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Physico-Chemical and Microbiological characterization of turkey litter compost

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***Abstract*—The region Chaouia-Ouardigha is the first producer of turkey in Morocco, which implies a high production of manure. The spreading of manure presents environmental risks (on agricultural soils and water resources) as well as health risks because of their high density of pathogens. The aerobic composting of turkey litter (a mixture of turkey manure, straw, waste feed, and feathers) is an effective technique to produce stabilized and sanitized compost. The objective of this study was to characterize the physicochemical and microbiological properties of turkey litter compost.**

After 5 months of aerobic composting in a heap, the assessment of physico-chemical parameters of the compost showed a stabilization of pH around neutrality, a self heating of the compost mass (Maximum of 64°C in thermophilic phase), a significant decrease (at significance level P <0.05) of the total nitrogen, organic matter, ammonium and NH4/NO3 ratio; a low C/N ratio (less than 8) and an increase of nitrate content.

The assessment of microbial populations, showed a significant reducing of the density (CFU/g) of : Total aerobic mesophilic Flora, indicators of fecal contamination (fecal coliforms, Enterobacteriaceae and Escherichia coli), the reducing-sulfite Anaerobic bacteria, Staphylococcus aureus, and yeasts and molds. As for Salmonella, it was absent in all the samples analyzed.

Keywords: Composting, turkey, litter, manure, hygienization.

I. INTRODUCTION

Each year, The Chaouia-Ouardigha region in Morocco, produces more than 300,000 tons of turkey manure. The number of poultry units producing turkey is 220 units. The production capacity is 5.1 million turkeys per breeding cycle [1]. Intensive livestock systems produce huge amounts of manure and cause environmental problems due to the release of odors, the spread of pathogens, nitrate leaching and pollution of surface water [2].

Composting is an effective way to promote these organic wastes. It implies the reduction of waste volume, the destruction of weed seeds and of pathogenic microorganisms. Compost is produced at a relatively low cost and brings positive effects on soil fertility [3].

Composting goes through two phases: (i) an active phase knowing a mineralization of organic matter due to intense biological activity, a significant increase in temperature and ammonia volatilization; (ii) a maturation phase leading stabilization and humification of the organic matter. The control of composting happens by monitoring several physicochemicals parameters such as temperature, C/N ratio, pH, moisture, porosity and aeration [4,5,6]. However, few studies have considered parameters indicating the changes in microbial activity [7].

The aim of this study was to characterize physicochemical and microbiological properties of turkey litter compost.

II. MATERIALS AND METHODS

A. Collecting manure

The turkey litter used in the present study was collected from five turkey farms located in Settat (a province of Chaouia Ouardigha region in northwest of Morocco). The litter was transported to the Center of Agricultural Qualification Ouled moumen (CAQ), the site of the experiment, where mixed hogeneously. We have taken six composite samples: three samples cooled and kept for microbiological analysis and three samples air-dried for physico-chemical analysis.

B. Operation of Composting

The litter was composted aerobically in a heap for 5 months. During composting process, moisture content was adjusted to around 50%. The heap has been manually turned once a week during bio-oxydative phase and two to three times

per month through the maturation phase. Heap temperatures were monitored using alcohol thermometer, at 3 locations: the top, middle and bottom. The ambient temperature was collected by the weather station to the CAQ. At the end of composting, 8 samples were collected in sterile plastic-bags to serve for microbiological and physico-chemical analysis.

C. *Physico-chemical analysis:*

All the samples were analyzed for the following parameters according to the manual of analysis methods [8]: Dry matter content was assessed by drying at 70°C for 48hours. pH and electrical conductivity (1:10 w/v Sample-water extract) were measured using a pH meter electrode and a conductivimeter respectively. Organic carbon (OC) was determined by titration using potassium dichromate. Organic matter (OM) was calculated according to the equation (OM = 1,724 OC). The total nitrogen determined by Kjeldahl method. Nitrates are determined by complexation with chromotropic acid and measuring the absorbance in a spectrophotometer at 410 nm [9]. Ammounium was determined colorimetrically at 636 nm. Phosphorus was determined by colorimetry at 882 nm [10] and potassium by extraction with ammonium acetate and determination using a flame photometer.

