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IN VITRO STUDY OF MINERALIZATION IN A MARKET GARDENING GROUND OF PHOTODEGRADABLE FILM OF POLYETHYLENE MULCHING : CASE OF ENDE PLAST

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Abstract

The use of the plastics experienced a considerable development these last decades in all the spheres of economic activity. One of the characteristics particularly interesting of the plastics is to be only with difficulty degradable for certain applications. However, elimination can pose problems in the sewage farms. The adopted solutions (incineration, composting, controlled discharge) present major disadvantages in particular the polluting gas emission at the time of the incineration. In the case of the applications leading to a great dispersion of this material which is thrown in nature in the form of "waste sauvage" constituting a visual pollution very badly felt aesthetically like the case of films used in agricultural mulching. To rectify such a situation an interesting solution among so much of others was proposed. It consists with the development polymer film easily degradable by the solar U.V and the telluric flora. The description of the modifications of the mechanical properties of these films, thanks to the additives containing iron stearate according to the Ende-plast process, thus will weaken film in small pieces which are then reinstated in the ground during the ploughings. In order to answer on becoming it of these pieces of film in the ground, we directed this present study on the telluric phenomenon of biological breakdown of these polymers. Using tests led to the laboratory thanks to a device of aerobic incubation we studied the mineralization of the organic matter of a market-gardening ground and added substances which are the glucose and of the photo polyethylene artificially degraded under lamps U.V. the experimental results obtained make believe that the degraded photo plastics conceal a positive effect on the mineralisatrice activity of the ground. They do not induce in any moment an inhibition of the biological activity. The results still showed that some is the amount of the substances incorporated on the ground their curves of total mineralization remain with the top of that of the witness (ground). This is probably due to the additives containing iron stearate which are easily metabolisable by the micro-organisms of the ground.

Keywords: Polymer; Polyethylene; Film photodegradable; Bio deterioration; Mineralization; Ground; Pollution.

1. Introduction

The attack of synthetic polymers by biological way is not possible that if a preliminary chemical degradation decreases the molecular weight of the polymer [1]. It results a fall from it from the physical properties and mechanical of this last. Exposed a polyethylene film for example outside to ultra purple solar, weakens and splits up in small pieces. This effect is a disadvantage for certain applications. On the other hand at others, this degradation is of technical interest as in the cases of agricultural mulching. In this case, the films degradable are advised to eliminate visual pollution quickly and certain embarrassments for the following cultures and become consequently easily assimilable by the micro-organisms of ground [2-3-4]. The reaction is named "biodeterioration" if it is considered non desirable. On the other hand if the reaction is desirable because it results from the mineralization of the pollutants (polymeric) it is named "biological breakdown [5]. Within the framework of this work we were interested more particularly in the problem of biological breakdown thanks to tests led to the laboratory in order to make a comparative study of the phenomenon of biological breakdown of the organic matter of a market-gardening ground and added susbances: glucose, irradiated polyethylene (Ende-plast). This in situ experiment consists has to study the mineralization of the organic matter of the ground and the substances added under controlled parameters which are moisture and the temperature which have a very great influence on the microbial activity of the ground [6-7-8] .

2. Materials and methods

Ground of reference: we used a market-gardening ground of firm pilot of El Harrouch to 30 kilometers of the place head of the wilaya of

Skikda, located at the Algerian North-East. It is about a ground of the horizon of surface (Ap) a depth of 20cm. This ground of reference was subjected to a chemical physico characterization to the laboratory including/ understanding granulometry (method of the pipette of Robinson), the pH (electrometric method), the total nitrogen (method of Kjeldahl, organic carbon (Anne method). It is about a ground with argilo-muddy texture having a pH slightly basic. The rate of the organic matter is rather high good provided in humus table1**.**

Soil of reference	A %	L %	S %	pH	C %	MO %	N %	C/N
Sol d'horizon de surface (Ap) (0 - 20) cm	33	34,4	32,4	Eau 7,8 Kcl 7,3	1,65	2,84	0,125	13,2

Table1: Characteristic physico-chemical of the ground of reference.

