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The effects of Insects on the Physicochemical Characteristics During Composting

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ABSTRACT

Insects have a vital role in solid waste composting process. Insects are detritus feeders that enhance changing the physical and chemical properties of decomposed materials during composting processes. This behavior makes insects excellent organisms in recycling of organic matter. The present study assesses the success of insects' population in relation with the degradation of solid waste. The study was carried out in the glass house facility of the College of Science, Salahaddin University in Erbil City, Kurdistan region of Iraq, using household organic waste. During composting process, three stages of lifecycle of insects were observed and recorded. The total number of insects reached to 849 individuals, belonging to the orders Coleoptera and Diptera, class Insects. Diptera individuals were the most abundant insects with 93.87% of the total belonged to three families (Muscidae, Calliphoridae and Milichiidae). Coleoptera individuals represented 6.13% of the total number, belonging to two families (Promecheilidae and Salpingidae). The measured physicochemical characteristics of the compost included: pH, EC, moisture, total organic carbon, total phosphorous and organic matter. The pH value of the composts ranged from 7.97 to 8.46. Organic carbon content and organic matter content ranged from 19.49 to 25.65 % and 33.20 to 43.97 %, respectively. It can conclude that household waste compost is not just a waste but has the potential to be transformed into a good quality organic nutrient through composting. Composting can convert solid organic waste into a valuable added material.

Keywords: compost, insect, decomposer, solid waste.

1. INTRODUCTION

Composting is a widely used method for organic waste management and soil amendment production. Composting is biodegradable stabilized and mineralized humus transformation process by bacteria, micro- and higher-level organisms of decomposable organic constituents (agricultural, urban commercial etc. wastes) in solid wastes. Compost is not fertilizer but is used only for the structural improvement of the soil. However, it is possible to obtain fertilizer in superior quality by adding enough nitrogen, phosphorus, and potassium to the compost (Uygun, 2012). Organic matter in the environment undergoes a process of decomposition which is influenced by thermal indicators. This process occurs in three stages. The first stage is the mesophilic or moderate temperature phase, during which the temperature of the decomposing material is typically between 20-45°C. This is the initial stage of decomposition where easily degradable compounds are broken down. As the temperature increases, the thermophilic or high-temperature phase begins, which typically occurs between 45-70°C. During this stage, the more complex organic matter is broken down into simpler compounds. The third stage is the cooling or maturing phase, which occurs as the temperature of the material gradually decreases to around 20-25°C. This phase is characterized by the continued breakdown of organic matter until it is completely broken down into stable compounds. The duration of each phase depends on various factors such as temperature, moisture, oxygen availability, and nutrient content, with optimum conditions favoring faster decomposition. The decomposition of organic matter is an important process that helps to recycle nutrients and sustain healthy ecosystems (Kostov *et al*. 1996; Li *et al.* 2022). Aerobic composting is the process of decomposition in an oxygenated atmosphere. Composting starts when appropriate organic ingredients are combined. Raw materials are mixed first and the air is supplied in sufficient amount to start the process. The microorganisms rapidly disintegrate oxygen and the precipitated materials eject the air out of the pore spaces. Aerobic degradation slows down as the oxygen in the environment decreases and the process stops if oxygen is not provided. The aerobic composting accelerates the decomposition of matter and brings about a higher temperature increase than the temperature required to destroy the pathogens. At the same time, aerobic composting also reduces unwanted odors (Argun *et al*., 2017).

Insects are a diverse group of animals that play a crucial role in various ecosystems. They belong to the class Insecta, which is one of the most extensive groups of arthropods in the animal kingdom. These animals are characterized by their unique body structure, which includes a head, thorax, and abdomen, six legs, two antennae, and one or two pairs of wings. One of the reasons insects are so successful is their ability to adapt to different environments. They can be found in almost every habitat on Earth, from the hot and humid rainforests to the cold and dry deserts. Insects play an essential role in various ecological processes such as pollination, decomposition, and nutrient cycling. They are also a significant food source for many other animals, including birds, reptiles, and mammals. insects are a fascinating and essential group of animals that play a vital role in maintaining the balance of nature. Their incredible diversity and adaptability make them one of the most successful groups of animals on the planet. (Price, 1997; Smith, 2022).

In comparison with other invertebrates, insect populations are potentially more active for biodegradation of organic matter due to the fact that insects develop in relatively short periods. Larvae of many species of the Diptera's order are especially interesting as they are able to develop in a wide diversity of media, have a high reproductive capacity and a relatively short life cycle. Overall, insects play a critical role in the composting process by aiding in the breakdown of organic matter, aerating the compost pile, and providing essential nutrients for plant growth (Jalal *et al.*, 2019). The aim of this study is to evaluate the insects' role during the composting process of urban solid waste, and to provide information about the relationship between insects and physicochemical parameters during composting process.

