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IMPACT OF CHAD-CAMEROON PIPELINE IN LITTER DECOMPOSITION

Pierre Dieudonné Akama[1], Guy Josens[2]

[1] Département des sciences biologiques, Ecole normale supérieure, Université de Yaoundé I, BP 47 Yaoundé
[2] Université Libre de .Bruxelles, .Ecologie végétale et biogéochimie Av. Roosevelt, 50 - cp 244 Plaine 1C5-206 &1C6-113

Abstract: **The litter decomposition depends on the nature of the interactions between substrate degraded, fauna decomposition, microflora mineralizer and climate. Therefore an evaluation of Chad - Cameroon pipeline disturbance on the litter decomposition has been launched, taken a litter of *Milicia excelsa* as model. The studies were conducted in localities subjected to Chad-Cameroon pipeline disturbance respectively at Mbikiliki, Mbong Sol and Meidougou. The experimental design at each site, consisted of two blocks of 10 x 2 m with one located in the area affected by the work of the pipeline and the other at 32 m in the controlled area. Whole leaves were placed in the "litter bags", small bags of nylon mesh size of 0.5 and 2mm respectively. The result showed that among the macrofauna, termites were the most abundant. However, the rate of litter decomposition was mainly dependent on its chemical characteristics and the dimensions of the mesh size than the disturbance and the ecosystem variability. In addition in the three ecosystems, C/N ratio was slightly lower in disrupted area than in the controlled one.**

Keywords: **litter, disturbance, chad-Cameroon pipeline, termites.**

I. INTRODUCTION

Energy flow and nutrient cycling are essential to the functioning of the ecosystem. The analysis of the quality and quantity of litter is an important parameter for understanding the energy flow and nutrient cycling in forest ecosystems [1]. The litter decomposition depends on the nature of interactions between substrate degraded, fauna decomposition, microflora mineralizer and climate [2]. This process is the basis of many food chains, biogeochemical cycles and also the main source of energy for saprophytic fauna in forest soils. Hence, the litter decomposition is fundamental in nutrient cycling [3].

The knowledge of the chemistry of litter is fundamental to its decomposition. The chemical components influencing litter decomposition including lignin, polysaccharides and peptides. During this process, nutrients which are coming from the degradation of plant organic matter are recycled within the ecosystem [1, 4]. High lignin content favors the immobilization of nitrogen compounds. Changes in concentrations of lignin and polysaccharide (eg. cellulose) that occur during the first phase of litter decomposition are important because they allow a better understanding of the last stage of the decomposition process [5]. Lignin, is a polyphenolic compound, characterizing vascular plants [6].

Organisms that degrading lignin in the nature are mainly fungi; most of these species are Basidiomycotina [7]. These fungi degrade lignin through their extracellular enzymes including lignin peroxidases and manganese peroxidases [8]. There are many kinds of actinomycetes and eubacteria that can solubilized and modified the structure of lignin, but their ability to mineralize it is limited [9].

Moreover, lignin is also implicated as a major source of compounds used in the formation of humus [10]. Nitrogen is present in the heterocyclic structures such as nitriles. Gaps observed in structures of humic acids are sufficient to capture and bind molecules such as trisaccharides and hexapeptides to form the soil's humic complex [11]. As for fulvic acids, they represent the fraction of humic substances.

Nutrients release from faeces and decaying animals are called rapid cycling, while, the release of nutrients from sediments is called long cycle [1]. The soil macrofauna activity, including the production of biogenic structures stimulates the activity of microfauna and microflora, this relationship involves functional niche complementary between the two groups of organisms [12]. A reduction in the diversity of soil macrofauna causes a change in the structure and activity of the microflora and microfauna [13]. It has been suggested that the activity of soil fauna, especially that of termites, accelerates nutrient cycling through faeces and litter fragmentation [14]. Recent studies in Nigeria have shown that the effects of saprophytic organisms on the decomposition of leaf litter of *Leucaena leucocephala* are dependent on site conditions such as climate, pH, temperature and humidity [15]; these conditions affect invertebrate abundance and consequently the rate of decomposition of the litter. We can therefore expect that the mesoclimate change related to the infrastructure of the Chad-Cameroon influences the rate of litter decomposition. Termites are involved at two levels: they are consumers of litter (groups I and II) and organic matter degraded (groups III and IV). The present study aims to evaluate the influence of the Chad - Cameroon pipeline disturbance on the litter decomposition. Specifically we will:

Evaluate the impact of the disturbance of the pipeline on litter decomposition using litter of *Milicia excelsa* as a model;

Evaluate the influence of the disturbance on the dynamics of carbon and nitrogen in the litter Evaluate the intervention of the macrofauna in litter decomposition.

