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Blatticomposting: A Sustainable Approach for Organic Waste Management

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Most chemically produced fertilisers emit methane and nitrous oxide into the atmosphere, which are toxic to humans, composting is a great alternative to artificial fertilisers. Half of the organic waste generated by mankind is compostable. Blatticomposting is an innovative method for managing organic waste using cockroaches as bio converters in sustainable waste management. It is an eco-friendly strategy and an efficient method for nutrient recycling and organic waste decomposition. Overall blatticomposting presents a unique opportunity to transform waste management practices and contribute to a more sustainable future. This review paper aims to provide an overview of blatticomposting and its process, its benefits, challenges and prospects. Furthermore, we explore

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the potential applications of this technique and its contribution to waste reduction, resource recovery, and sustainable agriculture which leads to the upliftment of mankind leading to a healthy life.

Keywords: Bioconversion; organic waste; blatticomposting; greenhouse gas emissions.

1. INTRODUCTION

As the human population is increasing rapidly there will be 60% increase in food demand [1], Consequently, the waste generated by human activity will be increased by 70% in 2050 [2]. In India recycling organic waste is not only essential for the environment, but it is also economically required. The globe is seriously threatened by environmental deterioration, which is mostly caused by the reckless use of chemical fertilisers that eutrophicate water supplies and also emit carbon dioxide in the process. Due to intensive farming methods, uneven use of chemical fertilisers and poor agricultural waste recycling, macro- and micronutrient deficiencies are frighteningly growing throughout our country [3]. More people are becoming aware that using ecological and sustainable practices is the only way to reverse the decline in global productivity and environmental preservation. According to reports, nearly 700 million tonnes of organic waste are reportedly produced in India each year, and the majority of it is either burned or discarded [4,5]. The enormous amount of agricultural waste produced in fields or marketplaces has led to major environmental problems. By improving the physical properties and other processes of the soil, returning organic waste to it can increase soil fertility and productivity [6,7]. Numerous micro- and macro-organisms that live in soil can convert organic waste into plant nutrients and organic matter, both of which are essential for controlling soil fertility and productivity [8]. A cutting-edge technique called blatticomposting uses cockroaches to convert agricultural waste into compost and in addition, they are nutritionally better than other insects due to their high protein levels, good amino acid balance and low-fat content [9]. Cockroaches are essential to the cycling of nutrients in both wood and soil avoiding wildfires in tropical and subtropical forests. It is routine to see cockroaches and they have a big impact on how things decompose [10,11]. According to FAO, one-third of the food produced worldwide is wasted annually. Research is being conducted on a global scale to determine the mechanisms that produce compost for plants that is nutrient-rich. It facilitates the efficient recycling of agricultural wastes, such as animal and plant remains and these roaches can be used in a novel way to recycle kitchen and agricultural waste [12]. As the importance of cockroaches has become clearer, research into using them for human purposes has started. Blatticomposting is still in its infancy as a composting technique [13]. In metropolitan locations, it might be difficult to dispose of kitchen waste and waste from vegetable markets [14,15]. Pests are kept out of compost bins because cockroaches live in dry environments and produce less unpleasant odours or mould growth. Therefore, studies on blatticomposting continues with the hope that it will one day be more widely used and aid in dealing with kitchen waste and agricultural farm waste with valuable bioresources.

2. LIST OF THE ROACHES SUITABLE FOR COMPOSTING

2.1 Ivory Head Cockroach, *Eublaberus sp. Ivory*

These roaches are not very common, usually grow very big in both size and length with straight forward wings and remarkable pronotum markings which helps to distinguish them from other roaches. These are tame and very social and breed at a very high rate at room temperature [10] (Fig. 2).

2.2 Six Spotted Roaches, *Eublaberus distanti* (kirby, WF, 1903)

These are found in South American caves where they live in crowded conditions on cave floors eating anything including bat poop and dead animals. They will grow about 2.5 inches. and the nymphs have distinctive patterns of six spots on their backs [10] (Fig.2).

2.3 Pantanal Roaches, *Eublaberus serranus* (Hebard, 1920)

This species are usually native to the "Pantanal" wetland area of Brazil and are known to love dampness. The adult Pantanal has various

pronotum designs ranging from T-shape to a dark blob with two headlamp marking spots [10] (Fig. 2).

