Eco Enzyme

Tackling the Climate Catastrophe with Plant-Based Reusable Products

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Abstract *The article "Eco Enzyme – Tackling the Climate Catastrophe with Plant-Based Reusable Products" deals with organic food waste and the extent to which vegetal agency mobilizes people to process plant-based food scraps into a variety of products instead of dumping them uncontrollably in landfills. The reduction of greenhouse gas emissions and other benefits, especially for women, are examined from an ecofeminist perspective.*

Due to its geographical location on the Pacific Ring of Fire, Indonesia is particularly exposed to various natural hazards which, in regions with dense populations, often develop into immense disasters (Hidajat 2008, 367–380). However, it is not only endogenous forces and processes such as volcanic eruptions and earthquakes that pose risks to the Indonesian population but also exogenous forces that are driven and increased in magnitude and frequency by climate change. Natural hazards caused by exogenous forces include tsunamis, sea level rise, floods caused by heavy rain, and the resulting mudslides (Djalante 2018, 1785–1810). By 2050, the global population is expected to reach 9.7 billion, with Indonesia being one of the nine countries with the largest population increases between 2019 and 2050 (United Nations 2019, 1). The increase in population not only results in higher exposure to natural hazards but also in an increase in food demand. In correlation with the population growth, the global food demand is expected to increase by 50 to 100% (Stuart 2015), and with it the correlating food waste. It can be predicted that with the growing population, the volume of waste will also increase by 70% by 2050, "with landfilling and open dumping being the main waste handling

methods" (Ermolaev et al. 2015, 1). To mitigate this issue, greater cooperation between plants and humankind will be required.

Approximately one quarter of the food available for human consumption is either wasted or lost in the food supply chain (Stancu et al. 2016, 7). While food loss refers to the decrease in quantity and quality of food at the production or manufacturing level, food waste relates to the decrease of quantity or quality of food due to decisions and actions made by retailers, food services, and consumers at the distribution and consumption stages (7). A country-based comparison of the different phases in which food waste occurs seems crucial in this context in order to show the country-dependent responsibility of different players with regard to food waste: while in affluent countries it is primarily consumers who must be held accountable, food waste in developing countries takes place even before it reaches consumers (EIU 2016, 39). According to the Indonesian Waste Management Directorate (*Direktorat Jenderal Pengelolaan Sampah*), a branch of the Ministry of Environment and Forestry (*Kemerinterian Lingkungan Hidup dan Kehutaan*), in 2023, food waste accounted for the largest share of trash across the country at 41.1%, followed by plastic (18.9%), wood (12.2%), and paper (10.6%). A study conducted in 169 Indonesian districts (*Kabupaten*) or cities (*Kota*) in 2023 found that 66.82% of waste is managed well, while 33.18% of the country's total waste is not managed properly (Direktorat Pengelolaan Sampah – Kementerian Lingkungan Hidup dan Kehutaan, Capaian Kinerja Pengelolaan Sampah, SIPSN). This wasteful attitude towards food and the extensive accumulation of organic food waste leads to the deep-seated assumption in people's minds that humans are in strong control over plants. The fact that the relationship between plants and humans is a well balanced interplay between both entities rather than a one-sided balance of power, is explained in more detail in this article. The terms food waste and organic waste are used as synonyms in the following paper, as besides organic food waste no other food waste was relevant in this research context.

Poorly managed food waste not only ends up in landfills but also in the sewage water system (Cahyani et al. 2022, 2). If organic waste enters waterways, the amount of oxygen decreases and the risk of the spread of harmful organisms rises. Not only during the food production and distribution stages are greenhouse gases emitted into the atmosphere. When food waste ends up in landfills, pollutants are released into the environment during ineffective transport as well as through burning. Furthermore, organic waste eventually decomposes in oxygen-poor landfills and emits methane into the atmosphere. Methane (CH4) is considerably more potent than carbon dioxide (CO2); thus,

it is one of the most effective greenhouse gases to drive climate change, which in further succession results in more frequent and intense extreme weather events (Kaza et al. 2018, 116–118). According to The Economist Intelligence Unit, methane emitted from food in landfills is even 21 times more efficient in driving climate change than CO2 (EIU 2016, 39). However, the role of the emitted CO2 must not be underestimated as food waste globally generates 4.4 GtCO2 eq[1] each year, which equates to 8% of the total anthropogenic greenhouse gas emissions based on carbon footprints (FAO 2015, 1). The potential of this specific property of plants, the emission of greenhouse gases during decomposition, is addressed in further depth in this article.

With estimated 300kg of food waste per capita per year, Indonesia is the second largest food waste producer worldwide (EIU 2016, 39). This results in a potential global warming impact of 1,702.9 Mton CO2 eq in the twenty-year-timespan of 2000–2019 which corresponds to an average annual contribution of 7.29% of greenhouse gas emissions in the archipelago (Ministry of National Development Planning/Bappenas 2021, 6). While this cycle may seem like it is extremely hard to break, a World Bank study in Indonesia found that even basic improvements like higher trash collection rates and controlled landfills can reduce greenhouse gas emissions by 21% (Worldbank 2018 as cited in Kaza et al. 2018, 119). Based on the National Strategy Policy Guidelines (Peraturan Presiden Republik Indonesia 97/2017), Indonesia declared itself to an advancement in food waste management with the goal of 30% waste reduction from the source and 70% waste treatment by 2025. However, as of 2022 with an interim outcome of 25.3% waste reduction and 49.2% waste treatment, this goal was still far from being reached (Farahdiba et al. 2023, 2).

