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# Stabilization of organic municipal solid waste by composting

The article examines the process of vermicomposting of municipal organic waste. To determine the optimal composition of bio humus, various options and proportions of mixing organic waste with soil are considered. In the course of the study, three different variations of organic waste were developed, mixed with manure: 1 — soil, paper, vegetables, fruits, wood waste, cow manure (1:0.5:1); 2 — soil, vegetables and fruits, wood waste (1:1); 3 — soil, cow manure (1:1). The results of the experiment showed that all substrates have high germination of tomato seeds. However, a mixture of soil, paper, vegetables, fruits, wood waste, cow manure increases the yield of tomatoes by 11 % compared to other experimental substrates. Vermicomposting E. was performed using *E. fetida* worms. This kind of worms is characterized by high yield. For vermic content, the moisture content must be at the level of 60 %. Bacteria also play an important role in vermicompost. With air humidity below 40 %, their activity decreases and stops at temperatures below 10 %. In this experiment, solid organic waste processing technology reduces the shortage of cheap organic fertilizers in the market and offers new opportunities for profit for small enterprises. The results obtained can be used for processing organic waste of the city on an industrial scale and applied as fertilizer in agriculture.

*Keywords*: organic waste, vermic suppression, safety, organic municipal waste, *E. fetida*, bio humus, vehicles process communal expenses.

## *Introduction*

The growth of the world's population has caused an increase in the consumption of goods and services, which has led to an increase in organic waste. These wastes are valuable organic resources. Organic waste can accumulate many pathogenic microorganisms and heavy metals. Overgrowth causes soil and environmental problems when the waste is applied directly to agricultural land.

Currently, the idea of organic agriculture is actively promoted around the world. Organic agriculture also contributes to the preservation of the environment through the rational use of natural resources. Demand for a safe and sustainable strategy for the treatment of organic waste includes best-known practices of composting and vermicomposting for the biological stabilization of solid organic waste, their conversion into a safe and stable material that can be used as nutrients and soil conditioners in agriculture [1].

Vermicomposting is one of the most effective tools for solving the problem of environmental pollution. Recently, many studies have been conducted to make bio humus one of the best organic substitutes for chemical fertilizers. Bio humus is richer in micronutrients and nitrogen-fixing and phosphate-loving bacteria than compost [2]. Vermicomposting is a mesophilic process accompanied by the action of earthworms [3]. These worms are active at a temperature of 10–32 °C. In the process of composting, organic waste goes through a thermophilic stage, during which it is disinfected by pathogenic microorganisms.

The purpose of this study is to assess the potential for stabilization of organic waste through vermicomposting using *E. fetida* larvae and to analyze the quality of organic fertilizers produced for agricultural purposes.

## *Experimental*

The experiment was organized according to the block diagram with three repetitions. Changes in the physicochemical and biological characteristics of vermicompost were studied at intervals of 20 days over 100 days using standard laboratory procedures. Biodegradation of wastes was determined by modifying the treatment of primary wastes (up to 2, 2.5, 3.0, 3.5, 4 kg) and by controlling the heterogeneous mixture of organic municipal solid wastes (2 kg). The same amount of worms was collected in each of the units in 5–6 days. The C:N ratio was estimated to analyze the nutrient concentration in the compost.

Procedure for taking samples. To assess the various physical, chemical, and biological variations of the vermicompost, representative samples were collected every 20 days from four different points (bottom, surface, side, and center) of the vermicompost heap.

Experiment and physicochemical analysis was held in the laboratory of Myrzakhmetov Koksheyau University.

*Results and Discussion*

Household waste was pre-sorted by hand into organic and inorganic fractions. It was then mixed with the soil according to the experimental scheme.

In the experiment, organic waste was mixed with manure:

№ 1 — soil, paper, vegetables, fruits, wood waste, cow manure (1:0.5:1);

№ 2 — soil, vegetables, and fruits, wood waste (1:1);

№ 3 — soil, cow manure (1:1).