2.4 Orange Head Roaches, Eulaberus *posticus* (Erichson,1848)

These roaches have some characteristics that do not make them good for composting. They are cannibalistic and they will eat one another, known for biting their wings and prefer warmer than room temperature [10] (Fig. 2).

2.5 Surinam Cockroach, *Pycnoscelus surinamensis* (Linnaeus, 1758)

Pycnoscelus sp. Is a burrowing cockroach, commonly burrowing in loose soil, humus, compost files, trash and other debris. It is originated in the Indomalayan region and is now cosmopolitan, found around the world. The populations are almost exclusively females and it reproduces through ovivivparity [10] (Fig.2).

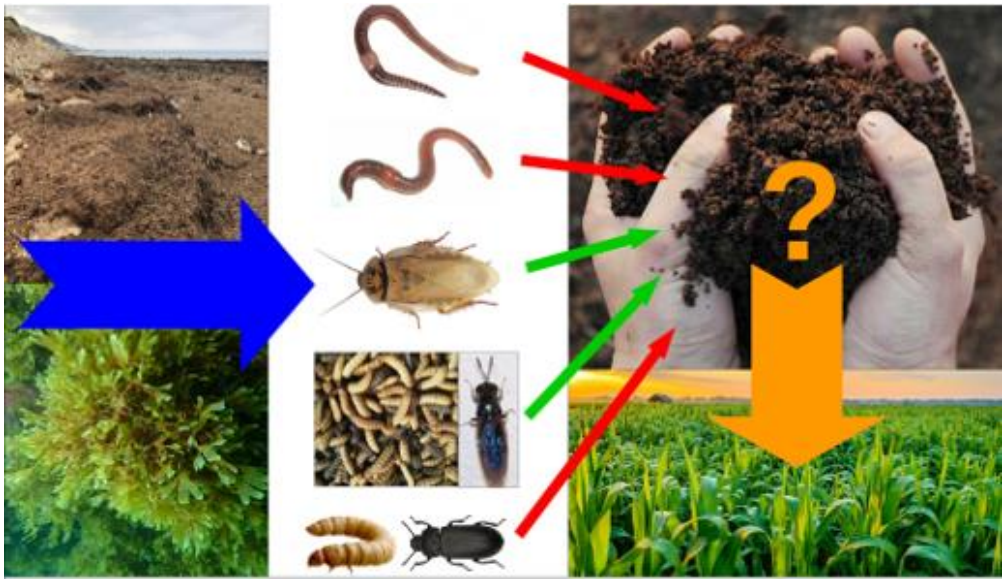
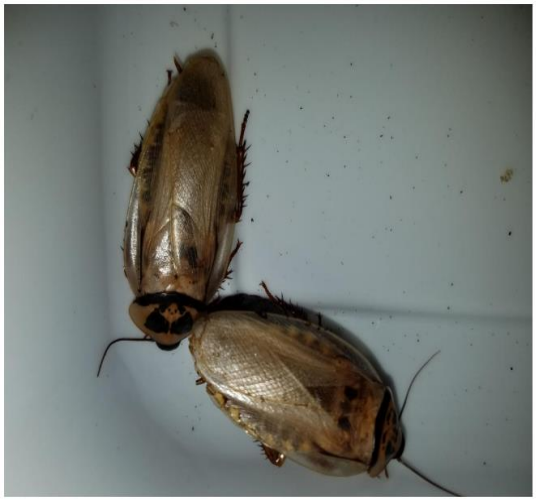
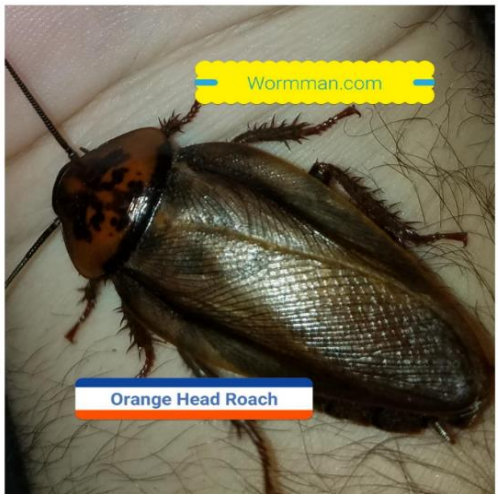


