The International Journal of Engineering and Science (IJES)
|| Volume || 11 || Issue || 8 || August || Pages || PP 13-20 || 2022 ||
ISSN (e): 2319-1813 ISSN (p): 20-24-1805

Zero Waste Management Integreted with Poultry and Maggot Production to Minimize Cost

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ABSTRACT
Waste is the symbol of inefficiency of any modern society and a representation of misallocated resources.Zero waste integrated between poultry and maggot cultivation was createdprotein source from the black soldier fly larvae (BSFL) itself. Maggots were very greedy on eating organic waste, included the poultry manure can be consumed by BSFL. Poultry manure was drop down to the maggot biopond, and was directly eaten by maggot. After the maggot in the pupae stage, the maggot put in poultry bin and was eaten by poultry as a protein supplement. They are three benefits in the integrated scheme, firstly poultry manure was used as maggot feed directly, it's reduce the labour and transportation to manage poultry manure. Secondly, maggot can replace the fish and soybean meal as a protein sources, it's reduce the feed's cost. Thirdly, compost material is very useful as a soil amendment and fertilizer. Overall, this integrated scheme of poultry and maggot production reduces the cost and increases the benefits.
Key words: *organic waste, maggot, protein, poultry, integrated*

Date of Submission: 25-08-2022 Date of Acceptance: 09-09-2022

I. INTRODUCTION

Waste is the symbol of inefficiency of any modern society and a representation of misallocated resources.[1]The issue of the municipal waste management are some of the most important challenges. They are many definition of zero waste. Zero waste vision requires a change in our way of thinking and establishment of practices. The zero concept is the form of waste management, the zero waste concept including a wide range of steps.[2]

Zero waste is defined as the conservation of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that treat the environment or human health.[3] Zero waste principles contributes to the circular economy.[4] Circular economy is an economic system that replacesthe ''end-of-life" concept with reducing, reusing, recycling and recovering materials in production, distribution and consumption phase of their life cycle.[5] Zero waste is connected to properties agriculture, design, energy, industrial, economical and community development.[6]

Zero waste is a visionary concept for confronting waste problems in our society. The idea is being developed and implemented in various sectors including waste management and treatment.Zero Waste is a strategic vision of a community.[6]It supposes that raw materials in the system will be recycled, and will not end in an incinerator or in landfills. However, in fact this is an attainable aim, and an increasing number of states, towns, municipalities and companies all over the world are gradually joining this movement.

In the very beginning it is necessary to realise that the term Zero Waste does not mean reduction of production of all waste to zero. The term means elimination of the present way of waste disposal by depositing to landfills and incineration. Selection of this aim is important, because it does not present a choice. We must do anything possible in order to achieve it.

Zero Waste vision requires a change in our way of thinking and of established practices. Instead of solving the problem of what to do with the produced waste, we must concentrate, especially, on the issue of how to manage natural resources more wisely, and how to reduce the total volume and hazardousness of waste. The Zero Waste conception is the form of waste management. In the first place, it is necessary to prevent waste creation, secondly, to minimise its amount and toxicity, and, thirdly, it is necessary to repair products. If these steps are not possible, then recycling is utilised.

The Zero Waste concept includes a wide range of steps. Some of them are already required by the present European legislation. The economic and system tools include responsibility of producers for their products. Briefly explained, this means that if a product and its packaging may not be re-used, recycled or composted, then the producer must be responsible for its collection and its safe disposal after the end of its

lifetime. In the EU countries, this concept is applied to packaging, oils, electrical waste, accumulators, batteries and single-cell batteries, discharge and fluorescent lamps, automobiles, tyres, and medicines.[2]

Zero waste is a goal that aim to minimize amount of resources and materials consumed, in effort to conserve water and energy an ultimately to multi at climate changes. It is not simply about Reuse, Recycling and diversion from landfills it represent shift in thinking to prevent waste from created in first place. Zero waste is a goal that is ethical, economical, and visionary, to guide people in changing their life styles to emulate sustainable cycles, where all discarded materials are designed to become resources for other use. [6]

Zero waste communities and business are those that divert 90% of their waste from landfills, incinerators and the environment. Zero waste is a goal that aim to minimize amount of resources and materials consumed, in effort to conserve water and energy an ultimately to multi at climate changes.[6]Zero waste is the most holistic innovation for achieving a true sense of sustainable waste management system. The concept has attracted much public attention. Today "the zero waste concepts used more both in Sweden and other parts of the world discussing different ways of modern waste management in order to reduce the amount of waste for final disposal as much as zero.[7]