2. MATERIALS AND METHODS

2.1.Sample collection and analysis

A study was conducted during the autumn months of 2022 to process waste in the Field of the College of Science. Degradable wastes, specifically non-cooked and free fat waste, were used for composting. To facilitate the composting process, 30 kg of solid urban waste was separated according to its source and placed in one pile. Composting piles were built in a plastic box with a bottom cover to prevent contamination from groundwater, humidity transfer from the ground to the compost, and to ensure appropriate handling of leachates. Homogenization and airing of the composting material were achieved through periodical turning, as recommended by Leege and Thompson (2001). Overall, this process creates a sustainable solution for waste management by converting degradable waste into nutrient-rich compost that can be used in various applications, such as gardening and agriculture.

The experiment was performed in 30 days after which the whole waste was converted into manure. Samples were withdrawn and collected at regular intervals (10 days). Samples were taken in different parts of the bed and from the surface to a 15 cm depth. The Parameters viz. moisture content, electrical conductivity, pH, organic carbon, total phosphorous and organic matter content were investigated during the study. The samples were withdrawn after mixing the whole substrate. Fresh samples were used for determining moisture content by oven. Electrical conductivity and pH were analyzed in a 1:5 water soluble extract by conductivity meter and pH meter, respectively. Total phosphorus was determined using ammonium molybdate with the $SnCl_2$ method (Ashrafi, 2014). However, to evaluate insect populations present at different stages during composting, samples of insects were taken in the 10^{th}, 20^{th} and 30^{th} days during composting. Each sample consisted of 0.5 kg of compost taken from three different points from the bed in order to obtain a representative sample including both immature and adult specimens (Morales and Wolff, 2010). Each sample was separated into two parts; one was deposited in a plastic can and covered with muslin until adults emerged, and the other was transported to the laboratory to collect immature insect stadium. Collected specimens were identified using several recommended keys including Dodge (1953), Carvalho and Mello-Patiu (2008), Thyssen (2010), and Aballay *et al.* (2014). Overall, using taxonomic keys is a common and important approach for classifying and studying different species in biology.

2.2. Statistical analysis

The data was analyzed statistically by using SPSS packages at significance level of P< 0.05. Two statistical packages were used to analyze data: Two- way ANOVA used to calculate physicochemical parameters, and correlation was performed between insects with physicochemical parameters.

3. RESULTS AND DISCUSSION

The results showed that the pH value of household composts was in alkaline side of neutrality level that ranged between 7.97 and 8.43. As the decomposition process progresses, nitrogen will bind with carbon make an organic compound. No more escape of excess nitrogen might be the reason for the decrease of pH after it had risen (Wilson, 1989). EC of initial composting mixture increased to 17.93 mS/cm on day 10, and then gradually decrease until the end of the composting process (Table 1). The increases in EC value in the beginning could be caused by the release of mineral salts such as phosphates and ammonium ions through the decomposition of organic substances (Fang and Wong, 1999). As the composting process developed, a decrease in the EC was detected. This could be probably due to volatilization of ammonia and the precipitation of mineral salts in the later phase of composting (Wong *et al.*, 1995). Utilization of nutrients by the larvae could also be a probable reason for the decrease in EC in later phases of composting. Moisture content is a measure of the sum of moisture present in a compost sample and is indicated as a percentage of fresh weight. Moisture content of the composting mix is an important environmental parameter as moisture supplies a medium for the transport of dissolved nutrients needed for the metabolic and physiological action of microorganisms (Elango *et al.*, 2009).Throughout the present study, the moisture content of compost samples ranged from 5.75 and 23.88%. . Initially the moisture content was high but it was decreased after decomposition of organic matter. The reduction in the moisture content percentage through the thermophilic phase of composting was reported to be caused by high evaporating rates (Larney and d Blackshow, 2003). A significant decline of organic carbon (19.44%) was observed in day 30 as compared to its initial value (25.65%). Decrease of the organic carbon was significantly affected by composting. From the beginning, the percentage of organic carbon decreased, which reflects the decomposition of waste by microbial population (Mondini *et al.*, 2003). Part of the carbon in the decomposing residues was reported to evolve as CO_2 while the other part assimilates by the microbial biomass (Cabrera *et al.*, 2005; Fang *et al.*, 2001; Nakasaki *et al.*,1985). Fares and colleagues described the carbon loss for initial total carbon throughout the composting process (Fares *et al.*, 2005) Total phosphorous ranged between 0.37 - 1.09% during composting, and previous studies noticed slowly increase of phosphorous through composting process (Elango *et al.*, 2009).