Substances incorporated on the ground: we took a substance of reference represented by the glucose which is easily degradable by the telluric microflore. With regard to the plastic photodegradable (Ende plast), it is about a polyethylene film of low density (P.E.B.D) of 30µ thickness containing a main mixture (additive) containing iron stearate. This type of polymer is composed of total carbon 84%. The polyethylene film was irradiated beforehand artificially under lamps ultra violets lasting approximately about fifteen days is approximately 310 hours. Before its incorporation in the ground the irradiated polyethylene film was crushed with the mortar in very fine powder of a few microns**.**

3. Experimental method and conditions

The study of the mineralization of the photodegraded polyethylene incorporated on the ground required a device described by [9-10-11]. It is based on incubation in aerobe at ambient temperature. It makes it possible to daily measure the quantity of carbon dioxide coming in major part of the organic matter mineralized by the telluric microflore Fig.1a. In this experiment we adopted the technique used by [12-13] which consists in using erlens with hermetic closing. Each erlens of 500 ml receives a quantity of ground corresponding to 100g of dry ground. The substances to be incubated are added and mixed on the ground with the respective amounts: 250 kg/ha, 2500 kg/ha, 12500 kg/ha are 0,01g/100g of ground, 0,1g/100g and 0,5g/100g of ground. The moisture of the ground is then brought back to 80 % of the water holding capacity Fig.1b. Emitted carbon dioxide is absorbed by a quantity of soda (N/2) contained in an erlenmeyer of 100 ml Fig.1c.

The use of barium chloride 1% ($Bacl_{2)}$ will precipitate the sodium carbonate formed according to following reactions:

$$2\ NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$
$$Na_2CO_3 + Bacl_2 \longrightarrow 2\ Nacl + BaCO_3$$

The proportioning of soda in excess is titrated with the hydrochloric acid (N/5) in the presence of phénolphtaléïne according to the following reaction:

$$Hcl + NaOH \longrightarrow Nacl + H_2O$$

Each treatment comprises three repetitions and incubation lasted 50 days.

4. Expression of results

In order to compare on the one hand the metabolic activity of the ground in the presence of the three polyethylene amounts and of the substance of reference (glucose) and another share the faculty to the mineralization of the latter, we calculated values every two days for each treatment except the holidays (Friday and festivals). We thus calculated the total rate of mineralization (T.M.G.) and the rate of complementary mineralization weekly (T.M.C.).

$$T.M.G = \frac{\text{Mg/carbon given off (enriched ground)}}{\text{Mg/carbon of the ground + Mg/carbon introduces}}$$

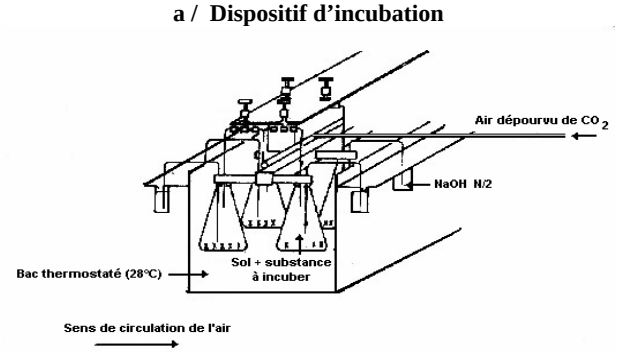
$$T.M.G = \frac{\text{released carbon} - \text{carbon given off}}{\text{carbon introduced } \textit{(glucose or polyethylene)}}$$

$$T.M.G = \frac{\textit{(enriched ground)} - \textit{(pilot ground)}}{\text{carbon introduced } \textit{(glucose or polyethylene)}}$$

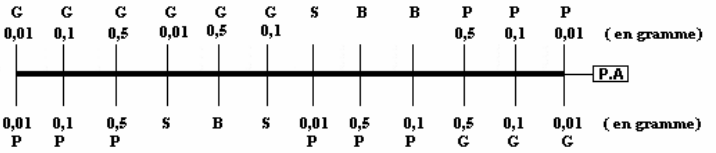
5. Results and discussion

Comparative evolution of the rate of total mineralization (T.M.G) of the ground and the various substrates. All incubations of the ground and the various substrates were led at the same time. We thus obtained curves of mineralization for each compared polyethylene photodegradable sample has the substance of reference which is glucose. In a general way we note a rate of mineralization total (T.M.G) definitely higher than the witness represented by the ground table 2. Fig. 2.