Bio humus showed high levels of potassium and nitrogen in all three variants.

Due to the effect of enzymatic and microbial activity that occurs during the process, vermicomposting produces a higher quality product than compost [4]. This process is faster than traditional compost. In addition, when the material passes through the digestive system of the worm, there is an acceleration of plant growth and a decrease in phytotoxic properties, found available N, C, P, K, Ca and Mg, vitamin B, D, and similar substances [5]. Plant growth hormones, in particular cytokinins and auxins, are found in organic waste treated by worms. Thus, the worms accelerate the rate of mineralization and convert the manure to a higher nutritional value and level of humification than traditional compost. The composition of total nutrients in biohumus: nitrogen 0.7–1.42 %, organic carbon 10.3–16.25 %, potassium 0.11–0.49 %, copper 2.3–8.95 mg/kg, sodium 0.05–0.31 %, phosphorus 0.1–0.30 %, iron 2.14–9.48 mg/kg, zinc 5.63–10.87 mg/kg.

Two tropical species, the *African slider*, *Eudrilus eugeniae* (Kinberg), and the eastern worm, *Perionyx excavatus* (Perrier) and two normal, red worms, *Eisenia andrei* (Bouche) and *Eisenia fetida* (Savigny) are widely used in vermicomposting. In the study, *E. fetida* worms are used. It depends on the speed of digestion, assimilation, and consumption of organic matter. In addition, they have a high tolerance to a wide range of environmental factors, short life cycles, high reproductive capacity, tolerance, and processing resistance. Several other species of *Drawida nepalensis*, *Lampito mauritrr*. Dichogaster spp., *Polypheretima*, long, *Amynthas* spp. *Dendrobaena octaedra*, *Eisenia hortensis* have also been used to make compost under certain conditions.

Before the process of vermicomposting, it is necessary to go through the process of composting. Thermophilic composting leads to disinfection of organic matter and elimination of toxic compounds. However, the elimination of the pathogen occurs during the transit of worms in the intestine, but it is recommended to make a thermophilic compost to prevent the death of worms.

Stages of vermicomposting:

1. Materials required for vermicomposting: carbon and nitrogen-rich organic matter, materials, shovels, earth, columns, hollow blocks, plastic sheets or used waste, water (depending on the season), and water sprinklers, shading materials, nylon nets, and worm composting.
2. Site selection: bio humus production can be done anywhere with cool and high humidity shades.
3. Grinding of organic waste: grinding of collected organic waste with mechanical separation. Selection of metal, glass, and ceramics.
4. Pre-fermentation of organic waste: it should be done at least 20–25 days in advance by mixing the waste with raw materials (for example, liquid manure of cattle). It is necessary to fill it with water. Cow manure should be stored for 20–25 days to prevent overheating during vermicomposting. It is important to mix carbon-containing substances with nitrogen to obtain the correct proportions of organic materials in the ratio C:N (30:1).
5. Preparation of worm cover. Requirements for this coating: good swelling potential, low protein content [5]. Depending on the different waste materials, the deviation capacity, volumetric potential, and C:N are included in Table 1.
6. Cover for vermiculture: the first floor — newspapers, straw, coconut waste, etc. at the bottom / in the container. Newspaper is one of the most digestible bedding materials. Low-average digestibility for sawdust. Spreading the second moistened fine sand crop 3 cm thick, followed by a layer of garden soil (3 cm). The floor of the unit should be sealed to prevent worms from entering the soil.
7. Construction of organic waste mix: the third floor is drained of pre-prepared organic waste. After that, a thin layer of cow manure mixture is placed on the surface of the waste as a primary feed for compost worms.

Then one needs to add compost worms without growing them. Earthworms consume various organic wastes and reduce their volume by 40–60 %. The worm eats waste equal to body weight and produces 50 % of waste per day.