The existing solid waste management system schemes have been developed and implemented including systems for recovery and reuse.In this study, zero waste lifestyle is measured by applying 3R theory (Reduce, Reuse, and Recycle). Several studies use 3R principles as the dimensions of waste management or zero waste lifestyle.[3,8,9]The Reduction principle is defined as minimizing the amount of waste through reducing consumption and waste avoidance. [3,4] The Reuse principle refers to using again a product or a component/material of the product according to the original purpose. While the recycle principle refers to the recovery operation when waste is reprocessed into products or materials. The zero waste concept includes a wide range of steps:

Ten steps to zero waste according to Moscone[10]: (1)Source separation; **(2)** Door-to-door collection; **(3)** Composting; **(4)** Recycling; **(5)** Reuse and repair; **(6)** Waste reduction initiatives; **(7)** Economic incentives; **(8)** Introduction zero waste research; **(9)** Demand better industrial design; **(10)** Respect.

Principle of Zero waste according to Sahu[6]; (a) System Wide Principles Flow of resources viewed as a cycle with minimized input and output. The responsibility by products for the life cycle impacts of products and packaging, creating incentive to design more benign products. Focusing on increasing benefits to communities and optimizing productive use of resources. Also focus on locally owed, independent industries. According for environmental costs and benefits. (b) Government Policies Eliminate waste by holding producers responsible for impact. Systematically optimize environmental, economic and social impacts of the production and consumption cycle. Create level playing field or outright subsidies to promote resource conservation industries. (c) Raw Material Supply The Emphasis on recycled material use and sustainable harvesting of natural resources. Also Emphasis on use of nontoxic materials. (d) Product and Packing Design Guided by design-for-environment principles to reduce resource use and environmental emissions, and to minimize recycling or reuse costs. Focus on waste minimization, durability, reparability, and recyclability. Maximized lifespans of products. (e) Manufacturing Practices Companies redesign entire operations to minimize resource use and environmental emissions and maximize product reuse and recycling. Producing companies are responsible for end-oflife management of their products and packaging. Producers influence Zero Waste throughout the system by adjusting specifications for suppliers and by taking responsibility for endof-life management. (f) Consumption Consumers select products based on environmental performance, price, and quality. Consumers participate in recycling and reuse programs. (g) End–of-life Management Programs create strong incentive to maximize diversion. Programs incorporate full cost accounting principles. Producers bear most costs of disposal.

According to Havel[2], Implementation of the Zero Waste concept requires: (a) To determine the year in which we want to achieve this aim - usually, this concerns a period of 15 to 20 years, the final aim should be planned in several stages; (b) To involve the public in the intention - local representatives, entrepreneurs, inhabitants. The public campaign must be a permanent part of the plan. The campaign may include issuance of a leaflet for each household, intensive campaign in the media, opinion polls, lectures, often it is necessary to personally contact households, from door to door, competitions for schools, exhibitions, notice boards on municipal authorities. (c) To promote and support projects for prevention of production of wastes, and for their re-use - local deposit system, second-hand store selling furniture, building materials, electronics, etc.; (d) To start biological waste composting - if possible, to support composting in households and communities in the first stage, and, later, a system of collection of biological waste and its composting in the municipality; (e)To create good conditions for separated collection of dry recyclable wastes for the inhabitants - to ensure sufficient number of containers for recyclable components; in the districts of family houses, a sack system and collection from door to door may be introduced; (f) To introduce collection of high-volume, hazardous wastes, and to set a system of building waste management; (g)To motivate households - provide for introduction of just fees according to the amount of produced waste; in the case of lump-sum fees, a lower fee may be offered to people who participate in the system; (h) To increase fees for landfilling and incineration of wastes - the income from

these fees should be used for setting up the Zero Waste system; (i)To support take-back programmes - to convince the local tradesmen to introduce a take-back system for their products, in accordance with the local conditions; (j) To refuse construction of an incinerator and landfills - incinerators are demanding from the economic point of view, and the investments do not stay in the region.

The initial aim of any waste management technique to be adopted is tomaximize profit from the generated waste and to likewise maintain environmentalsafety standards, hence there is need in an issue of both profitability, affordability and sustainability.