II. METHODS

2.1 Study sites:

The Chad-Cameroon pipeline is approximately 1069 km. It is designed to carry oil from Doba in Chad to Kribi in Cameroon coast. The studies were conducted in localities subjected to Chad-Cameroon pipeline respectively at Mbikiliki Mbong Sol and Meidougou (figure 1 and table 1):

2.2 Litter bags:

Milicia excelsa (Welw.) CC Berg (Moracea) leaves or iroko, were chosen in this experiment because this plant is present in all types of ecosystems in sub-saharian africa, from Gambia until Tanzania, on both sides of the equator at latitudes between 6°30' N to 23°29' S [16, 17] see figure 2; therefore the study of litter decomposition of this plant can be used as a model. Considering its results of chemical characterization, fresh tissue of *Milicia excelsa* contains 43.9% carbon and 0.4% nitrogen [18].

Milicia excelsa's leaves (iroko), recently fallen to the ground, were collected and dried in the open air for two weeks in the laboratory (ambient temperature of laboratory) and then in an oven at 40°C for 24 hours, and weighed until their mass becomes constant. Whole leaves were placed in the "litter bags", small bags of nylon mesh of 0.5or 2 mm, after being weighed, and each litter bag to contain 30 g of iroko leaf, weighed close to centigram. An experiment on the litter bags was conducted from 25/11/08 to 10/07/09; climatically, this period is characterized by the long dry season and the small rainy season for Mbikiliki and Mbong Sol sites, and the dry season and the beginning of the long rainy season for Meidougou sites.

The experimental design at each site, consisted of two blocks of 10 x 2 m with one located in the area affected by the work of the pipeline and the other at 32 m in the controlled area. In each plot, eight litter bags of 15 x10 cm were deposited at the surface, four (4) of 2 mm mesh size (M1) and the others four (4) of 0.5 mm mesh size (M0). The litter contained in bags of small mesh is subject to colonization and microbial degradation and the content in the large mesh bags (M_1) is subject to colonization and fragmentation of a part of soil macrofauna.

After 3 to 6 months, eight litter bags (half consisted of large mesh bags) were taken from each site and placed in plastic bags. No macro invertebrate was found in litter bags with small mesh; those from large mesh bags were removed and placed in tubes containing 70% alcohol. After extraction of the macrofauna and roots colonized litter, they were sieved using 0.5 mm siever, recovered by flotation, dried in an oven at 40°C and weighed. The Macrofauna extracted from the litter was identified and counted; the litter decomposition was characterized by the coefficient k of the method of Olson (1961) using the formula:

$$M_t = M_0 e^{-kt}$$

Where M_0 = mass of a litter at time t = 0 initial mass of litter (at time t = 0); M_t =mass of a litter at time t, k is a constant (unitless); t= exposure time of a litter in months

2.3 carbon and total nitrogen dosages:

Concentrations of carbon and nitrogen were determined for each period in the residual litter. Nitrogen was determined by the Kjeldahl method; organic carbon was determined by dichromate oxidation, both on samples of finely ground leaves.

2.4 Data analysis:

The data were recorded in an Excel spreadsheet and then subjected to analysis of variance (ANOVA) followed by the factorial Tukey HSD at 5% in the STATISTICA 9.0 software.

III. RESULTS AND DISCUSSION

3.1 Loss of litter mass and the parameter k of litter decomposition:

During the observation period 132 arthropods were found in bags, termites were the most abundant (121 specimens). Among termites, the genera *Nasutitermes* and *Ancistrotermes* (group II) were abundant in sacks harvested after 3 months and after 6 months, soldierless Apicotermitinae and genera *Fastigitermes* (groups III and IV) were found. A total of 67 soil feeding and 54 wood feeding was recorded after 6 months. Others macrofauna elements include ants (8 specimens), annelids (2 specimens) and millipedes (1 specimen) were also found.