8. Composting process: after the addition of compost worms, 15 days pass until the end of the thermophilic process. During this process, a rapid temperature rise is observed, followed by a gradual decrease. The temperature should be maintained at 30 °C, it is recommended to raise and moisten the coating at ambient temperature (<35 °C).

The absorption capacity of the waste is illustrated in Table 1.

Table 1

**Absorption capacity of wastes**

| Waste | Absorption capacity | C:N ratio |
|---|---|---|
| Cow manure | medium – high | 20–44 |
| Peat | Good | 58 |
| Oat straw | below | 52–87 |
| Wheat straw | below | 113–143 |
| Paper waste | average | 120–165 |
| Cardboard paper | average | 560 |
| Shrubs | average | 50 |
| Sawdust | below | 145–700 |
| Waste from deciduous trees | below | 440–760 |
| Waste from coniferous trees | below | 200–1200 |

Table 1 shows that the optimum absorption capacity of peat is lower than that of sawdust and straw. Many worms decompose organic matter, but plants need an organism that produces stable humus with the nutrients available. Bio humus requires an optimal level of C:N (30:1) ratio, as it is beneficial to the life of the worm. Food waste is usually 15:1, fruit waste — 35:1, tree leaves — 60:1, and sawdust — 500:1. If this ratio increases, the decomposition slows down. If the ratio decreases, the nitrogen concentration disappears and bad odors appear. The ratio of C:N concentration in the experiment is shown in Figure 1.

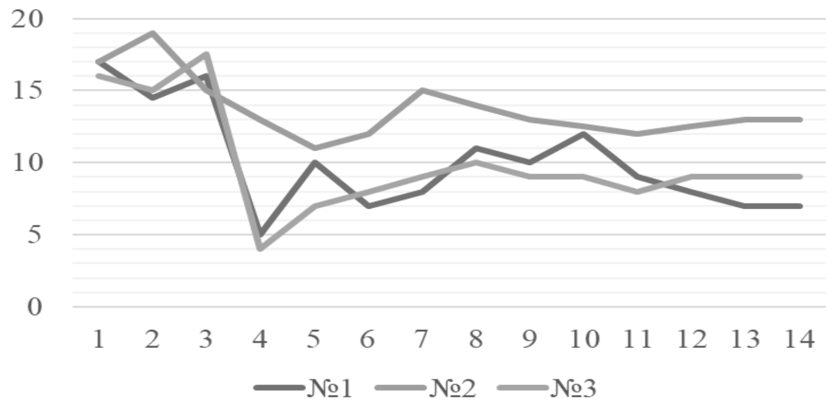


Figure 1. The ratio of C:N concentration in the experiment

C/N ratio is one of the main factors affecting compost quality. The results show that as the duration of composting increases (from the first to the 12th week), the proportion of organic carbon decreases, and over time, the total concentration of nitrogen changes. This means that the C/N ratio for all types of composting changes from time to time. However, over time, the C/N ratio in all types of compost has decreased, indicating the emergence of a stable product.

The average values of the ± standard error of the chemical and biochemical properties of the primary raw waste used in the study are demonstrated in Table 2.

T a b l e 2

**Mean values of ± standard error of chemical and biochemical properties of primary raw wastes used in the study**

| Chemical and biochemical properties | Raw materials | | |
|---|---|---|---|
| | № 1 — soil, paper, vegetables, fruits, wood waste, cow manure (1:0.5:1) | № 2 — soil, vegetables and fruits, wood waste (1:1) | № 3 — soil, cow manure (1:1) |
| pH | 6.34 ± 0.02 | 7.39 ± 0.02 | 6.67 ± 0.01 |
| Nitrogen N (g $kg^{-1}$) | 26.23 ± 0.09 | 10.08 ± 0.16 | 15.59 ± 0.19 |
| Organic carbon C (g $kg^{-1}$) | 299.38 ± 2.25 | 308.13 ± 1.65 | 301.88 ± 1.08 |
| C:N ratio | 23:54 | 58:125 | 125:175 |
| Growth rate | 42.06 ± 1.27 | 6.475 ± 0.48 | 31.84 ± 1.58 |