II. Black Soldier Fly (BSF)

Insects are natural food source for poultry, chickens, for example can be found picking worms and larvae from the top soil and litter where they walk. Most trials indicate that partial or even total replacement of fish meal is possible.[11]

Quality and quantity of feed is important for poultry growth.Fresh or flour BSFL can be used as protein supplement to substitute of fish meal or soybean meal.Insect larvae, such as black soldier fly larvae (BSFL: *Hermetia illucens*) are currently being considered as an alternative source of protein for poultry and aquaculture industry while in the same time apply as agent to manage organic wastes, in which black soldier fly considered as the best candidate. BSF Larvae have a high protein content, making them suitable as additional feed for livestock. Mass balance in BSFL cultivation as shown in Figure 1.

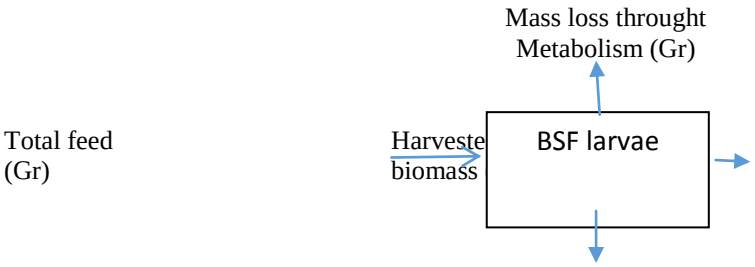

Figure 1. Mass balance model of bioconversion of organic waste into body biomass of BSF.[12]

Principally, degraded organic waste can be used as feed for natural insects, especially in the larva phases. Feed use to metabolismthe body of maggot into mature, and then mature maggot harvested and use as poultry feed. Undigested feed is rejected to environment as a compost to soil amendment. BSFL can able to degrade and consumeorganic waste that can reduce animal or poultry dung and municipal solid waste.[13]BSFL its self can be able directly consume the degraded organic waste, while mature BSF live itself without feed.
Mass balance is an approach to design biomass production system and to predict the digestibility of diet. Based on the approach, the total number of feed consumed by larva was divided into three output, the mass of diet material that use to maintain homeostasis of larva, the mass of undigested diet material, and the harvested biomass (Fig.1).

During larvae stage, insect consumes a large quantity of food as a reserve for adult stage. The weight of larvae highly depends on the composition of food. Protein to produce heavier larvae which explained the lighter prepupa weight.[14]Prepupa weight highly affects the growth, survival, and biological traits related to reproduction of adult flies.[15]Factors influence the production of maggots such as humidity, temperature, nutrition and odours of materials in fermentation.[16]

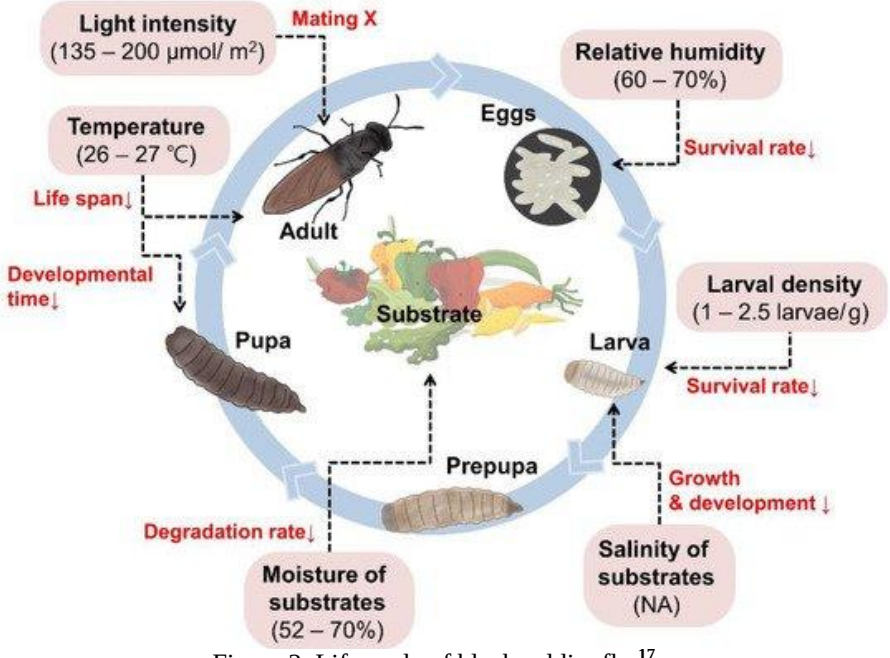

Figure 2. Life cycle of black soldier fly.[17]

BSF life cycle as shown in Figure 2. From eggs to BSF pupaemature approximately take 40-43 day.[18] Just birth BSFLto mature BSFL or pupa needs feeding.Larvae to prepupae needs 2 weeks, prepupae to pupae needs 1 week time, that is time to consume food effectively. BSF mature is not need feeding, just matting and gave eggs.