The loss of mass was subjected to analysis of variance factorial through 4 factors. Either disturbance (1 df, $F = 0.86$, $p > 0.05$) or ecosystem (2 df, $F = 0.84$, $p > 0.05$) can influence the loss of mass. However, it is significantly greater with 2 mm mesh than mesh of 0.5 mm (1 df, $F = 39.93$, $p < 0.001$), and, of course, it is higher after 6 months than after 3 months (1 df, $F = 34.10$, $p < 0.001$) (see Figure 3). There is no interaction between the factors.

The average loss of mass was calculated after 3 months and after 6 months respectively depending on the mesh size of litter bags (see table 2). The difference in loss of weight due to the macrofauna was about 19% and 25% after 3 months and 6 months respectively.

On the basis of a period expressed in months, the parameter k is on average 0.24 ± 0.14; k parameter was subjected to factorial analysis of variance. The results show that disturbance (1df, $F = 0.22$, $p > 0.05$), ecosystem (2ddl, $F = 0.06$, $p > 0.05$), or the duration (1ddl, $F = 0.16$, $p > 0.05$) did not influence the k parameter, however, it was significantly larger ($k = 0.33 \pm 0.14$) with 2 mm mesh than 0.5 mm mesh ($k = 0.16 \pm 0.03$) (46 df; $F = 26.89$, $p < 0.001$). There was no interaction between the factors.

The physicochemical environment, the litter quality and diversity of the soil fauna are three main factors controlling litter decomposition in an ecosystem [19, 20, 21, 22, 23]. Among parameters determining litter quality, there is nitrogen concentration and C/N ratio (especially lignin/nitrogen) [19, 21, 24].

The process of litter decomposition is mainly biological, but it is also influenced by abiotic factors through soil fauna and microorganisms. However, in some climate zones relatively constant at the tropics, litter quality appears to be the best indicator of the rate of decomposition, while the characteristics of the soil and microclimate tend to be less important [25, 26].

Bushfires are recurrent in the savanna ecosystems in Africa, the heat produced eliminates a fraction of soil microorganisms and soil fauna that changes the structure of their communities with the momentary decrease of their activity. In contrast in the Atlantic and semi-deciduous forest sites, the humidity is constant which promotes the activity of soil microorganisms. One would therefore have expected litter decay faster in forest than savannah ecosystem.

In our study, the rate of decomposition (parameter k) of litter *M. excelsa* is independent of the type of ecosystem and pipeline disturbance, suggesting that factors in this litter which have prevailed on the variability of environments and although the litter bags were deposited in savannah shortly after the passage of fires in the dry season. These results are in agreement with those of [27] and [28] who have shown that the rate of litter decomposition was not affected by the opening of the canopy.

Moreover, the fact that the parameter k is independent of the duration of exposure of litter bags suggests that the decomposition process is constant during the field work. Stages of leaching and post-leaching decompositions, even if they exist, are not highlighted by our results. This is not really surprising since we only have three points in time (0, 3 and 6 months).

In our experiments, the values of the coefficient of litter decomposition k observed, show that the influence of mesh size on litter decomposition is significant regardless of its environment. Large mesh bags were given passage to a portion of the soil fauna (that can pass through 2 mm mesh) and especially termites. Wood feeding termites were most abundant at the end of the first three months and those of groups III and IV (soil feeding) just slightly abundant at the end of six months, which suggests that these organisms play a major role in the decomposition of the litter. The influence of macrofauna on litter decomposition is twofold because it ensures its fragmentation and induction of changes in abundance fungivores and macrophages [29]. The litter supports a wide variety of trophic chains [1]. It should also be noted that the presence of an organism in a litter bag does not necessarily mean that it is involved in the decomposition of this litter; litter bags placed in the soil represent a curiosity to explore new habitat for soil fauna.