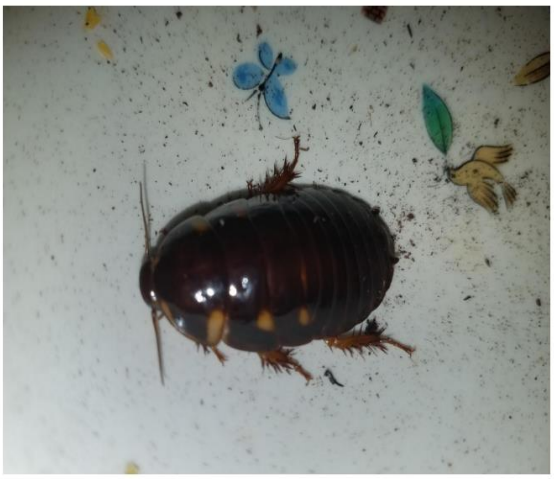
Fig. 1. Organic compost produced from insect world (Paton et al., 2022)



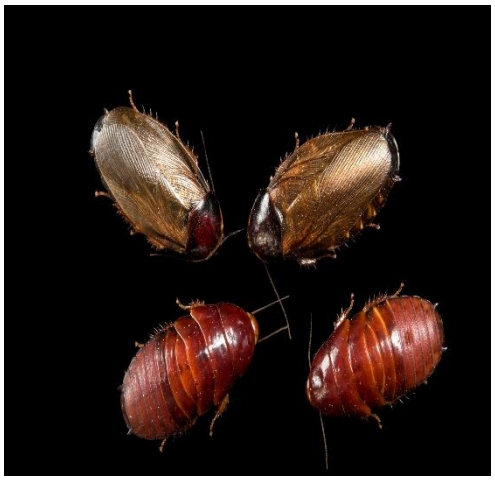
Ivory head cockroach



Orange Head cockroach



Six spotted cockroach



Surinam cockroach

Pantanal cockroach

Fig. 2. Cockroaches suitable for composting (Chiarella, 1997)

3. BLATTICOMPOSTING – PROCESS

Due to the shortcomings of traditional vermiculture in hot environments, other composting alternatives based on the use of different insect species are being tested in numerous Mediterranean climatic zones. Because of their low trophic specificity, adaptability to a wide range of conditions, strong prolificacy, voracity, lack of requirement for light, and great tolerance to overcrowding, cockroaches were utilised in the bioremediation of organic wastes of various types [16,17]. Blatticomposting also called cockroach composting, is an organic waste management process that utilizes some species of cockroaches to break down and convert organic waste into nutrient-rich compost (Fig. 3). This process is an alternative to traditional composting methods and has gained attention due to its sustainability.

The blatticomposting process involves the following steps:

1. Selection of roaches: Certain species of composting cockroaches such as the red runner cockroach (*Nauphoeta cinerea*), Burrowing cockroach (*Pycnoscelus surinamensis*) and the Dubia cockroach (*Blaptica dubia*) are used in blatticomposting. These species are well-suited for composting due to their ability to digest a wide range of organic wastes. The cockroach *B. dubia* can be used as a model species in other experimental setups due to its easy culturing, high instar production rate, and easy maintenance in the laboratory [18].

2. Preparation of substrate for composting: “Substrate” is a term used to describe the base of the composter. The substrate allows the roaches to hide, but it also enables to bury the food scraps so that they won’t attract flies. The organic waste material such as kitchen waste, vegetable peelings, farm waste, coconut coir bedding, egg crates and shredded paper, serves as the composting substrate. It is essential to maintain the proper moisture content and carbon-to-nitrogen ratio to ensure optimal conditions for cockroach composting [10].
3. Cockroach feeding and digestion: The cockroaches feed on the organic waste, breaking it down through mechanical and enzymatic digestion. They have efficient digestive systems that allow them to consume various organic materials, including cellulose-rich items that are difficult for other composting organisms to digest it. The intestinal microbiota found in cockroaches is the main cause of cellulolytic digestion. The intestinal microbiota of *Pycnoscelus* cockroaches with the cellulolytic strain *Bacillus pumilus* IB-320 helps in the bioconversion of several kinds of paper waste [19].
4. Decomposition and nutrient enrichment: Decomposition process results in the excretion of digested waste in the form of faecal matter known as frass. This frass is rich in nutrients, such as nitrogen, phosphorus, and potassium, which contribute to the overall nutrient enrichment of the compost. Over time, the compost matures and transforms into a dark and stable material.
5. Harvesting and utilization: Once the compost reaches maturity, it can be harvested for use in gardening or agriculture. The resulting compost is nutrient-rich and thereby it improves soil fertility. It also helps to retain moisture in the soil and enhances its structure and promotes plant growth. The compost bin will need to be cleaned out every month and the frass can be used or stored for later use. The monthly cleaning is to remove old food peels, uneaten food and to remove excess frass [20].