D. *Microbiological Analysis*

Microbiological analysis have focused on enumeration of 8 groups of microorganisms by determination of the number of colony forming units (CFU/g). The enumeration of total aerobic mesophilic flora was determined using the Petri dishes containing a medium of agar glucose and yeast extract; inoculated and incubated at 30 °C for 72 hours [11]. Enterobacteriaceae was inoculated in VRBG medium (Violet Red Bile Glucose) at 37 °C for 24h [12]. Fecal coliform was inoculated in VRBL agar (Violet Red Bile Lactose) at 44 °C for 24 hours [13]. Escherichia coli at 44 ° C for 48 hours according to Mackenzie test [14]. The population of Staphylococcus aureus was determined in the Baird-Parker medium at 37 °C for 48 hours [15]. Sulfite-reducing anaerobic bacteria was inoculated on TSN agar (tryptone, sulfite, neomycin) at 46 °C for 24 hours [16].Yeasts and molds inoculated on Sabouraud agar at 25 °C for 3 days [17]. Salmonella was determined in 25g sample on SS agar (salmonella-shigella) at 37°C for 48 hours [18].

E. *Statistical Analysis*

The results were statistically analyzed using SPSS statistics 17.0 software for analysis of variance (ANOVA) at a significance level of 5% ($P < 0.05$). The analyses were performed in two repetitions.

III. RESULTS AND DISCUSSION:

A. *Temperature Monitoring:*

Temperature has been widely recognized as one of the most important parameters in the composting process [19]. Fig. 1 shows the evolution of the ambient temperature and that of compost throughout composting. The peak temperature that recorded in the heap was 64°C. The rise in temperature indicates an intense microbial activity; it should reach 55°C to destroy pathogenic microorganisms [6]. The optimum temperature range for composting is between 40 and 65 ° C [20].

A graph shows two distinct phases: a bio-oxydative phase divided into three sub phases (mesophilic, thermophilic and cooling); and maturation phase. Turning of heap have made activation of the decomposition operation despite low ambient temperatures. It permits to prevent serious anaerobic conditions, odours and maintain high temperature [21]. The end of this phase was marked by a drop in temperature in the heap to reach ambient value.

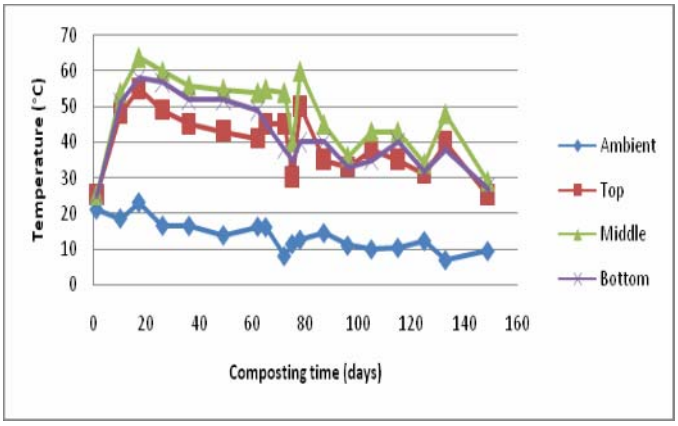

Figure 1. Air and heap temperature changes during composting of turkey litter

B. *Physicochemical analysis:*

Table 1 shows the average values obtained in the analysis of samples taken before and at the end of composting. During composting process, the pH increase to reach neutral values. This slight increase (+0.26), in the final compost, may be due to protein degradation [22, 23, 24]. Neutral pH is an indicator of stabilized organic matter [19].

