0.100	0.082	0.018	18.130
5.	LDG20	0.150	0.125	0.025	16.740

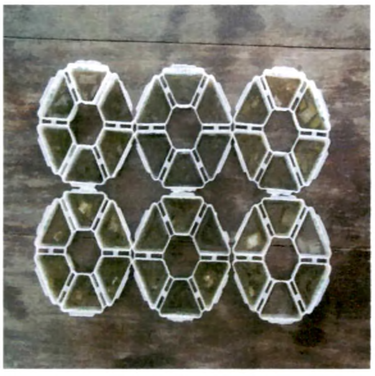
6.	LDG25	0.100	0.087	0.013	13.120
7.	LDS5	0.150	0.117	0.033	21.927
8.	LDS10	0.100	0.083	0.017	16.920
9.	LDS15	0.150	0.137	0.013	8.820
10.	LDS20	0.100	0.088	0.012	12.430
11.	LDS25	0.150	0.141	0.009	5.793
12.	HD00	0.100	0.098	0.002	1.640
13.	HDG5	0.150	0.143	0.007	4.540
14.	HDG10	0.100	0.096	0.004	3.950
15.	HDG15	0.150	0.138	0.012	7.893
16.	HDG20	0.150	0.104	0.046	30.427
17.	HDG25	0.150	0.127	0.023	15.087
18.	HDS5	0.150	0.125	0.025	16.427
19.	HDS10	0.150	0.122	0.028	18.873
20.	HDS15	0.150	0.113	0.037	24.807
21.	HDS20	0.150	0.126	0.024	15.700
22.	HDS25	0.150	0.108	0.042	27.820
23.	PS00	0.150	0.121	0.029	19.593
24.	PSG5	0.150	0.105	0.045	29.827
25.	PSG10	0.150	0.128	0.022	14.873
26.	PSG15	0.200	0.107	0.093	46.565
27.	PSG20	0.150	0.130	0.020	13.167
28.	PSG25	0.150	0.129	0.021	14.187
29.	PSS5	0.100	0.096	0.004	4.000
30.	PSS10	0.100	0.089	0.011	10.810
31.	PSS15	0.150	0.128	0.022	14.760
32.	PSS20	0.100	0.080	0.020	19.640
33.	PSS25	0.150	0.116	0.034	22.667
34.	PP00	0.200	0.103	0.097	48.620
35.	PPG5	0.150	0.115	0.035	23.093

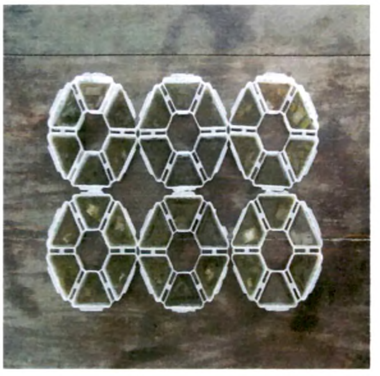
36.	PPG10	0.100	0.080	0.020	20.340
37.	PPG15	0.150	0.110	0.040	26.760
38.	PPG20	0.100	0.087	0.013	13.340
39.	PPG25	0.150	0.120	0.030	20.240
40.	PPS5	0.100	0.082	0.018	18.260
41.	PPS10	0.200	0.119	0.081	40.260
42.	PPS15	0.100	0.079	0.021	21.230
43.	PPS20	0.200	0.122	0.078	38.965
44.	PPS25	0.200	0.088	0.112	55.970

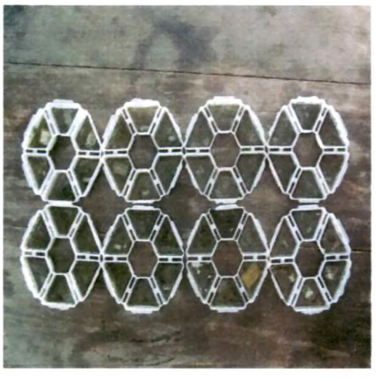
Photograph: 4.29 Specimens after exposure to microorganism for 16 weeks. Typical color change and greater growth was observed in some specimen. The fragmentation of the specimen was clearly observed.

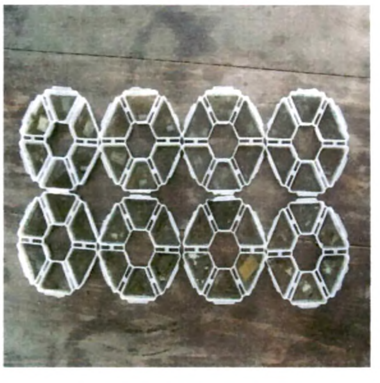












Photograph: 4.30 LDPE specimens after exposure to microorganism for 16 weeks.

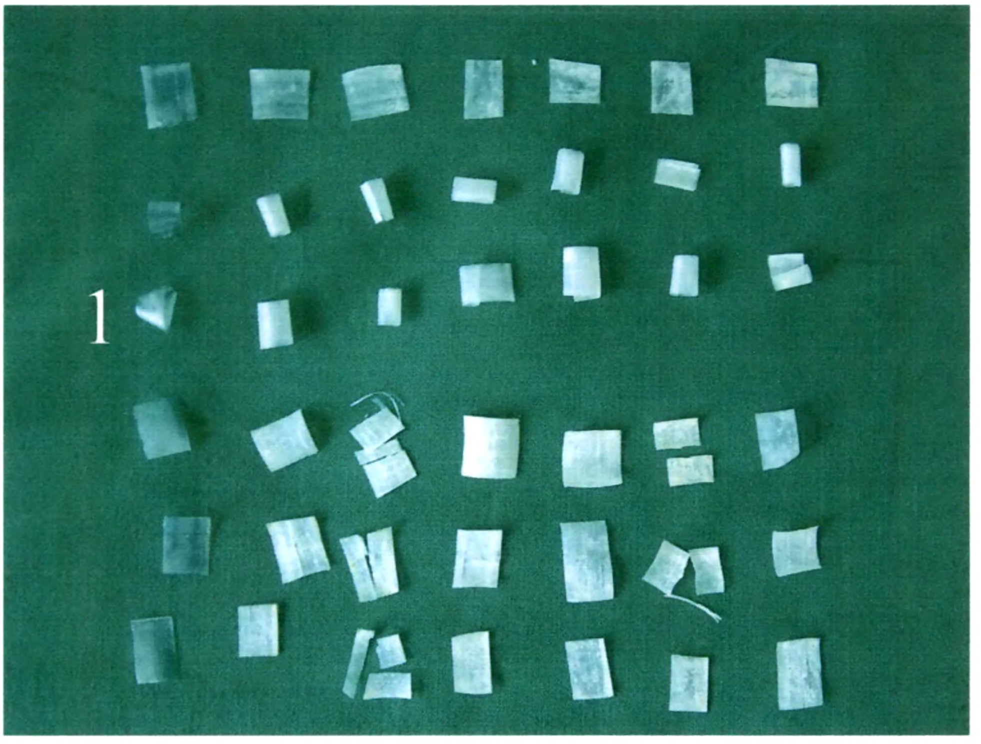


TABLE 4.26: KEY TO THE SPECIMEN IN PHOTOGRAPH 4.30

Original specimen	Specimen in Pseudo monas aeruginosa	Specimen in Staphylo coccus	Specimen in E-Coli	Specimen in Aspergillus niger	Specimen in Rhizopus	Specimen in Consor tium
LD00	LD00	LD00	LD00	LD00	LD00	LD00
LDG5	LDG5	LDG5	LDG5	LDG5	LDG5	LDG5
LDG10	LDG10	LDG10	LDG10	LDG10	LDG10	LDG10
LDG15	LDG15	LDG15	LDG15	LDG15	LDG15	LDG15
LDG20	LDG20	LDG20	LDG20	LDG20	LDG20	LDG20
LDG25	LDG25	LDG25	LDG25	LDG25	LDG25	LDG25

Photograph 4.31: LDPE specimens after exposure to microorganism for 16 weeks.