The optimum moisture content of compost for microorganisms is 60 %. There is a direct link between the moisture in the waste and the growth of worms. It was identified that the growth of worms is optimal at 65–75 % humidity. The compost used to make compost must retain sufficient moisture, as the worms breathe through the skin, which can lead to the destruction of the worms when the moisture content of the compost is less than 45 %. *E. fetida* and *E. Andrei* worms can withstand humidity from 50 % to 90 %, but the optimum humidity for them is 80–90 %. Bacteria also play an important role in vermicomposting. When the moisture content is below 40 %, their activity decreases and stops below 10 %.

The conditions for the use of different types of waste in compost are shown in Table 3.

T a b l e 3

**Conditions for the use of different types of waste in compost**

| № | Waste | The effect on the life of worms |
|---|---|---|
| 1 | Furniture chips | Do not use them as they are treated with chemicals |
| 2 | Wood waste, branches | They need to be crushed to increase processing efficiency |
| 3 | Leaves, grass, and straw | It is necessary to follow the moisture of the mass |
| 4 | Citrus residues | Ventilation is required |
| 5 | Oils | Sources of unpleasant odors |
| 6 | Weeds | They must be pasteurized at high temperature in an opaque package |

*Checking the growth and yield of mature compost samples.*

Before sowing tomato seeds in compost samples, equal parts of compost samples (1 kg each) were placed in plastic bags and the compost samples were watered under running water to keep them moist for several days. After that, each tomato seed was sown in permanent and finally composted specimens. Indicators of the chemical and biochemical properties of the sampled raw materials are shown in Table 4.

T a b l e 4

**Indicators of chemical and biochemical properties of sampled raw materials**

| Chemical and biochemical properties | Raw materials | | |
|---|---|---|---|
| | № 1 — soil, paper, vegetables, fruits, wood waste, cow manure (1:0.5:1) | № 2 — soil, vegetables and fruits, wood waste (1:1) | № 3 — soil, cow manure (1:1) |
| Growth rate | fast | average | fast |
| The average vegetation of the bush | 4.5±0.8 | 3.7±1.6 | 4.3±1.2 |

The number of germinated seeds was calculated for the study of seedlings, and it was determined that all seeds germinate and grow in composted samples. Consequently, all compost samples obtained were rated as mature.

As can be seen from Table 1, it is recommended that compost paper mixed with various municipal organic wastes, vegetables, fruits, wood waste, cow manure (1:0.5:1) be processed in the ratio. Tomatoes are grown in a mixture of № 1 yield on average 11 % more than composts № 2 and № 3. In the mixture, tomatoes grew rapidly.

### *Conclusions*

This study shows that cow manure should be added to create an optimal mass composition for vermicomposting municipal waste. In the experiment, three compositions for vermicomposting were created: № 1 — soil, paper, vegetables, fruits, wood waste, cow manure (1:0.5:1); № 2 — soil, vegetables, and fruits, wood waste (1:1); № 3 — soil, cow manure (1:1). Composition № 1 showed 11 % more tomato growth efficiency than other compositions. Therefore, the proportions: soil, paper, vegetables, fruits, wood waste, cow manure (1:0.5:1) are the most suitable for making vermicompost.

In the context of this experiment, the technology of solid organic waste treatment will reduce the shortage of cheap organic fertilizers on the market and offer new revenue opportunities for small businesses. In addition, the quality of compost was of standard quality as a fertilizer in agriculture can be used as seed yeast to improve ripe compost and obtain ready-made compost with good characteristics.