TABLE I. CHEMICAL PROPERTIES AT THE BEGINNING AND THE END OF COMPOSTING

Echantillon	Initial compost	Final compost
	Mean ± SD	***Mean ± SD***
pH	6,64 ± 0,09	6,9 ± 0,06
EC (dS/m)	7,00 ± 0,00	7,00 ± 0,00
OM (%)	50,17 ± 1,42	30,52 ± 3,24
N tot (g/kg)	40,4 ± 3,2	22,3 ± 1,1
NO3 (g/kg)	0,73 ± 0,05	7,59 ± 1,36
NH4 (g/kg)	7,47 ± 0,03	4,89 ± 1,21
NH4/NO3	10,6 ± 0,38	0,66 ± 0,22
P (g/kg)	3,29 ± 1,52	7,31 ± 3,04
K (g/kg)	1,51 ± 0,02	1,07 ± 0,18

SD : Standard deviation; EC : Electrical conductivity; OM : Organic matter; N tot : total Nitrogen; P : phosphorus; K : potassium

Moisture content decreased during composting to 36.7% for the final compost. This loss was explained by the evaporation of large quantity of water occurred due to the temperature rise and frequency of turning. However, the reduction in moisture content was limited by the composting period characterized by high relative humidity and low ambient temperature. Electrical conductivity (EC) reflects the degree of salinity in the heap before and after composting. The EC values were relatively high (7.0 dS/m). No changes for EC values may be explained by the offset of the ions concentrations, due to weight loss, by an intense consumption from the microbial flora.

Furthermore, the significant Organic matter (OM) decrease could be due to the decomposition and mineralization by microorganisms during composting. Similar reductions of OM were reported by [19]. Biodegradation of OM depends on its composition: Labile organic compounds, such as simple carbohydrates, fats and amino-acids, are degraded quickly in the first stage of composting [6].

Total nitrogen content was decreased from 4.03% to 2.22% in the final compost. This significant change can be explained by volatilization of nitrogen as ammonia, Effect of turning operations, leaching or consumption by the microorganisms. The C/N ratio decreased fewer than 8 in the final compost. This could be due to a high consumption of carbon content used as energy source of microbial flora. According to [25], a C/N ratio less than 12 is an indicator of compost maturity.

On the contrary, nitrates (NO3) content showed an increase from 0,73 to 7,59 g/kg in the initial and final compost respectively. This significant increase is due to the nitrification of organic nitrogen by nitrifying bacteria. Significant reducing was observed for ammonium content (NH4). This decrease is noted as an indicator of both high quality composting and maturation process [21,26]. Therefore, NH4/NO3 ratio registered a significant drop during composting process (from 10,6 to 0,6). The latter value (less than 3.0) is an indicator of compost maturation according to the California Compost Quality Council [27].

Furthemore, Phosphorus content has increased significantly from 3.3 to 7.3 g/kg. This variation would probably be due to a concentration of this element following the reduction of the pile mass. Nevertheless, the loss of potassium was recorded because of consumption by the microbial flora.

C. Microbiological Analysis:

One of the problems posed by the direct use of poultry manure in agriculture is the risk of plant and human contamination by pathogens [7]. Reducing the survival of these pathogens in manure is one of the main roles of composting for decreasing the risk of contamination.

Initially, the heap showed a high density of microorganisms. These analyses involved 8 microflora. The total aerobic mesophilic flora (Fig. 2) was significantly reduced by 2.1 Log units. This decrease was probably due to the high temperature and unfavorable conditions established during the thermophilic phase [21,28].