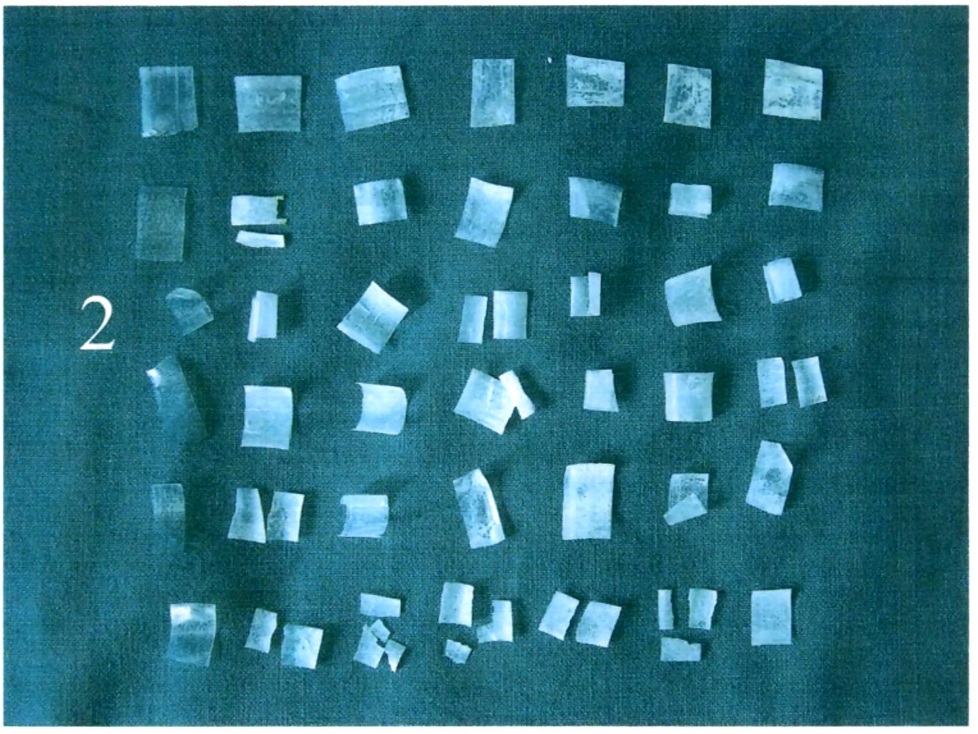


TABLE 4.27: KEY TO THE SPECIMEN IN PHOTOGRAPH 4.31

Original specimen	Specimen in Pseudo monas aeruginosa	Specimen in Staphylo coccus	Specimen in E-Coli	Specimen in Aspergillus niger	Specimen in Rhizopus	Specimen in Consor tium
LD00	LD00	LD00	LD00	LD00	LD00	LD00
LDS5	LDS5	LDS5	LDS5	LDS5	LDS5	LDS5
LDS10	LDS10	LDS10	LDS10	LDS10	LDS10	LDS10
LDS15	LDS15	LDS15	LDS15	LDS15	LDS15	LDS15
LDS20	LDS20	LDS20	LDS20	LDS20	LDS20	LDS20
LDS25	LDS25	LDS25	LDS25	LDS25	LDS25	LDS25

Photograph: 4.32 HDPE specimens after exposure to microorganism for 16 weeks.

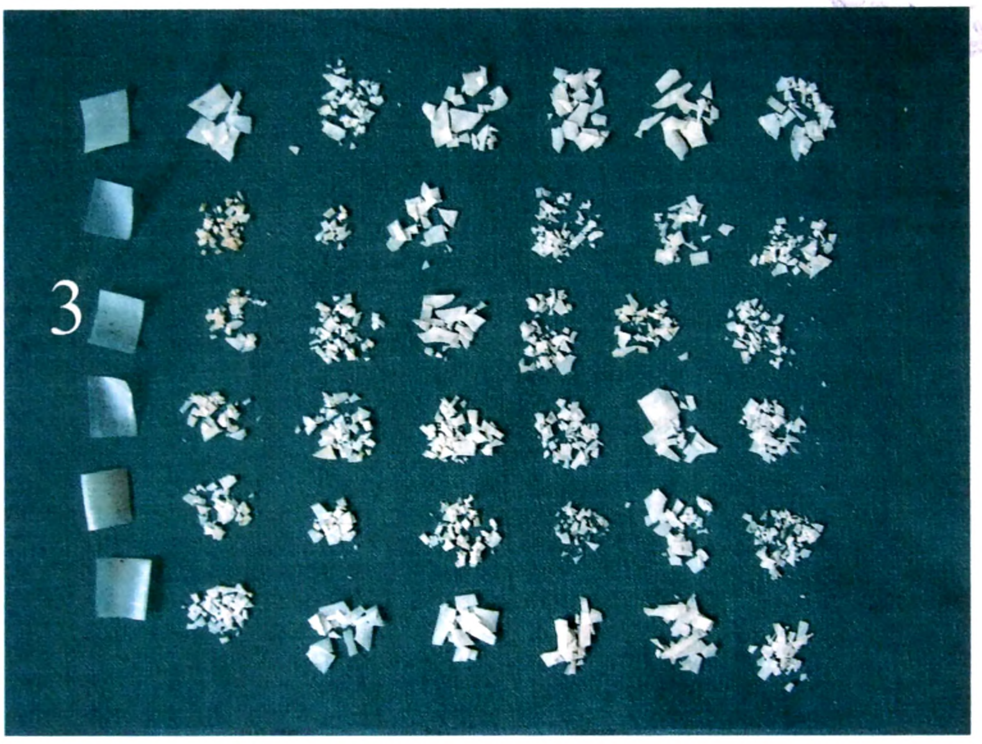


TABLE 4.28: KEY TO THE SPECIMEN IN PHOTOGRAPH 4.32

Original specimen	Specimen in Pseudo monas aeruginosa	Specimen in Staphylo coccus	Specimen in E-Coli	Specimen in Aspergillus niger	Specimen in Rhizopus	Specimen in Consor tium
HD00	HD00	HD00	HD00	HD00	HD00	HD00
HDG5	HDG5	HDG5	HDG5	HDG5	HDG5	HDG5
HDG10	HDG10	HDG10	HDG10	HDG10	HDG10	HDG10
HDG15	HDG15	HDG15	HDG15	HDG15	HDG15	HDG15
HDG20	HDG20	HDG20	HDG20	HDG20	HDG20	HDG20
HDG25	HDG25	HDG25	HDG25	HDG25	HDG25	HDG25

Photograph: 4.33 HDPE specimens after exposure to microorganism for 16 weeks.