In addition to composting studies revealed that the American cockroach (*Periplaneta americana*) has high nutritional qualities. Proximate nutrient composition indicated that cockroach has high shelf-life and can be preserved in good quality long after preparation and confirmed the fact that cockroaches are indeed a good source of fat, protein and other micro and macronutrients which were readily present and should therefore be recommended as both food and feed for humans and animals [21,22] .

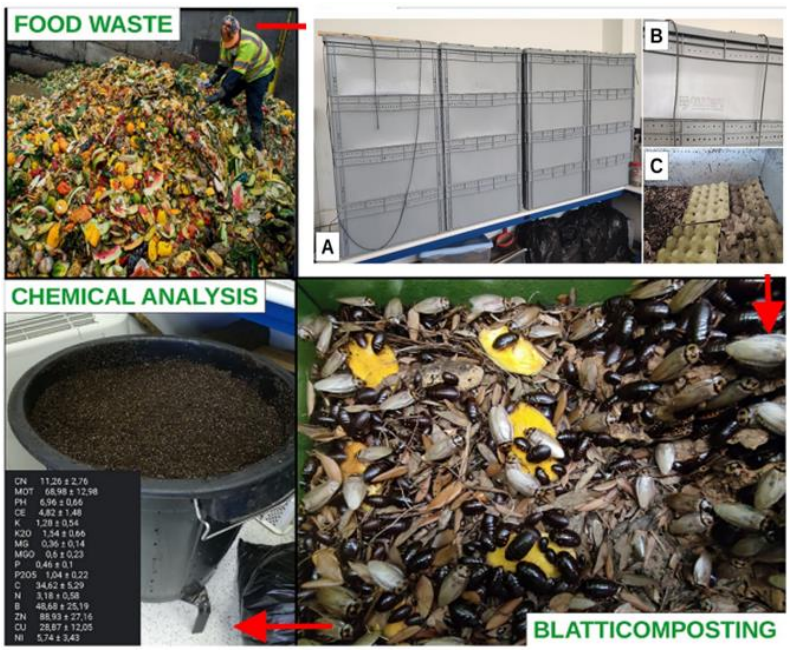


Fig. 3. Process of blatticomposting (Paton et al., 2023)

3.1 Efficiency of Blatticomposting

The efficiency of blatticomposting refers to the ability to convert organic waste into nutrient-rich compost. It has higher conversion rates compared to conventional composting methods because of their feeding behaviour and digestive symbionts. It produces compost with high nutrient content, enhancing its value for agricultural and horticultural applications and also has antimicrobial properties in their digestive tracts, which help to suppress the growth of harmful bacteria and pathogens. This contributes to the production of safer and hygienic compost (Fig. 1). The ivory cockroaches *Eublaberus spp.* are the species that consume the algae and is the easiest to maintain, thus allowing the creation of bioremediation plants on an industrial scale [16]. The efficiency of blatticomposting can be influenced by various factors, including the choice of cockroach species, composting substrate, environmental conditions (such as temperature, moisture, and pH), and management practices.

Aside from the pest species, other species of cockroach do not cause harm to humans and live outdoors in the wild, feeding on leaf litter and other organic materials. Like every other insect, they play a significant role in the food chain, as after feeding on different materials, many predators feed on them. In tropical regions, cockroaches also play an immense role in nutrient cycling, eating leaves and wood thereby converting them into the soil [10]. A popular and profitable technique of creating organic fertilisers that are not only a source of nutrients but also hostile to microbiota by composting solid organic waste.

Pycnoscelus surinamensis which was found in the compost sample in Surabaya, despite the species being known to be a host of parasitic organisms, however with appropriate management, can be employed in organic waste processing. Moreover, the symbionts of *P. surinamensis* can be explored for hydrolytic enzymes that are involved in organic material degradation, including the recalcitrant cellulosic materials. Exploration in biotic association, molecular biology, and method for application of this species are needed for optimum utilization in the organic waste processing plant [12].