The composition of flour maggot was shown in Table 1.There is a considerable variation in nutrient composition of maggot meal reported in literature. The reported crude protein varied from as high as 64%[19] to as low as 39.16%. The composition of flour maggot is varies because of the composition of feed of maggot also different, especially in amino acid essential.[16]

Table 1. Proximate composition of maggot flour.[20]

Parameters	Results
1. Protein (%)	38.22
2. Carbohydrate (%)	20.17
3. Ask (%)	9.425
4. Total lipid (%)	25.66
5. Moisture (%)	6.52
6. Lipid energy (Kcal/100 g)	230.94
7. Total energy (Kcal/100 g)	464.5

Mature maggots were harvesting, separated from substrate and then washing, frying, and milling to get flour maggot. Protein content of flour maggot is high enough to replace of fishmeal or soybean meal. The effects of time harvest of maggot, after 48 hours harvesting, the crude protein was decreased.[21]

III. Poultry cultivation

The cost portion of cultivation of livestock was about 60 – 70% the total cost.[11,22,23] The high cost of feeding is associated with the inclusion of the conventional protein sources like the fishmeal and soybeans meals which are very expensive.[23] As a result, the focus of livestock and fish nutritionists has been to valorise alternative sustainable protein sources such as the maggot meal which can be produced easily using readily.

Maggot meal production is less costly and less tedious when compared with other sources of animal protein.[24]Protein digestibility of maggot was lower than fishmeal.[25]

The waste quantity of poultry mature approximately 0.068 Kg/each.day,[26] and the moisture content of 72-74%.[27]Chicken manure can be used as substrate maggot production.[28] Sanou[29]show that poultry litter was the best substrate to produce maggots, with a production output of more than 80 g of maggot per 4 kg of poultry litter. The maggots consume the organic substrates and reduce its quantity and quality during their development inside the substrate. Horse manure also used for maggot substrate. [12]

Composting chicken manure get a stable end product without much loss to the nutrients.[26,30]The compost is useful for amendment and fertilizer of soil. Chicken manure was fermented in the digester to get biogas as an energy alternative.[31,32]Biogas can be used for fuel and lightening.

III.1 The equipment used for BSFL farm

The equipment to cultivate BSFL:

1. Biopond for BSF matting and gave eggs
2. Biopond for BSFL cultivation
3. Biopond for egg collection
4. Biopond for keeps BSFL
5. Plastic container for young and mature Maggot
6. Probiotic (EM4)
7. Paddy rice skin
8. Feed formula for maggot new bird
9. Municipal solid waste for BSFL cultivation

Full costing to calculate the cost production:

1. Raw materials cost
2. Labour
3. Fixed overhead
4. Variable overhead
5. Fixed production cost

That is the minimum equipment use and materials cost to cultivated BSFL.

IV. TECHNICAL ANALYSIS

Sanou[29] showed that poultry litter was the best substrate to produce maggots, with a production output of more than 80 g of maggot per 4 kg of poultry litter (dry matter basis). Poultry manure is rich in nitrogen but also contains significant quantities of phosphorous and potassium. Due to the composition and the content of selected nutrients poultry manure can be applied as a fertilizer to improve soil properties and fertility. However, with increasing quantities of poultry manure there is no sufficient agricultural land for application of poultry manure. Excessive quantities of poultry manure require transportation, storage and further handling and/or processing.[33]Uncontrolled management of poultry manure can cause emission of methane, carbon dioxide and ammonia into the atmosphere. Therefore, managing poultry manure requires a complex approach. There is a number of available technologies that would allow recovery of nutrients and energy from poultry manure on site using the infrastructure of poultry farms. However, some of those already commercially available technologies would require the adjustments of farm infrastructure and substantial capital investment. Complex approach to efficient management of poultry manure would require overcoming a number of obstacles that include handling and transportation.