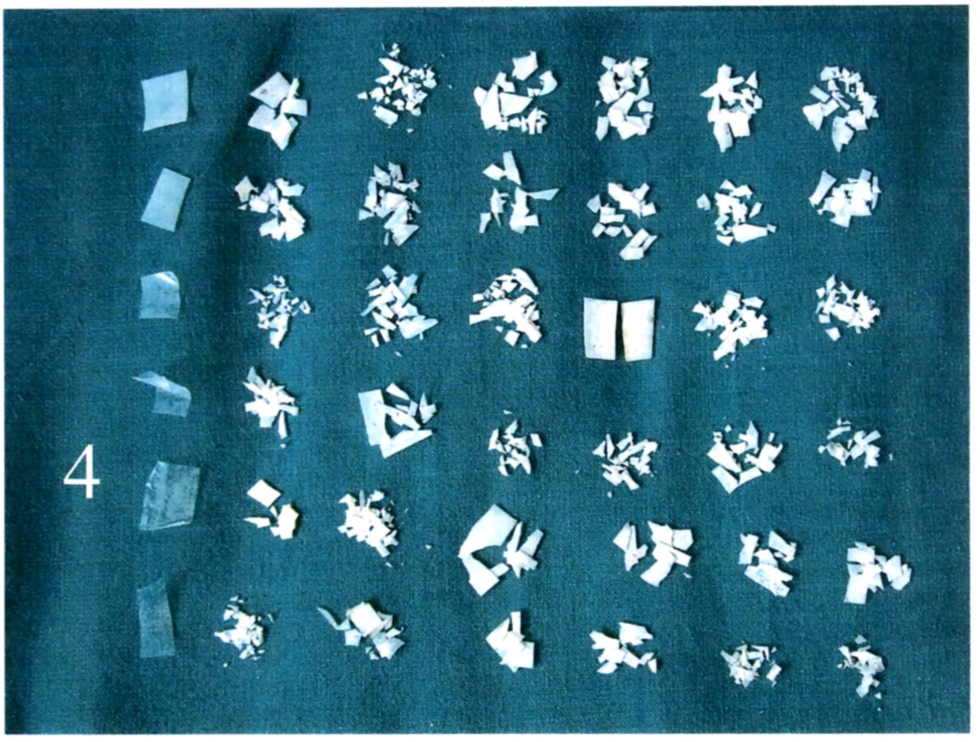


TABLE 4.29: KEY TO THE SPECIMEN IN PHOTOGRAPH 4.33

Original specimen	Specimen in Pseudo monas aeruginosa	Specimen in Staphylo coccus	Specimen in E-Coli	Specimen in Aspergillus niger	Specimen in Rhizopus	Specimen in Consor tium
HD00	HD00	HD00	HD00	HD00	HD00	HD00
HDS5	HDS5	HDS5	HDS5	HDS5	HDS5	HDS5
HDS10	HDS10	HDS10	HDS10	HDS10	HDS10	HDS10
HDS15	HDS15	HDS15	HDS15	HDS15	HDS15	HDS15
HDS20	HDS20	HDS20	HDS20	HDS20	HDS20	HDS20
HDS25	HDS25	HDS25	HDS25	HDS25	HDS25	HDS25

Photograph: 4.34 PS specimens after exposure to microorganism for 16 weeks.

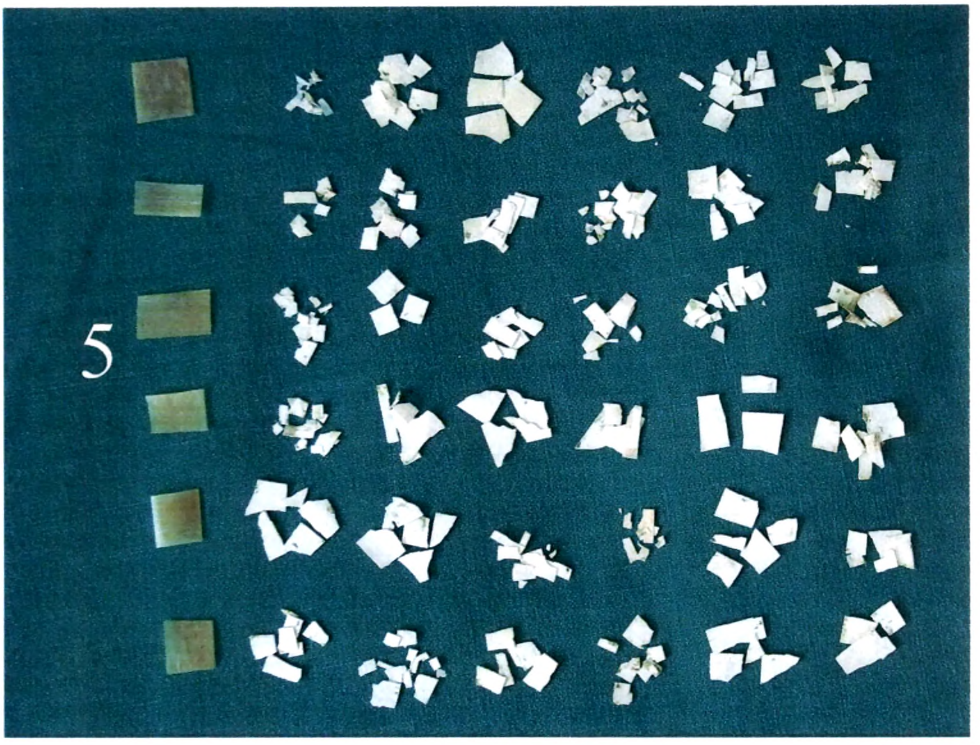


TABLE 4.30: KEY TO THE SPECIMEN IN PHOTOGRAPH 4.34

Original specimen	Specimen in Pseudo monas aeruginosa	Specimen in Staphylo coccus	Specimen in E-Coli	Specimen in Aspergillus niger	Specimen in Rhizopus	Specimen in Consor tium
PS00	PS00	PS00	PS00	PS00	PS00	PS00
PSG5	PSG5	PSG5	PSG5	PSG5	PSG5	PSG5
PSG10	PSG10	PSG10	PSG10	PSG10	PSG10	PSG10
PSG15	PSG15	PSG15	PSG15	PSG15	PSG15	PSG15
PSG20	PSG20	PSG20	PSG20	PSG20	PSG20	PSG20
PSG25	PSG25	PSG25	PSG25	PSG25	PSG25	PSG25

Photograph: 4.35 PS specimens after exposure to microorganism for 16
weeks.

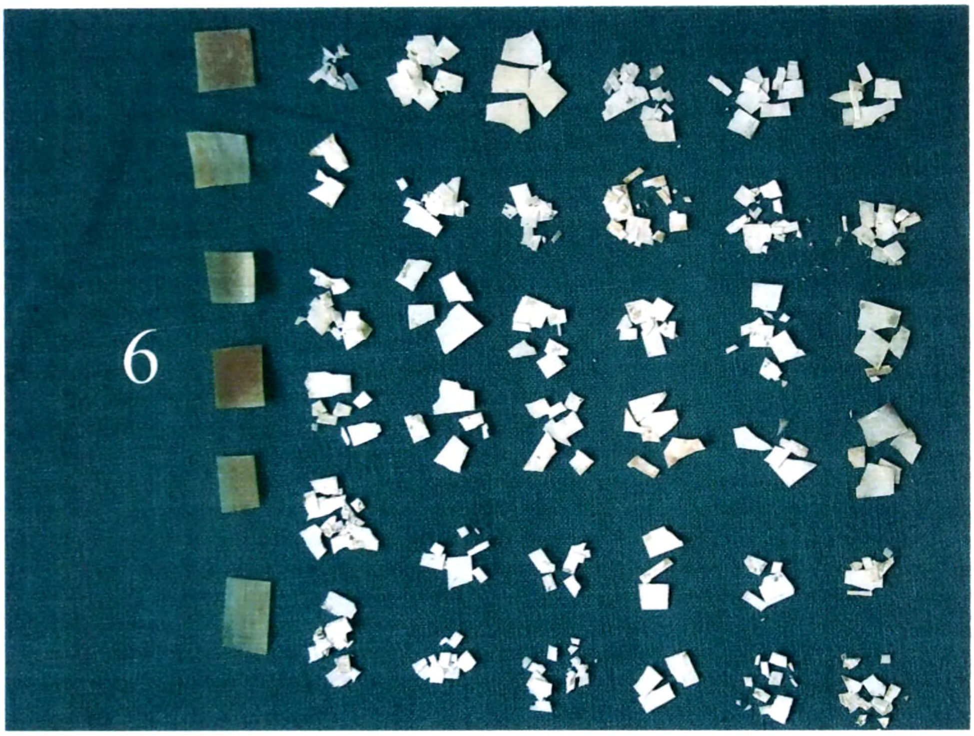


TABLE 4.31: KEY TO THE SPECIMEN IN PHOTOGRAPH 4.35

Original specimen	Specimen in Pseudo monas aeruginosa	Specimen in Staphylo coccus	Specimen in E-Coli	Specimen in Aspergillus niger	Specimen in Rhizopus	Specimen in Consor tium
PS00	PS00	PS00	PS00	PS00	PS00	PS00
PSS5	PSS5	PSS5	PSS5	PSS5	PSS5	PSS5
PSS10	PSS10	PSS10	PSS10	PSS10	PSS10	PSS10
PSS15	PSS15	PSS15	PSS15	PSS15	PSS15	PSS15
PSS20	PSS20	PSS20	PSS20	PSS20	PSS20	PSS20
PSS25	PSS25	PSS25	PSS25	PSS25	PSS25	PSS25

Photograph: 4.36 PP specimens after exposure to microorganism for 16 weeks.