The water solubility of phosphorus decreases with humification so that phosphorus solubility during the decomposition was subjected to further immobilization. The phosphorous content during this study was identical to that detected by Elango *et al.* (2009). The organic matter content of the studied compost ranged from 33.20 to 43.97%. The organic matter declined during different stages of composting to the maturation stage because of the increase in the decomposition of organic substances (Table 1).

Table 1: Physico-chemical characteristics of the compost.

Parameters	**Days**		
	10	**20**	**30**
pH	7.97	8.46	8.43
EC (mS.cm $^{-1}$)	17.93	15.02	11.16
Moisture%	23.88	12.69	5.75
TOC%	25.65	21.13	19.49
T. Phosphorous%	0.42	1.09	0.37
Organic Matter %	43.97	35.95	33.20

Throughout the study, a total of 849 individuals were collected from the process of composting. Individuals within class Insecta belonged to two orders; Diptera with an individual's number of 797 and Coleoptera with an individual's number of 52. Diptera represented the most abundant and diverse group with 93.87% of the total with 3 families (Muscidae, Calliphoridae and Milichiidae), while the order Coleoptera was represented 6.13% of the total number, belonging to two families (Promecheilidae, and Salpingidae (Table 2).

Table 2: Insect population found during solid waste composting.

Order	Family	Genus and species	10^{th} day	20^{th} day	30^{th} day
Coleoptera	Promecheilidae	*Parahelops* sp. (L)	0	12	31

6.13%	Salpingidae	*Elacatis kraatzi* (L)	2	3	4
Diptera 93.87%	Muscidae	*Musca domestica* (L, P&A)	219	145	414
	Calliphoridae	*Chrysomya bezzianna* (L)	0	9	2
	Milichiidae	*Phyllomyza* sp. (A)	0	0	8

L: larvae A: adult

From the results, it is obvious that the process of decomposing solid waste provided suitable substrate for feeding, egg laying and the development of individuals. During the composition process, three different stages were recorded; easily biodegradable substrates, formation of humus-like substances, and organic matter stabilization. Family Miscidae of the order Diptera had the highest number of the collected individuals throughout the entire study period with individual number of 778 especially during the 30th day. This family was represented only by *Musca domestica* in the form of larval, pupal and adult stages. While the family Calliphoridae was represented by 11 individuals of *Chrysomya bezzianna*, all of them were in the larval stage. These families have already been shown to be associated with the composting processes (Laos et al, 2004), food sources availability and, in many cases, favorable environmental conditions (Sharanowski *et al.*, 2008; Montoya *et al.*, 2009). The third most abundant family was Milichiidae and the only species identified in this family was the adult *Phyllomyza* sp. (8 individuals). Larvae of this family are saprophagous or coprophagous and this behavior performs a recycling function in this substrate (Hervani and Sari, 2022). However, the lowest number of individuals belonged to the order Coleoptera with 52 individuals from two different families. The family Promecheilidae was the most abundant with individual number of 43 of the larval stage represented by one species, *Parahelops* sp. Salpingidae was the second abundant family of their order, represented by 9 larvae of *Elacatis kraatzi*.

According to the correlation matrix illustrated in (Table 3), total phosphorous% and *Chrysomya bezzianna* (0.96) However, the highest negative correlations were found between most of the physicochemical parameters and the collected species of insect. The lowest correlations were found between EC and *Parahelops* sp. (- 1) and EC with *Elacatis kraatzi* (- 1).

Table 3: Correlation between physicochemical parameters and insect taxa

Parameters	***Parahelops* sp. (L)**	***Elacatis kraatzi* (L)**	***Musca domestica* (L, P&A)**	***Chrysomya bezzianna* (L)**	***Phyllomyza* sp. (A)**
pH	0.76	0.84	0.20	0.71	0.45
EC mS.cm -1	-1.00	-1.00	-0.76	-0.13	-0.90
Moisture%	-0.97	-0.99	-0.60	-0.34	-0.79

TOC%	-0.92	-0.97	-0.49	-0.46	-0.71
T.Phosphorous%	-0.20	-0.07	-0.76	0.96	-0.56
Organic Matter %	-0.92	-0.96	-0.48	-0.47	-0.70

4. CONCLUSIONS

In the present study, compost showed good physical and chemical properties with alkaline side of neutrality pH and low electrical conductivity, due to the increasing decomposition and high organic matter content. The taxa of insects are widely distributed during the composting process. The most dominated genera belonged to orders Diptera, with few numbers of Coleoptera. Strong positive correlations were observed between the percentage of total phosphorous and *Chrysomya bezzianna*; pH and *Elacatis kraatzi*. Meanwhile, the highest negative correlations were found between most of the physicochemical parameters and collected species of insect. The lowest correlations were between the lowest correlations were found between EC and *Parahelops* sp. (- 1) and EC with *Elacatis kraatzi*.

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