Insects are natural food sources for poultry. Chickens, for example, chicken can be found picking worms and larvae from the topsoil and litter where they walk. Maggot meal has been included in broiler diets as a replacement for conventional protein sources, such as fish meal. Most trials indicate that partial or even total replacement of fish meal is possible, though the optimal inclusion rate is generally lower than 10%.[11]

IV.1 Design of poultry and maggot farm

The goal of zero waste Management is to maximise the profit that used the poultry manure as feed the maggot. The maggot bioreactor is placed under poultry coops, the manure drop was collected in the maggot bioreactor. The poultry coops and maggot bioreactor were designed series about 20 bioreactor. The maggot bioreactor can be moved forward until the maggot growth from larvae to pupae.The series of maggot bioreactor mush be adjusted every day to move forward to older pupae steps.

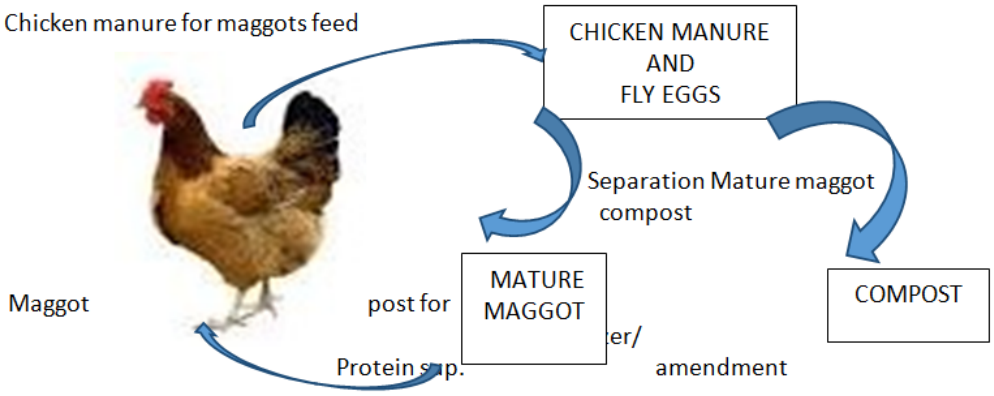

Figure 3. The cycle of chicken manure eat by maggot and maggot was eaten by the chicken.[34]

When Chicken manure drop directly to maggot bioreactor and then maggot was eaten the chicken manure. After the maggot grow up to the pupae, the pupae is ready for chicken feed.