TABLE 4.32: KEY TO THE SPECIMEN IN PHOTOGRAPH 4.36

Original specimen	Specimen in Pseudo monas aeruginosa	Specimen in Staphylo coccus	Specimen in E-Coli	Specimen in Aspergillus niger	Specimen in Rhizopus	Specimen in Consor tium
PP00	PP00	PP00	PP00	PP00	PP00	PP00
PPG5	PPG5	PPG5	PPG5	PPG5	PPG5	PPG5
PPG10	PPG10	PPG10	PPG10	PPG10	PPG10	PPG10
PPG15	PPG15	PPG15	PPG15	PPG15	PPG15	PPG15
PPG20	PPG20	PPG20	PPG20	PPG20	PPG20	PPG20
PPG25	PPG25	PPG25	PPG25	PPG25	PPG25	PPG25

Photograph: 4.37 PP specimens after exposure to microorganism for 16 weeks.

TABLE 4.33: KEY TO THE SPECIMEN IN PHOTOGRAPH 4.37

Original specimen	Specimen in Pseudo monas aeruginosa	Specimen in Staphylo coccus	Specimen in E-Coli	Specimen in Aspergillus niger	Specimen in Rhizopus	Specimen in Consor tium
PP00	PP00	PP00	PP00	PP00	PP00	PP00
PPS5	PPS5	PPS5	PPS5	PPS5	PPS5	PPS5
PPS10	PPS10	PPS10	PPS10	PPS10	PPS10	PPS10
PPS15	PPS15	PPS15	PPS15	PPS15	PPS15	PPS15
PPS20	PPS20	PPS20	PPS20	PPS20	PPS20	PPS20
PPS25	PPS25	PPS25	PPS25	PPS25	PPS25	PPS25

4.3.1 ANALYSIS AND DISCUSSION FOR WEIGHT LOSS AFTER 16 WEEKS:

◊Weight loss between 5-70% was seen in each specimen. The weight loss with Aspergillus Niger as the base microorganism was highest with all specimens.

◊All 264 specimens were broken into fragments. This implies tremendous loss of tensile strength.

◊Though the weight loss was not very high, the environmental problem created by the non degradable film could be solved by fragmentation to some extent. This could be related with the biodegradability of the conventional biodegradable films available commercially wherein the starch, water soluble content or the naturally degradable polymer content is only consumed.

◊As seen from the Photographs the size of fragments of the specimen were very small and they were entangled by the microorganism and the corresponding biomass. Hence it was very difficult to separate the fragments from the medium containing biomass, microorganism and water.

◊Very fine fragments were not isolated from the medium and were considered as weight loss.

◊ The fragmentation of the un modified specimen and the breakage of nylon filament was also observed. A biological system comprising of a concentrated culture of specific microorganism, water, the specimen, the plasticizer and the atmospheric condition may have developed. This biological system may have supported the growth of some new flora of microorganism that could consume the unmodified polymer as the sole source of nutrition.

◊A study related to identification of microorganism, their change in structure would be interesting. Hence the test for identification of microorganism was carried out.

4.4 RESULTS FROM GROWTH RATINGS ASTM G - 21

After 4 weeks the samples are observed for the % growth of the microorganism on the specimens.

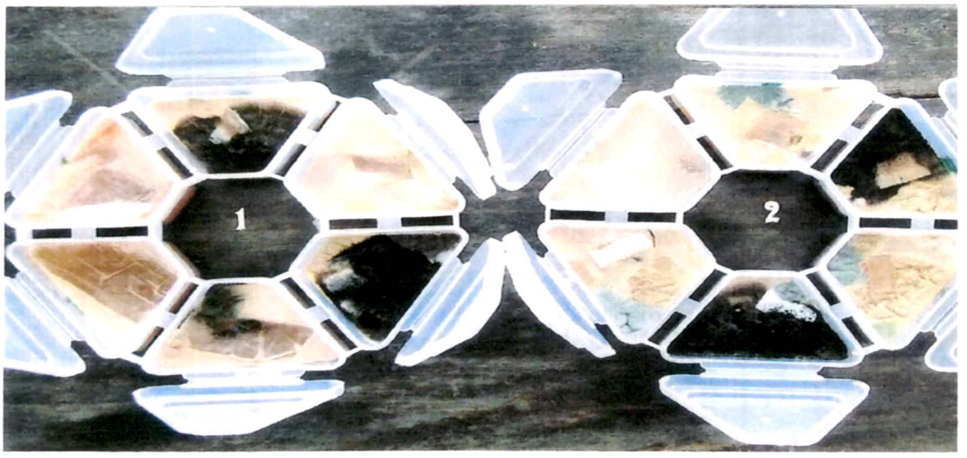
TABLE 4.34: PERCENT GROWTH OF MICROORGANISM ON SPECIMEN

SR. NO.	SPECIMEN	PERCENT GROWTH ON SPECIMEN	COLOUR OF GROWTH	APPARENT MICROORGANISM
1.	LDOO	Growth surrounds the specimen	Yellow spore	Aspergillus niger
2.	LDG25	100%	Black spore	Aspergillus niger
3.	LDS25	100%	Black spore	Aspergillus niger
4.	HDOO	Growth surrounds the specimen	Black spore	Aspergillus niger
5.	HDG25	Growth surrounds the specimen	Grey/"DIRTY" greenish	Aspergillus niger/Pennicillium
6.	HDS25	100%	Black spore	Aspergillus niger
7.	PSOO	Growth surrounds the specimen	"DIRTY" yellow	Aspergillus niger/Pennicillium
8.	PSG25	100%	Black spore	Aspergillus niger
9.	PSS25	100%	"DIRTY"	Aspergillus

			yellow	niger/Pennicillium
10.	PPOO	Growth surrounds the specimen	White fungal base+ "DIRTY" green	Unknown fungi + Aspergillus niger
11.	PPG25	Growth surrounds the specimen	"DIRTY" yellow with white spots	Unknown fungi
12.	PPS25	100%	Black/brown spore	Aspergillus niger

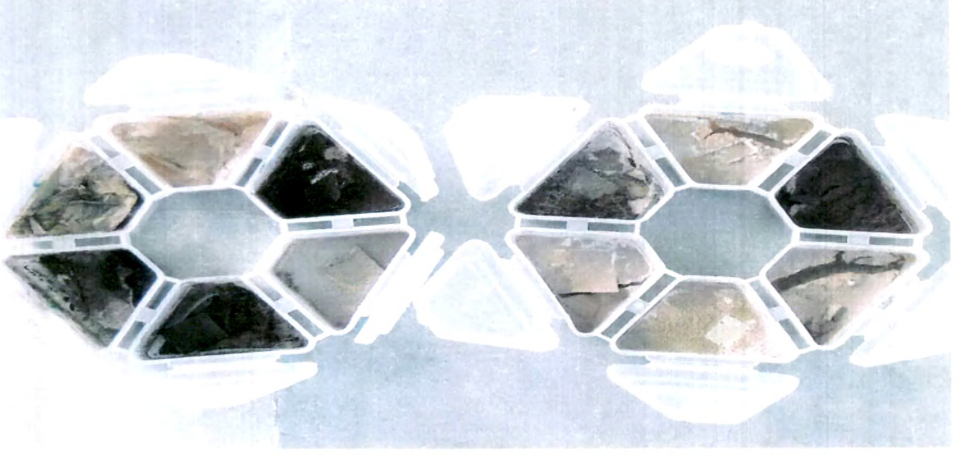
Photograph 4.38:

Growth on specimen after 1 week in growth ratings ASTM G - 21



Photograph 4.39:

Growth on specimen after 4 week in growth ratings ASTM G - 21



4.4.1 ANALYSIS AND DISCUSSION FOR GROWTH RATING:

◊Modified specimen shows 100% of growth. With HDG25 and PPG25 the growth surrounds the specimen but the specimen was clearly seen. Unmodified specimen shows growth surrounding the specimen but the specimen was clearly seen.