a / Dispositif d'incubation

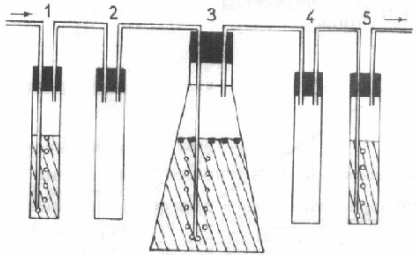


b / Schéma sur la disposition des erlens à incuber



G : Glucose - **S** : Sol (Témoin) - **P** : Plastique (Ende-plast) - **B** : Blanc (erlenmeyer vide)
P.A : Pompe à air humidifié et purifié du CO_2

c / Equipement de culture



Flacon 1 et 5 : solution de NaOH (N/2)
Flacon 2 et 4 : flacons vides « soupapes de sécurité »
Flacon 3 : unité de milieu contenant l'échantillon

Figure 1: Experimental protocol.

The curves of mineralization day labourer present successive peaks corresponding to as many metabolic stages ensured by microbial waves various [12-14]. We notice that the outburst of carbon dioxide is very significant during the first week of incubation. This reaction is probably due to the fact that the organic substrates are rich in easily fermentable substances. During the week which follows, a clear decrease due appears has the exhaustion of the studied substrates, this decrease is followed at once by a second resumption of mineralization because of certain newly formed products at the time of the first week of incubation. During this phase, the micro-organisms of the ground attack not only the pre-existent organic matter, but also the newly formed products. Finally we observe a last phase of slow and regular mineralization until the end of incubation. This stage corresponds to the stabilization of the product newly formed (humus) like to the exhaustion of the easily biodegradable substances. We note in a general way, some is the concentration of the substrates added on the ground, graphically they answer the phenomenon accurately described above (figure 1a, 3b, 3c). In the three cases, the substance of reference (glucose) is mineralized more quickly than the witness (ground) and the plastic.

Samples / T(°C)	Days	Temoin (Sol)	Glucose 0,5 g	Glucose 0,1 g	Glucose 0,01 g	Plastique 0,5 g	Plastique 0,1 g	Plastique 0,01 g
28	1	0,039	0,330	0,113	0,183	0,069	0,065	0,065
27	4	0,065	0,502	0,264	0,227	0,154	0,066	0,126
27	6	0,097	0,291	0,124	0,188	0,139	0,018	0,162
26	8	0,120	0,292	0,133	0,155	0,127	0,130	0,124
26	11	0,102	0,155	0,149	0,139	0,104	0,104	0,103
26	13	0,084	0,176	0,088	0,149	0,127	0,128	0,136
25	15	0,119	0,140	0,144	0,168	0,120	0,136	0,168
23	17	0,038	0,046	0,043	0,122	0,043	0,057	0,039
25	19	0,029	0,057	0,080	0,105	0,052	0,072	0,050
25	21	0,050	0,064	0,070	0,065	0,063	0,080	0,053
23	25	0,032	0,057	0,036	0,035	0,050	0,094	0,057
26	27	0,029	0,048	0,033	0,032	0,046	0,058	0,053
25	29	0,030	0,043	0,039	0,032	0,044	0,055	0,061
23	33	0,032	0,040	0,035	0,032	0,043	0,047	0,053
24	35	0,026	0,037	0,030	0,028	0,043	0,028	0,030
24	39	0,026	0,035	0,030	0,028	0,050	0,039	0,038
24	41	0,024	0,030	0,026	0,026	0,036	0,032	0,034
23	43	0,019	0,026	0,022	0,025	0,035	0,030	0,026
23	45	0,019	0,026	0,022	0,020	0,030	0,028	0,026
23	47	0,016	0,020	0,018	0,018	0,030	0,028	0,020
23	51	0,011	0,019	0,015	0,013	0,024	0,200	0,018

Table 2: Comparative evolution of the rate of total mineralization (T.M.G) of the ground and the various substrates.