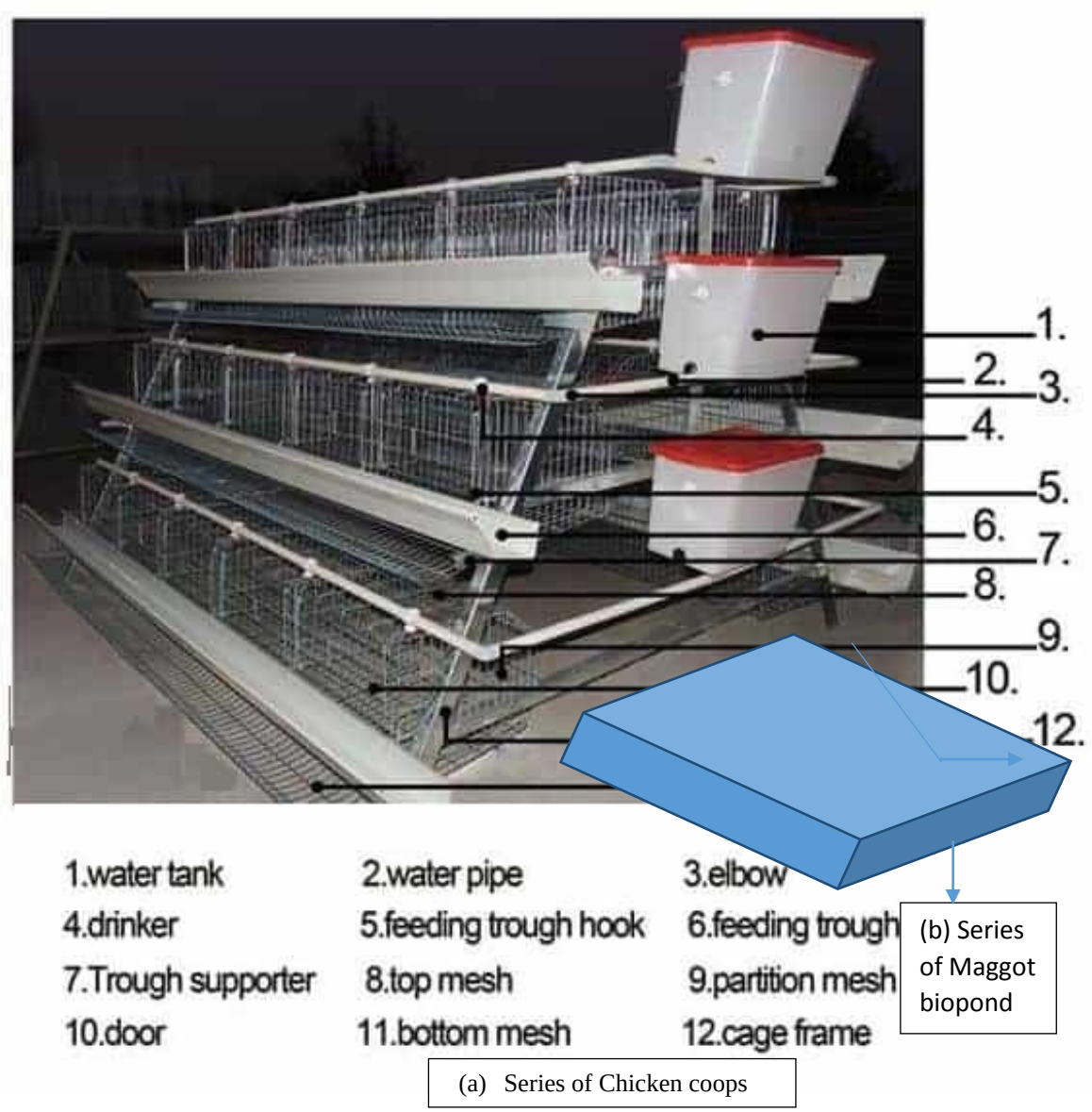

Figure 4. Chicken coops. From Hightop. Poultry equipment (a)and maggot biopond()(b). The maggot biopond is inserted under chicken coops.

Design of chicken and maggot farm as shown in Figure 4. Chicken coops are placed in the upper of the maggot biopond, maggot biopondis inserted under chicken coops. The chicken manure drop directly to the maggot biopond and then the chicken manure was eaten by maggot. Because of the chicken manure drop to the maggot biopond, there is no need to handle and transport of the chicken manure any more and there is no accumulationof the chicken manure in one place.

V. CALCULATION OF THE SIZES CHICKEN AND MAGGOT FARM

The female of Black Soldier Fly (BSF) can give of 500 eggs each BSF as long as 5 to 8 days after pupae. The egg will bird become larvae in 4 to 5 days. Larvae BSF can grow until 25 cm long and wide 6 cm and the weight larvae 220 mg in the end of they grow. The larvae can consumeof organic waste as large as 500 mg organic waste each larvae per day.[35]The life cycle of black soldier fly as shown in Figure 2. Weight of egg around 0.026-0.03 mg each. The female BSF just give egg one along their life.[18]

There are many based of calculation, firstly, based on the amount waste being proceeded. The amount of waste will impact on the square of maggot farm and resulted the amount of the maggot bioreactor, and the size of chicken farm would be equivalent to the maggot bioreactor existing.

Secondly, the size of chicken farm will be built is not limited. The amount of maggot bioreactors equivalent with the chicken manure products, where the maggots able to degrade the manure. The amount of wastethat used to feed the maggot, the amount of waste is enough to feed the maggot, the size will be equivalent with maggot bioreactor existing.

VI. CONCLUSION

Zero waste management can be run effectively in many steps, that is includedto maximize economic benefit, used of waste to benefit conversion. It is measuring by applying 4R(reducing, reusing, recycling and recovering). The conversion of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with no discharges to land or water. Integration of chicken and maggot farm gave many benefits. The maggots effectively eaten the chicken manure and the maggots were fed to the chicken. Overall will get the benefits. Firstly, the amount of protein chicken feed was reduced, it's replaced by maggots. Secondly, no needs collecting, transportation of the chicken manure, it's reduced the labours. Thirdly, there is no accumulation of chicken manure in one place.

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