◊Different structures of microorganism have grown on different specimen because microorganisms responsible for the degradation differ from each other and they have their own optimal growth conditions. Also the type of nutrition affects the growth, and the structure of microorganism.

◊Microorganism from the environment may also have grown due to the type of nutrition available.

◊It would be interesting to study the structure of different microorganism grown on the specimen.

4.5 STUDY OF THE STRUCTURE OF VARIOUS MICROORGANISMS:

Individual microorganism slants were prepared from the growth in specimen No. 1- LD00, 2- LDG25, 5- HDG25, 9-PSS25, 10- PP00, 11-PPG25 and 12- PPS25 to develop colony of growth from individual microorganism. The structure of the microorganisms were studied and compared with those of the original specie with the help of Photographs. The Photographs were taken with 100x magnification and 450 x magnifications.

Photograph 4.40:

Colony growth of microorganism on slants for the study of the structure of various microorganisms: Different colors of microorganisms were seen.

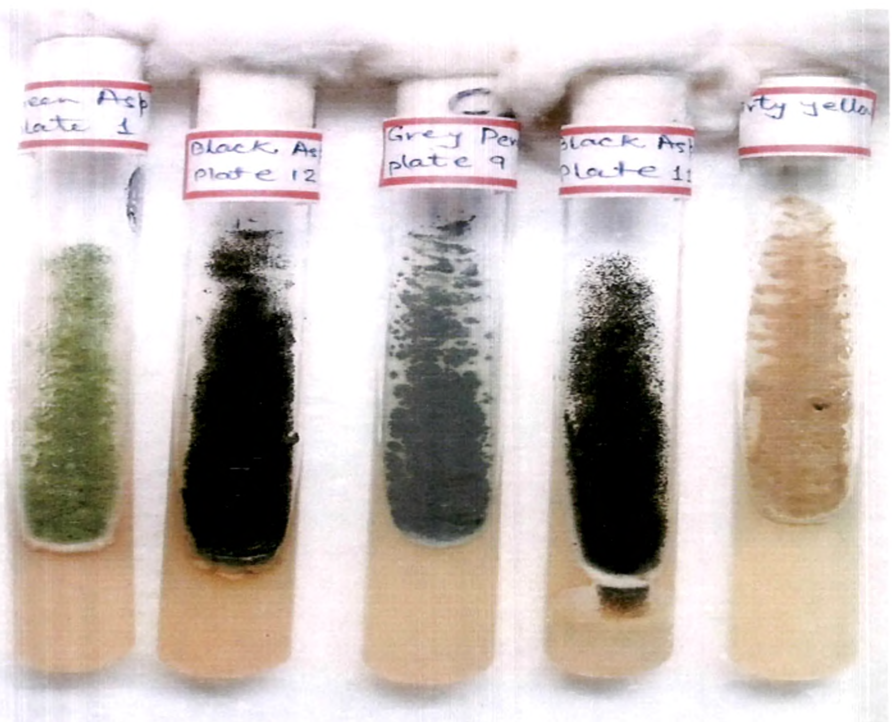
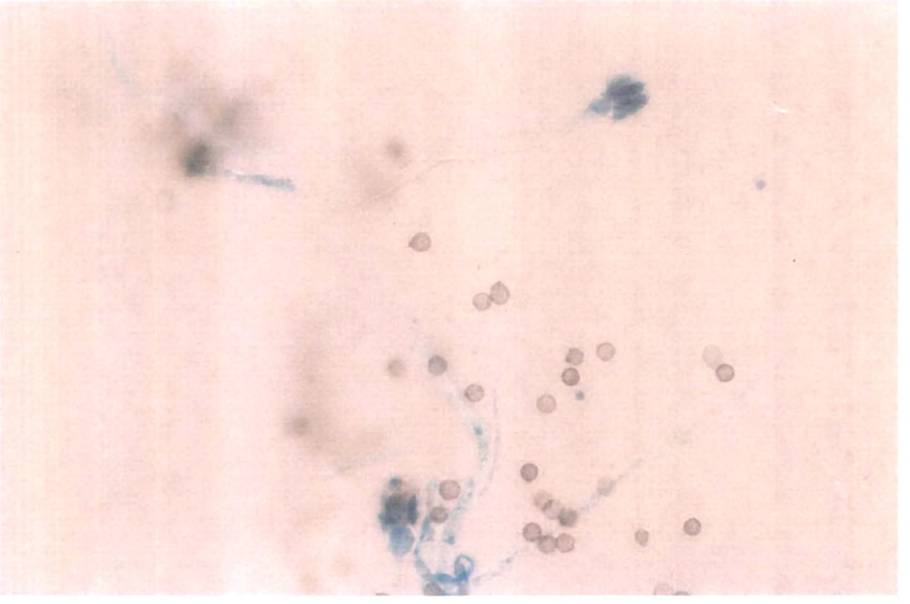


TABLE 4.35: IDENTIFICATION OF MICROORGANISM FROM THE COLOUR OF GROWTH

PHOTO NO.	COLOR OF GROWTH	MAGNIFICATION	MICROORGANISM
41.	BROWN	100	Aspergillus niger
42.	BROWN	450	Aspergillus niger
43.	WHITE	100	Unidentified fungi
44.	WHITE	450	Unidentified fungi
45.	GREEN	100	Aspergillus fumigatus
46.	BLACK	100	Aspergillus Niger
47.	BLACK	450	Aspergillus Niger
48.	GREY	100	Aspergillus ustus
49.	GREY	450	Aspergillus ustus
50.	"DIRTY" YELLOW	100	Unidentified fungi
51.	"DIRTY" YELLOW	450 SPORES	Spores of Unidentified fungi
52.	"DIRTY" YELLOW	450 STRUCTURE	Structure of Unidentified fungi
53.	"DIRTY" YELLOW	100	Paecilomyces specie
54.	"DIRTY" YELLOW	450 STRUCTURE	Structure of Paecilomyces specie

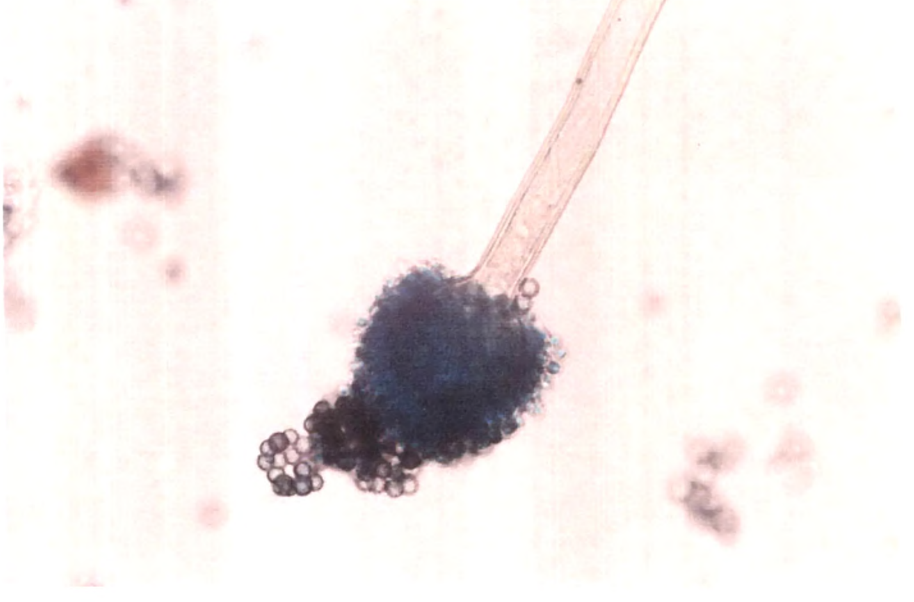
Photograph 4.41:

Brown aspergillus niger with magnification of 100x



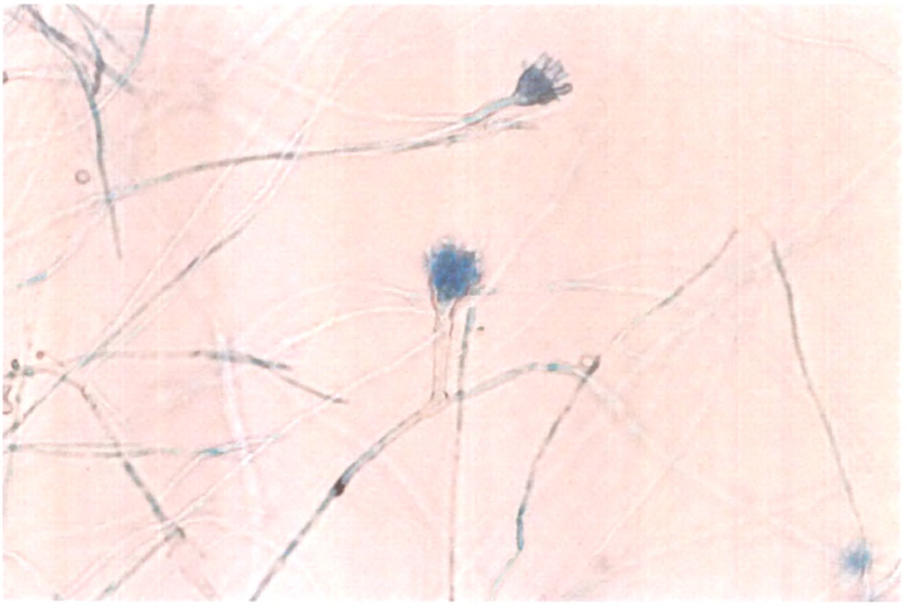
Photograph 4.42:

Brown aspergillus niger with magnification of 450x



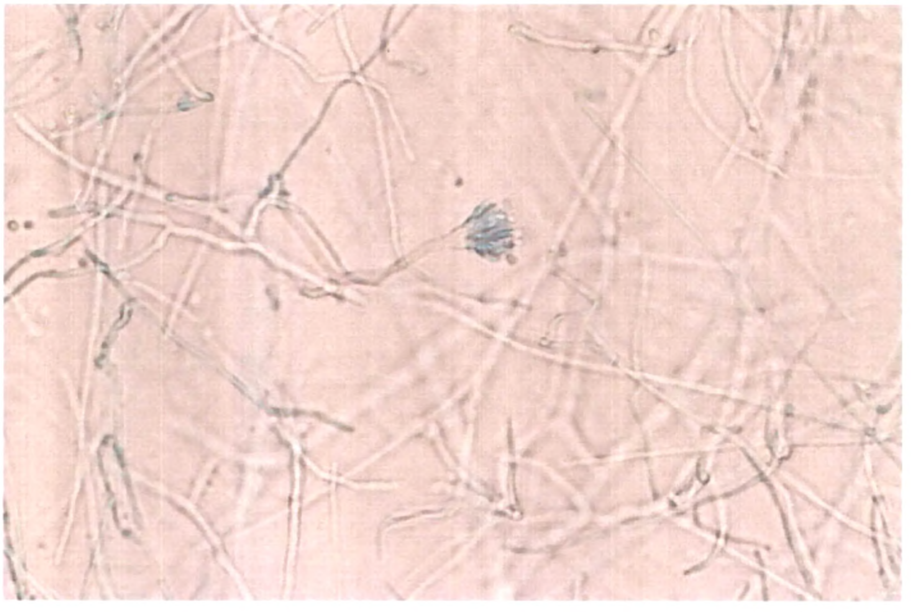
Photograph 4.43:

White unidentified fungi with magnification of 100x



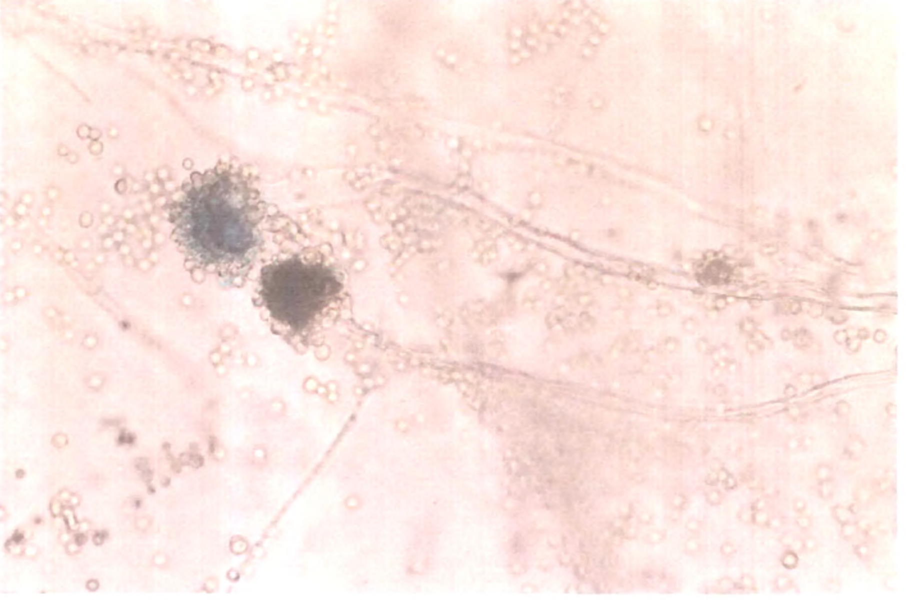
Photograph 4.44:

White unidentified fungi with magnification of 450x



Photograph 4.45:

Green aspergillus fumigatus with magnification of 100x

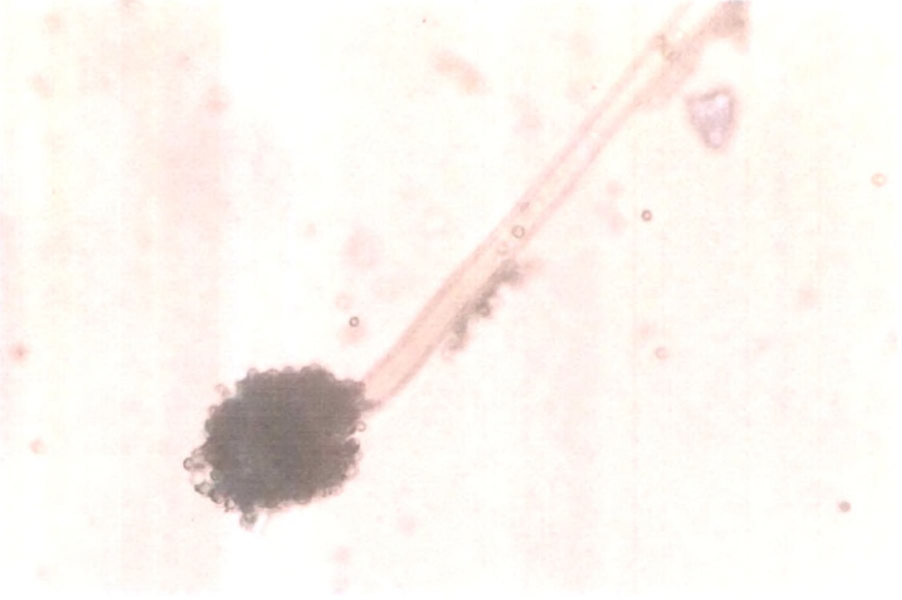


Photograph 4.46:

Black aspergillus niger with magnification of 100x

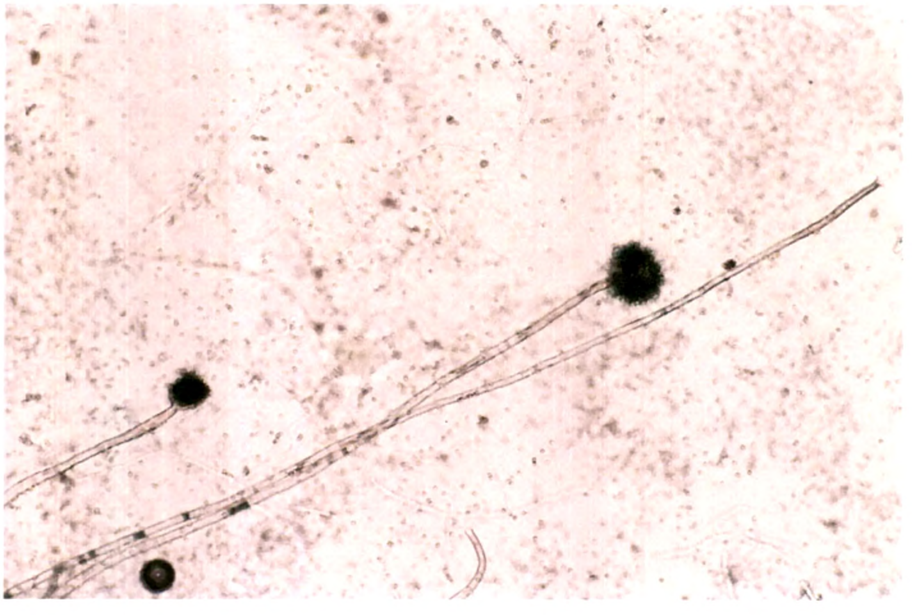
Photograph 4.47:

Black aspergillus niger with magnification of 450x



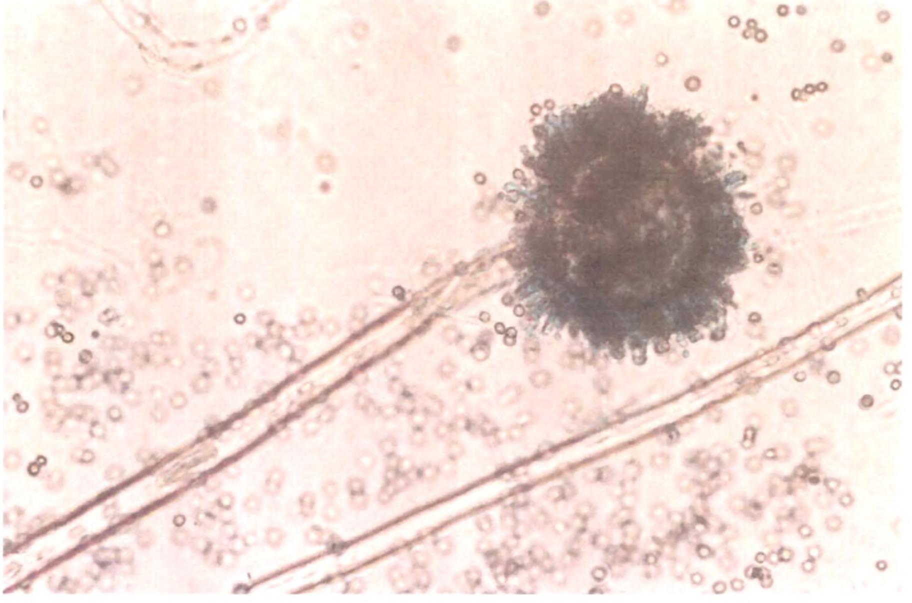
Photograph 4.48:

Grey aspergillus ustus with magnification of 100x



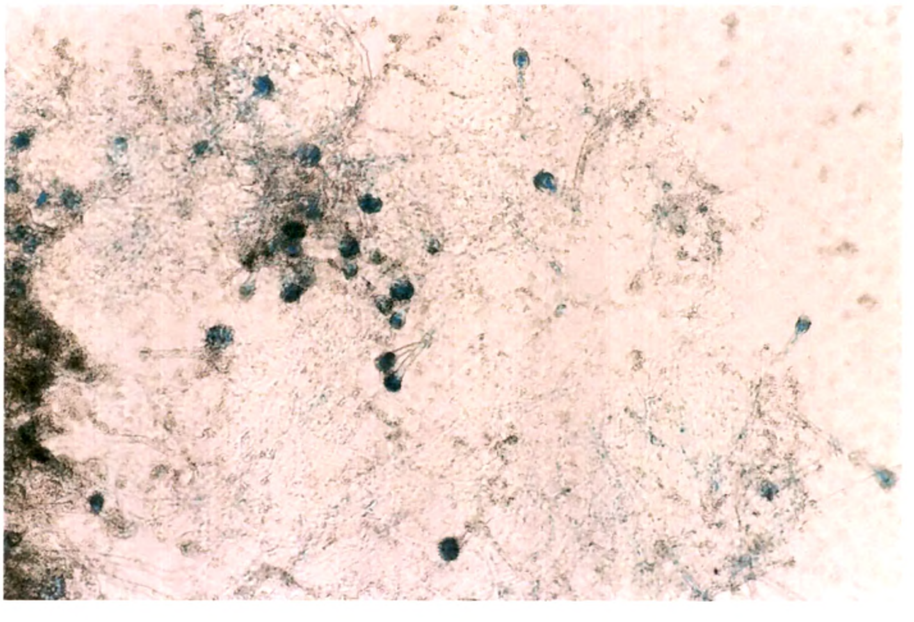
Photograph 4.49:

Grey aspergillus ustus with magnification of 450x



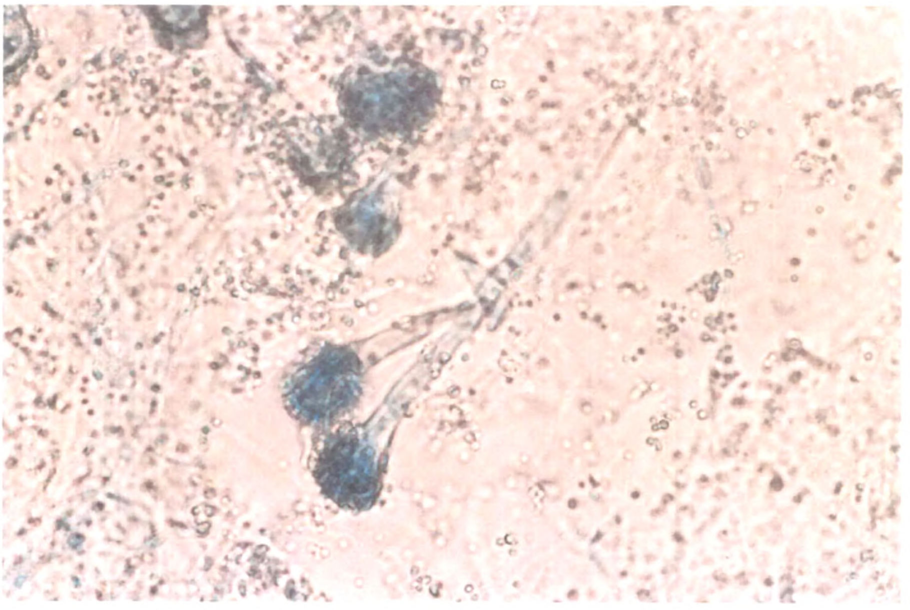
Photograph 4.50:

"Dirty" yellow unidentified fungi with magnification of 100x



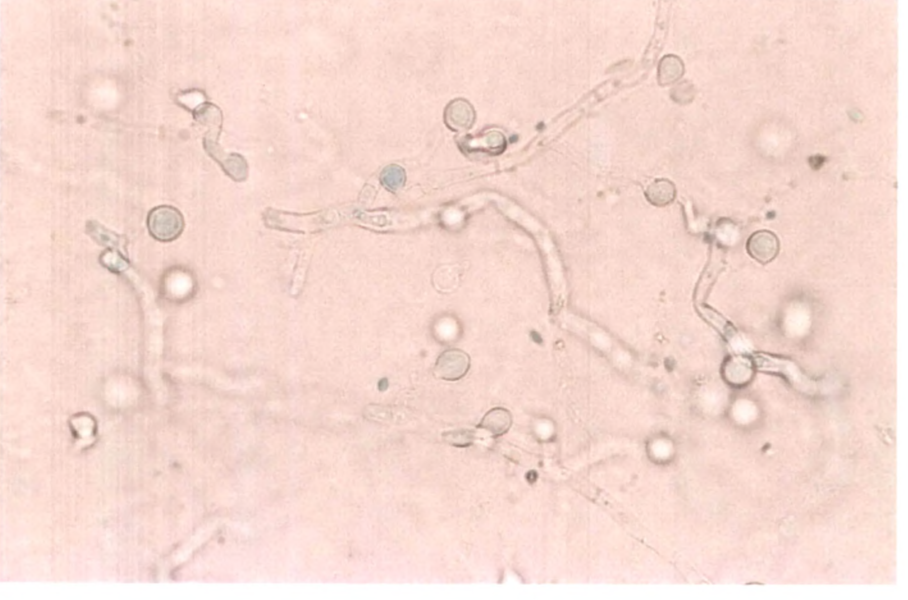
Photograph 4.51:

Spores of "Dirty" yellow unidentified fungi with magnification of 450x



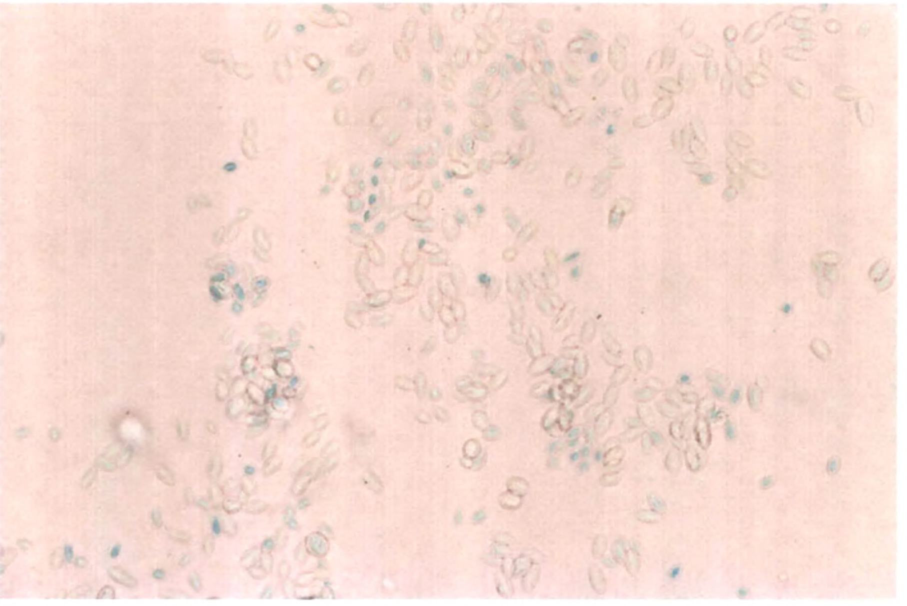
Photograph 4.52:

Structure of "Dirty" yellow unidentified fungi with magnification of 450x



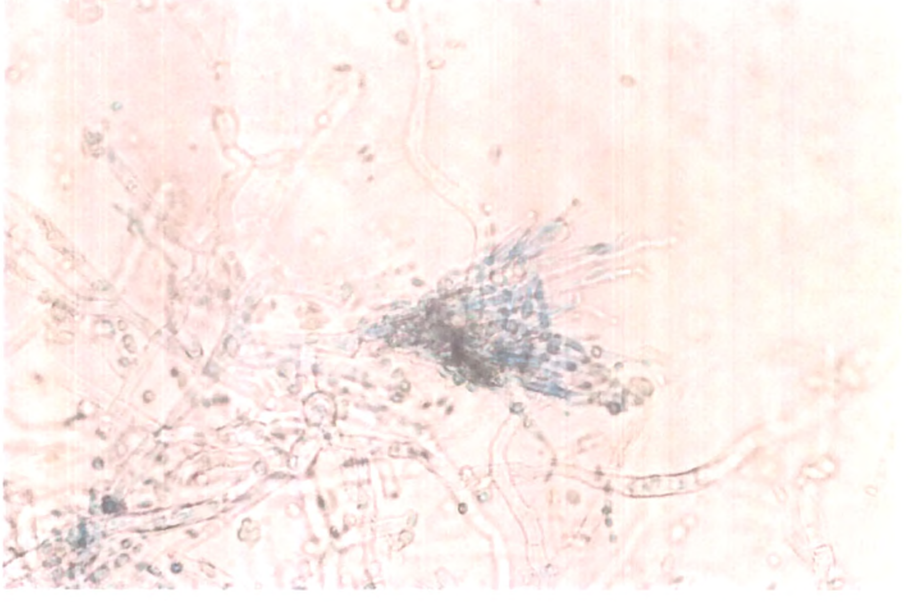
Photograph 4.53:

"Dirty" yellow paecilomyces specie with magnification of 100x



Photograph 4.54:

Structure of "dirty" yellow paecilomyces specie with magnification of 450x



4.5.1 ANALYSIS AND DISCUSSION FOR STRUCTURE OF MICROORGANISM:

The structure of the microorganisms that were initially used was changed.

The different specie of Aspergillus fungi was formed. This could be due to the change in nature of the nutrition available to the microorganism.

Aspergillus Niger was formed with LDPE and PS, Aspergillus fumigatus was formed with HDPE, Aspergillus ustus was formed with PP. Also some unidentified fungi have developed.

It would be interesting from the microbiology point of view to identify the exact microorganism specie.

The present study only required the structure of the microorganism affecting the biodegradability of the polymer. The study of growth of such microorganism at the laboratory scale and the factors affecting there growth would be interesting from the microbiology point of view.

4.6 RESULTS FROM PLANT TOXICITY TEST:

◊ After 21 days the growth of fenugreek was seen and the Photograph of degraded plasticized LDPE film was taken.

◊ In the same soil palakh (a kind of leafy vegetable) was seeded over plasticized LDPE films.

◊ After 3 months the growth of vegetable was seen and the Photograph of degraded plasticized LDPE film was taken.

◊ The growth of the vegetables was satisfactory. Hence the soil burial of LDPE film retains the fertility of the land.

◊ The original soil and the soil after degradation of the plasticized LDPE films was tested for the fertility i.e. soil value was measured.

Photograph 4.55:

Growth of fenugreek after 21 days: Shows satisfactory growth of vegetables.

Photograph 4.56:

Degraded plasticized LDPE film after 21 days

Photograph 4.57:

Growth of vegetable after 3 months: The growth of vegetable was satisfactory.

Photograph 4.58:

Degraded plasticized LDPE film after 3 months: The traces of film were seen as white powder.

Photograph 4.59:

Soil containing the traces of plasticized LDPE film

The traces of film were clearly seen as white powder.

4.6.1 ANALYSIS AND DISCUSSION FOR PLANT TOXICITY TEST:

The test result shows the complete degradation of polymer film after 3 months and traces of fine powder was observed. The growth of vegetables was not adversely affected by the soil burial of film. Thus land filling of the plasticized film could be possible. This could resolve the environmental problem to a greater extent. Also the plasticized film when buried in the soil would act as mulch film and the advantage of mulch film like lower weed growth, less consumption of water etc. could be achieved.

4.7 RESULT FORM SOIL ANALYSIS TEST:

The soil before the burial of the film and after the burial of film for 3 months were analyzed to measure the changes in the carbon content of the soil due to the burial of the film.

TABLE 4.36: SOIL ANALYSIS:

SOIL PROPERTY	INITIAL VALUE	VALUE AFTER 3 MONTHS	REMARKS
ELECTRICAL CONDUCTIVITY	0.20	0.21	ORGANIC CARBON CONTENT WAS FOUND EXTRAORDINARILY HIGH.
PH	7.7	7.6	
ORGANIC CARBON	0.31	0.95	
P2O5	47	44	
K2O	430	450	

4.7.1 ANALYSIS AND DISCUSSION FOR SOIL TESTING:

◊ The plant toxicity test and the soil analysis show the increase in the carbon value of soil from 0.31% to 0.95%. Hence it could be inferred that the degradation of the polymer do not adversely affect the soil or its fertility.

◊With the increase in the carbon content of the soil it could also be inferred that the residue of the plasticized degraded LDPE films contain carbon structure.

◊After 21 days holes were observed in the film and the film lost the strength and the film was torn. Thus the film would act as mulch film till the vegetable growth was completed.