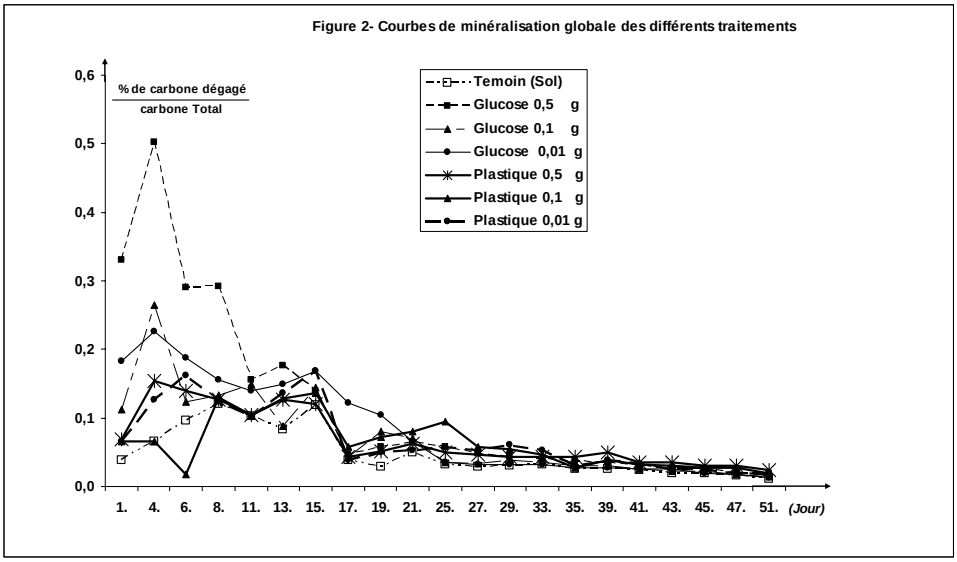


Figure 2: Curves of global mineralization of the different treatments.

At the beginning of the first week of incubation the plastic 0.5 G, 0.1et 0.01g is mineralized more quickly than the reference (ground). This can be explained by the fact why plastic contains additives containing iron stearate which is a substance easily metabolisable. Follow-up of the complementary rate of mineralization.The complementary rate of mineralization represents the difference between the quantities of carbon dioxide released by the witness (ground) and the ground enriched by the substrate to incubate. This difference does not represent in an exact way the real biological breakdown of the substrate incorporated on the ground. But it is not useless

to recall that the complementary rate of mineralization makes it possible to envisage the aptitude for mineralization in the ground of different the substrate studied and to determine their speed of disappearance by biological breakdown. Table 3 corresponds to the rate of mineralization complementary to the various substrates to 7,14,21,28,35,42 and 49 days.

	7ème	14ème	21ème	28ème	35ème	42ème	49ème
Glucose 0,5 g	5,03	6,28	6,58	6,83	6,95	7,06	7,15
Glucose 0,1 g	7,65	9,37	11,57	11,84	12,09	12,29	12,49
Glucose 0,01g	26,30	28,25	30,28	35,75	38,46	40,54	45,60
Plastique 0,5 g	0,40	0,51	0,61	0,71	0,80	0,90	1,00
Plastique 0,1 g	1,32	2,04	3,25	4,49	4,84	5,16	5,52
Plastique 0,01g	16,50	22,39	24,25	26,32	27,36	30,20	32,37

Table3: Comparison of the complementary rate of mineralization at the end of 49 days.

According to data's we can make the classification of the complementary rate of mineralization according to glucose 0,01g + plastic 0,1g, glucose 0,1g, plastic 0,1g, and finally plastic glucose 0,5g. We will notice in a general way that the glucose which is natural organic substance compared has to us mineralization complementary superior to the plastic.

6. Conclusion

According to experimental results' obtained we can think that the plastics conceal a positive effect on the mineralisatrice activity of the ground. Indeed, the plastics do not induce in any moment an inhibition of the biological activity of the ground as we note it on the curves of total mineralization (T.M.G) some is the introduced amount; the curves of those are located at the top of that of the witness. If however the glucose which is a natural organic substance were easily metabolisable during all the incubation period, this remains valid for the plastic only with the course des10 first days of mineralization where all the additive containing iron stearate is metabolized. Thus the plastic caused a strong microbial activity which appeared during 4th and the 6th day of incubation. It would be interesting to consider studies on the accumulatif effect in the long run of the plastics photodegradable on the chemical physico properties of the ground and the studies of identification of the microbial stocks of the ground which have a great affinity for the studied plastic substrates.

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