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## Органикалық коммуналдық қалдықтарды компосттау әдісімен тұрақтандыру

Мақалада коммуналдық органикалық қалдықтарды вермикомпосттау процесі зерттелген. Биогумустың оңтайлы құрамын анықтау үшін органикалық қалдықтарды топырақпен араластырудың әртүрлі нұсқалары мен пропорциялары қарастырылған. Зерттеу барысында көң араласқан органикалық қалдықтардың үш түрлі вариациясы жасалды: № 1 — топырақ, қағаз, көкөністер, жемістер, ағаш қалдықтары, сиыр көңі (1:0,5:1); № 2 — топырақ, көкөністер мен жемістер, ағаш қалдықтары (1:1); № 3 — топырақ, сиыр көңі (1:1). Эксперимент нәтижелері барлық субстраттарда қызанақ тұқымдарының жоғары өнгіштігі бар екенін көрсетті. Бірақ топырақ, қағаз, көкөністер, жемістер, ағаш қалдықтары, сиыр көңінің қоспасы басқа тәжірибелік субстраттармен салыстырғанда қызанақтың өнімділігін 11 %–ға арттырады. Вермикомпостинг *E. fetida* құрттарының көмегімен жүргізілді. Құрттардың бұл түрі жоғары өнімділікпен сипатталады. Вермикомпостинг үшін ылғал мөлшері 60 % деңгейінде болуы керек. Бактериялар вермикомпостингте де маңызды рөл атқарады. Ауаның ылғалдылығы 40 %—дан төмен болған кезде олардың белсенділігі төмендейді және 10 %— дан төмен температурада тоқтайды. Осы эксперимент жағдайында қатты органикалық қалдықтарды қайта өңдеу технологиясы нарықтағы арзан органикалық тыңайтқыштардың тапшылығын азайтуға және шағын кәсіпорындар үшін пайда табудың жаңа мүмкіндіктерін ұсынуға мүмкіндік береді. Алынған нәтижелер қаланың органикалық қалдықтарын өнеркәсіптік ауқымда өңдеу үшін пайдаланылуы және ауыл шаруашылығында тыңайтқыш ретінде қолданылуы мүмкін.

*Кілт сөздер*: органикалық қалдықтар, вермикомпостинг, копмостинг, коммуналдық органикалық қалдықтар, *E. fetida*, биогумус, вермикомпостинг процесі, коммуналдық шығындар.

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## Стабилизация органических коммунальных отходов методом компостирования

В статье изучен процесс вермикомпостирования коммунальных органических отходов. Для определения оптимального состава биогумуса рассмотрены различные варианты и пропорции смешивания органических отходов с почвой. В ходе исследования были разработаны три различных вариации органических отходов, смешанных с навозом: № 1 — почва, бумага, овощи, фрукты, древесные отходы, коровий навоз (1:0,5:1); № 2 — почва, овощи и фрукты, древесные отходы (1:1); № 3 — почва, коровий навоз (1:1). Результаты эксперимента показали, что все субстраты имеют высокую всхожесть семян томатов. Но смесь почвы, бумаги, овощей, фруктов, древесных отходов, коровьего навоза увеличивает урожайность томатов на 11 % по сравнению с другими подопытными субстратами. Вермикомпостинг проводили с помощью червей *E. fetida*. Этот вид червей характеризуется высокой урожайностью. Для вермикомпостирования содержание влаги должно быть на уровне 60 %. Бактерии также играют важную роль в вермикомпостировании. При влажности воздуха ниже 40 % их активность снижается и прекращается при температуре ниже 10 %. В условиях этого эксперимента технология переработки твердых органических отходов позволяет сократить дефицит дешевых органических удобрений на рынке и предложить новые возможности для получения прибыли для малых предприятий. Полученные результаты могут быть использованы для переработки органических отходов города в промышленных масштабах и применены в качестве удобрения в сельском хозяйстве.

*Ключевые слова*: органические отходы, вермикомпостинг, компостинг, коммунальные органические отходы, *E. fetida*, биогумус, процесс вермикомпостирования, коммунальные расходы.

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