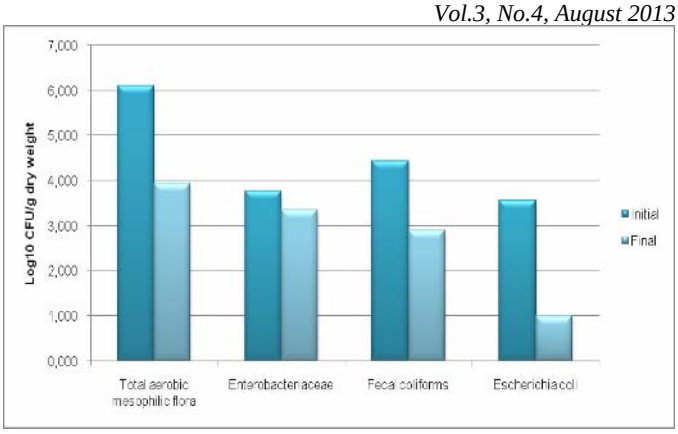

Figure 2. Populations of total aerobic mesophilic flora, enterobacteriaceae, fecal coliforms and Escherichia coli at the beginning and the end of composting

The reducing in concentration of microorganisms used as an indicator of fecal contamination was also significant (Fig. 2): Populations of Enterobacteriaceae, Fecal coliforms (FC) and Escherichia coli were significantly Log reduced by 0.42, 1.52 and 2.56 respectively in the final compost. The concentration of thermotolerants (FC) is below the recommended limit (10^3 CFU/g) indicating the composting efficiency **[29]**. The decrease of Escherichia-coli population was presumably the result of the high temperature and aerobic conditions **[30]**.

Furthermore, the population of staphylococcus exceeded 10^6 CFU/g, it was significantly reduced by 2,1 Log during composting (Fig. 3). The remaining density might be due to a quality of the pathogen as ubiquitous bacteria. Despite successful composting, the health risk relative to a potential pathogen growth is still present **[23,31]**. This risk is greater in the peripheral parts **[32]**.

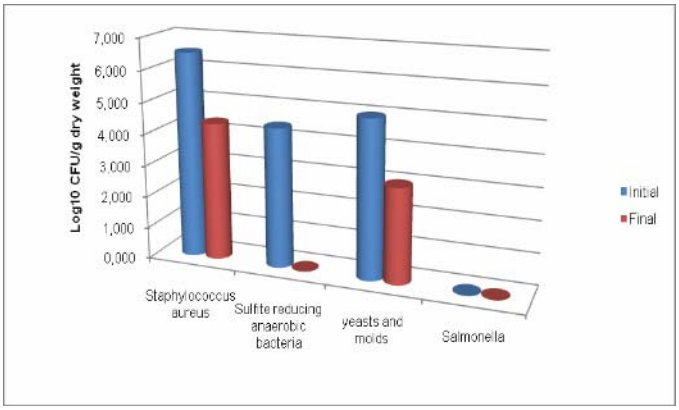

Figure 3. Populations of Staphylococcus aureus, sulfite-reducing anaerobic bacteria, salmonella, and yeasts and molds at the beginning and the end of composting

Further, total destruction of sulfite-reducing anaerobic bacteria was recorded; it may be due to high temperature in thermophilic phase, the aerobic conditions and the presence of nitrates.

Salmonella was not detected in all samples before and after composting. This can be explained by compliance with regulatory requirements for turkey farming and the absence of post-contamination factors that may contaminate the pile during composting.

Finally, Yeasts and molds were log reduced by about 2 units. The mushrooms are mostly mesophilic. Therefore the temperature rise over 50°C had certainly a lethal effect. The rest of the fungal population is concentrated mainly on the periphery of the pile where the temperature is lower **[33]**. Another explanation could justify the presence of fungal microflora is the presence of favorables conditions in maturation phase : A low water activity and the prevalence of complex substrates (lignin and cellulose). These conditions can promote the growth of fungi and actinomycetes **[19,20]**.

These results indicate that composting of turkey litter in the heap can be a safe and an effective technique to reduce pathogen microorganisms and to stabilize nutrients and organic matter.

IV. CONCLUSION

Due to its high organic matter content, turkey litter degrades in the composting process by aerobic respiration. Composting process in the heap was capable to produce heat, stabilize organic matter and lead to hygienisation by reducing pathogen populations. The aerobic composting of turkey litter is an effective technique to produce stabilized and sanitized compost.

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