3.2 Dynamics of C, N and C / N ratio in the litter decomposition:

To monitor the dynamics of carbon and nitrogen during our experiment, amounts of carbon and nitrogen presents in the leaves of *M. excelsa* in terms of time was calculated and their losses were expressed as percentage versus time. Carbon losses were subjected to factorial analysis of variance. The results of this analysis were quite similar to that of the loss of mass: no effect of disturbance (1ddl, $F = 0.86$, $p > 0.05$), or the ecosystem, but significant effect of the mesh (1ddl, $F = 39.93$, $p < 0.05$) and time (1df, $F = 34.10$, $p < 0.05$), there was no interaction between the factors. Nitrogen losses were subjected to the same analysis of carbon ones and gave similar results with no effect of disturbance (1df, $F = 0.43$, $p > 0.05$). The C/N ratios were subjected to factorial analysis of variance at 4 factors. None of these factors influenced the C/N ratio except disturbance which was weakly significant (1 df, $F = 3.93$, $p = 0.059$) in the three ecosystems. The C/N ratio was lower in areas disrupted than in those controlled, but not significantly.

The determination of organic carbon: *M. excelsa* leaves recently fallen gave values ranging from 35.6 to 57.3% (N = 4) given mean ± SD of 46.2 ± 10.2%. The average is consistent with the levels reported by [18] or [30] ranging from 43.9 to 47.6% in leaves of tropical trees, but the standard deviation associated with this average seems overly large. Fortunately, this variability somewhat chaotic is manifested only in "fresh leaves" no value measured on the residual leaves harvested after 3 or 6 months (N = 48) is beyond the range from 36.0 to 41. 7%.

The determination of total nitrogen: the «fresh leaves " (N = 2) titrate 0.21% nitrogen while [30] found nitrogen concentrations ranging from 0.7 to 0.9% in leaves of savanna trees and [18] mentioned 0.4% of nitrogen in leaves of *M. excelsa*. This weakness of concentration of nitrogen can be explained by the previous treatment of the leaves in an oven before the determination of total nitrogen and also high temperatures in tropical zones that facilitate the evaporation of most nitrogen compounds. Further on residual leaves harvested after 3 or 6 months (N = 48) are within a range of 0.12 to 0.36%.

From all of this it follows that the ratio C/N = 17.8 is indeed abnormally low for M. excelsa "fresh leaves". According to [18] and [30], it should be between 50 and 100. In addition, it seems to change very little: C/N = 17.2 average after 3 months and 16.2 on average after 6months. All litter bags showed a carbon and nitrogen loss, with a significant difference between the different mesh bags, betraying the intervention of the soil fauna. Nitrogen loss in small mesh bags probably reflects the action of fungi that are able to translocate nitrogen via their hyphae whereas bacteria immobilize nitrogen on site.

It should be noted that during the study of litter decomposition of *M. excelsa*, the mesh size did not influence the concentration of nitrogen in the residual litter this is in contradiction with the work of [31] who showed that the nitrogen content increased with the litter wheat contained in thin mesh bags.

Variation of carbon and nitrogen are closely linked during decomposition: bacteria finding their energy in breaking carbon bonds (with loss of carbon as CO_2) and elements necessary for the construction of their protein. The most fermentable organic matter is used as an energy substrate by microorganisms, while the most recalcitrant can be stabilized more or less long term [32]. A net increase in the concentration of nitrogen in the litter may result from the absorption of atmospheric nitrogen or translocation by fungi or the colonization of litter by microfauna [33]. In this regard, we will retain that in three ecosystems studied; the C/N ratio of the residual litter is lower in the disturbed areas than in those controlled. Since we did not observe any difference between ecosystems, it is not possible to evoke a direct influence of climate. The differences probably result from differences in the litter surrounding and the intervention of the microflora.

IV. CONCLUSION

This study showed that the decomposition rate of litter *Milicia excelsa* is not affected by the disturbance caused by the pipeline despite the opening of the canopy; the litter quality appears to be the determining factor. The humification process is however changed since the C/N ratio decreases more rapidly in disturbed areas than in controlled ones. It also showed that soil organisms passing through 2 mm mesh accounts for about 20% of the mass loss of the litter.

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APPENDIX - A

LIST OF FIGURES:

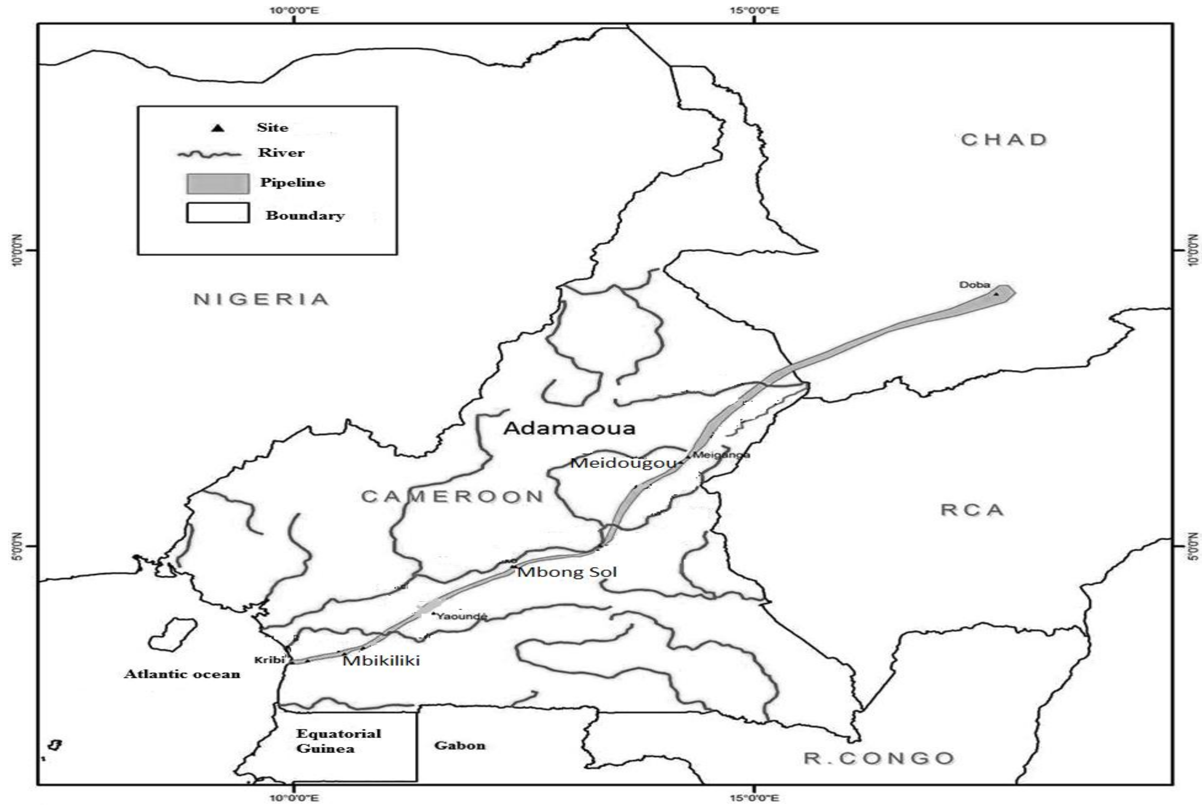

Figure.1: localities traversed by the Chad-Cameroon pipeline

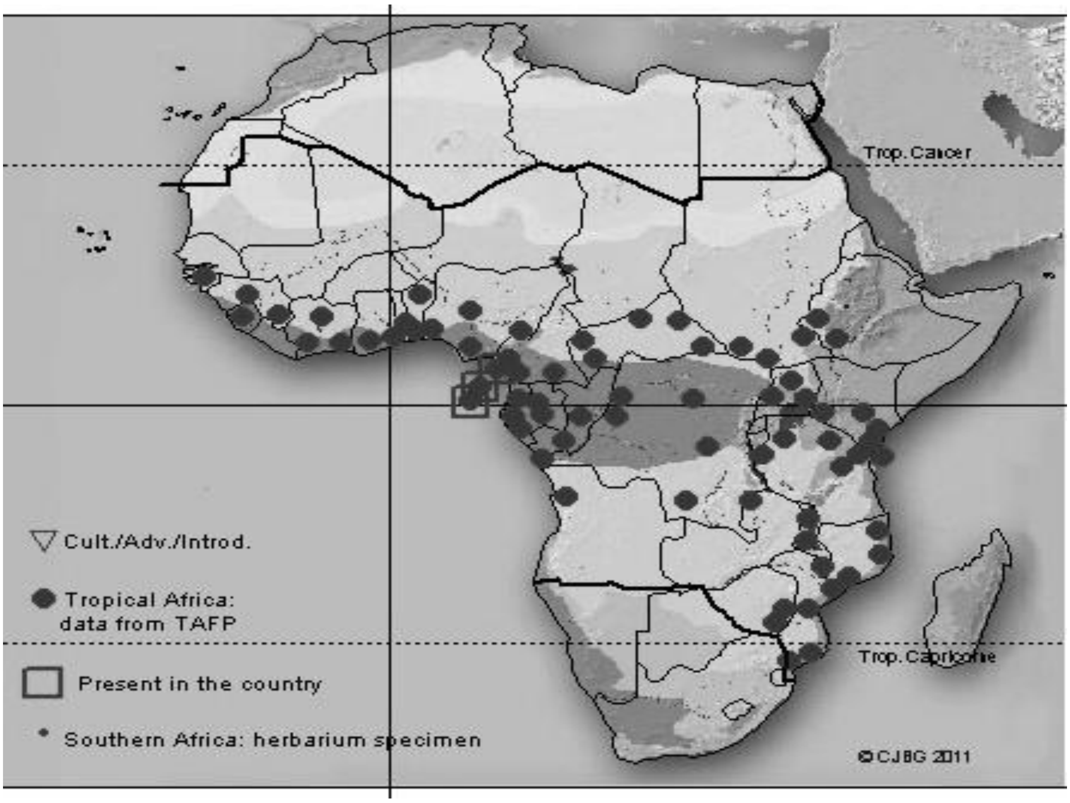

Figure 2: Range of Milicia excelsa in Africa from African Plant Database

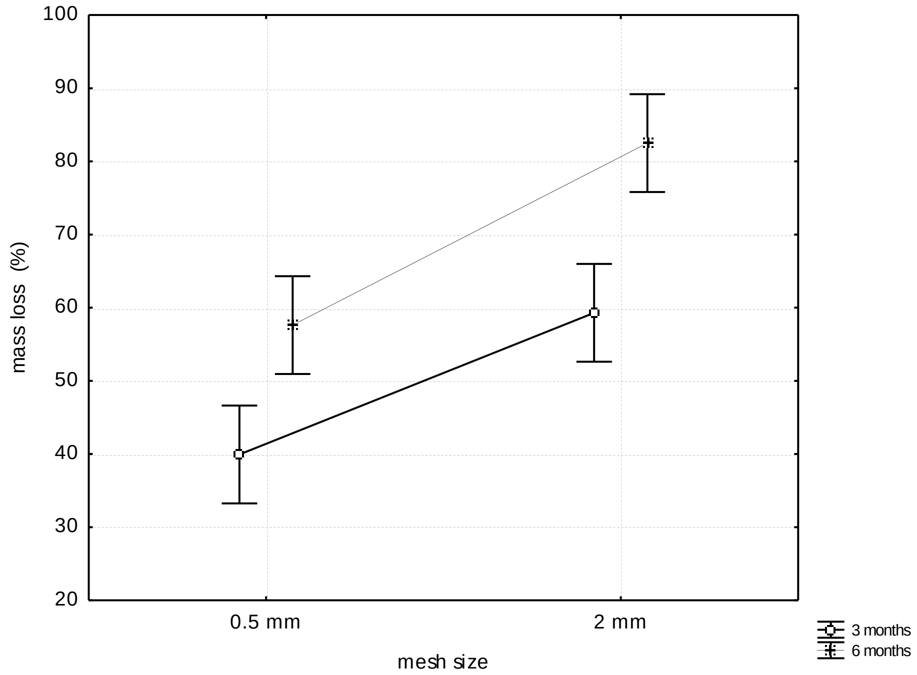

Figure 3: mass losses (%) after 3 and 6 months depending on the mesh size of litter bags

LIST OF TABLES:

Table 1: Locations and characteristics of the study sites

location (Ecosystem)	Annual rainfall and mean temperature	Coordinates
Mbikiliki (Evergreen Atlantic forest)	3030 mm, 23°C	3°10.48 N, 10°32.73 E, 307m alt.
Mbong Sol (Semi-deciduous forest)	1570 mm, 21°C	4°39.49E, 12°24.37 E, 643m alt.
Meidougou (Savannah)	1530 mm, 23°C	6°25.65 N, 14°12.13 E, 1042 m alt.

(data from 2007 to 2008)

Table 2: Differences in mass losses (%) after 3 and 6 months depending on the mesh size of litter bags

Period	0.5 mm	2 mm	Difference
3 months	39.9 ± 7.8	59.3 ± 6.6	19.4
6 months	57.7 ± 5.3	82.5 ± 9.8	24.9