4. CHALLENGES AND LIMITATIONS

Blatticomposting offers several advantages, it also faces challenges and limitations that need to be addressed for its widespread adoption and implementation.

- Public acceptance as there is a negative perception of these roaches associated with unsanitary conditions. Awareness campaigns are necessary to dispel myths and promote the benefits and safety of the process. Based on the fact that cockroaches can transmit pathogenic microorganisms, it is necessary to clarify that these are only present in the food they consume when they feed in landfills or sewers [23].
- Odour control measures must be implemented using well-ventilated composting systems and managing moisture levels to avoid fruit flies, gnats and mites in the substrate.
- Cockroach populations if left uncontrolled can quickly grow and potentially become a nuisance. Some species of feeder and pet cockroaches, when they are used for composting, can climb glass and plastic and some can even fly away and leave the compost.
- Some species require high temperatures to grow and breed. Hence, while selecting the species of roaches for composting, the optimum temperature requirement should be considered.
- All types of organic waste is not suitable for roaches. Some waste materials, such as large woody debris or materials with high lignin content, may not be readily consumed by cockroaches and only certain species of roaches are right for composting.
- Decomposition processes may be subject to regulatory oversight, particularly regarding potential health and environmental risks and non recycling waste can generate serious health issues for the people residing near landfills due to the proliferation of pathogenic microorganisms, increased greenhouse gas (GHG) emissions, infiltration of toxins into groundwater, and loss of quality of life due to increased odours [24,25].

Technological innovations, best practices development and collaboration among stakeholders will contribute to the sustainable advancement and wider acceptance of blatticomposting.

5. APPLICATIONS AND PROSPECTS

Blatticomposting holds significant applications and promising prospects in various areas.

- It can be integrated into existing waste management infrastructure to enhance overall efficiency. It can be combined with other composting methods, such as vermicomposting to diversify waste treatment options.
- World Bank has allocated more than $4.7 billion to more than 340 solid waste management programs in many countries around the world since 2000 [1].
- Urban and peri-urban waste management as space for traditional composting methods may be limited. Its ability to efficiently convert organic waste into compost makes it a viable solution for managing household waste.
- It holds particular promise in developing countries. Its low-cost and relatively simple setup makes it accessible to communities with limited resources and provides valuable compost for local agricultural practices.
- It forms a circular economy by promoting resource recovery and it contributes to closing the nutrient loop by converting organic waste into nutrient-rich compost, which can then be used to enrich soils. It is a cost-effective method of obtaining organic fertilizers that are not only a source of nutrients but also hostile to microbiota. It is an eco-friendly strategy that leads to sustainable agriculture and safe human exposure.
- Technological advancements in blatticomposting can open up new possibilities and improve its efficiency and this includes exploring cockroach species with enhanced composting abilities, optimizing composting systems, developing automated monitoring and control systems, and investigating the potential use of cockroach-derived enzymes from gut microbiota for waste degradation.

In an urban organic waste processing facility, the investigations demonstrated that the blatticompost is rich in nutrient composition. The organic waste, in particular, was from kitchen trash, food and agricultural industrial waste, which determined the quantity of mass ingested by *Pycnoscelus* cockroaches and the gut microbiota present in the species that are responsible for litter digestion [12].

The roach frass is 100% organic and serves as excellent fertilizer and manure that are required by plants to grow healthy. Roach frass can be used for seedlings and on all plants, lawns and gardens. A small amount will be enough for seedlings which can be mixed with the soil or just dump it on the ground of the seedling. A few tablespoons are enough in plants and research studies show that one pound should cover 350 – 400 sq ft [10].

6. CONCLUSION

The world is facing a very serious problem with organic waste, as its production is increasing enormously. It emphasizes the potential of blatticomposting to address the growing global waste crisis while offering numerous environmental and agricultural benefits. Blatticomposting has the potential to revolutionize the way we manage organic waste. Kitchen waste and other organic waste is challenging in future in the urban areas. As a part of composting, Blaticompost is still in its infancy stage, more studies are in need to explore. The main aim of this review paper was to evaluate efficient organic waste recyclers from the insect world like cockroaches and to improve organic waste management.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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