This is where the agency of plants comes into play by animating the non-governmental organization Eco Enzyme to exert its zero-waste approach. Due to its ability to release methane into the environment during composting, organic waste encourages environmentally conscious and ecologically minded people to take responsibility for themselves. Eco Enzyme uses fermentation processes to ferment organic food waste mixed with water and molasses or sugar into a liquid substance, that also holds the name Eco Enzyme. From this

1 $GtCO_2$ eq, also called Carbon dioxide equivalent or CO_2 equivalent is a "metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential" (eurostat – Statistics Explained 2023).

liquid, products with multiple purposes of use and benefits for the health of humans and animals, soils, water bodies, and the air can be derived (Eco Enzyme Kulon Progo 2023, 2). The ratio of 1 part sugar, 3 parts organic waste, and 10 parts water must be maintained. In principle, all types of organic food waste, such as the peel of fruit and vegetables or fruit infested with insects, can be processed into Eco Enzyme (Eco Enzyme Kulon Progo n. d., 6). It is important to ensure that the skin or fruit is not too greasy (such as avocado peel) or too dry or hard (such as the skin of snake fruit or the stone of a peach or avocado). Apart from these few exceptions, any peel, any fruit, and any vegetable, such as pineapple, peaches, melons, banana peel, and lettuce, can be used to produce Eco Enzyme (Research Diary 2023). The organization is thus contributing to less food waste being disposed in landfills and in the environment and subsequently plays a part in lowering greenhouse gas emissions.

Against this backdrop of the general relevance and the motivational background of Eco Enzyme, I elaborate on the services that the plant-human network and Eco Enzyme in particular provide for the local population of the Kulon Progo administrative district and the region itself. To this end, I briefly discuss the methodology in the following chapter to provide an insight into the context of this article. Chapter two gives an overview of the organization Eco Enzyme I worked with during my fieldwork in May 2023. I dedicate a separate chapter to this organization as it is the main actor besides plants when it comes to plant-human-interaction. I then give a general introduction into the underlying theoretical framework, which addresses plants as engaging agents and recognizes a vital and equal interaction between both entities, plants and humans, and link the concept of vegetal agency with Eco Enzyme. Chapter three outlines the effects of Eco Enzyme for the local population in Kulon Progo as well as in the region itself. Firstly, I address the organized events and the Pustaka Merdesa (translates to 'decent library'). Secondly, I elaborate on the economic aspects and female empowerment, the services, and the inclusion of women before explaining further environmental and community services in the subsequent section. In the conclusion, I summarize the core statements.

Methodology

I collected the data used during a three-week fieldwork internship in the Special Region of Yogyakarta (*Daerah Istimewa Yogyakarta*). I spent a total of 14 days in the field and collaborated with three students from *Universitas Gad-*

jah Mada during my research. The method that I most frequently used was informal conversations with informants, especially Atiek Mariati and Andre Moedanton on whose property I lived during this time. This allowed me to fully immerse myself in the field and made it possible to collect information in an informal and casual setting. I also carried out participant observations as well as observations in which I merely took on the role of the observer. Furthermore, I conducted research online – especially on the Instagram account @ecoenzyme.jogja. I kept a research diary in which I recorded my observations and conversations and wrote down my thoughts. The most prominent foci points were knowledge transfer, socialization and female participation. I base this work on the notes and protocols in this research diary. This article is an extension of a seminar paper that I handed in after my field stay at the University of Vienna.

Eco Enzyme

Eco Enzyme is a non-governmental organization (NGO) operating not only in Indonesia but also in Thailand, Malaysia, and Vietnam. It has its origin in Thailand where the central formula for the fermented liquid was invented by Rosukon Poompanvong, the founder of Thailand's Organic Agriculture Association. She has been conducting topic-related research since the 1980s. Eco Enzyme gained more popularity through Malaysian Naturopathy researcher Joean Oon (Eco Enzyme Nusantara 2021, 7).

Eco Enzyme Nusantara

Eco Enzyme Nusantara refers to the organization's activity in the archipelago of Indonesia. It became more popular in the regency (*Kabupaten*) Kulon Progo when a resident of Kulon Progo attended an online workshop organized by Eco Enzyme Nusantara Bali in 2020. Shortly thereafter, Eco Enzyme was disseminated to the wider society through personal contacts and free online courses in governmental and private institutions, schools, Islamic boarding schools, farming groups, kindergartens, and various communities in the Kulon Progo Regency (Eco Enzyme Kulon Progo n. d., 2). As of 2023, there are 22 Omah Eco Enzymes (Eco Enzyme houses) spread all over the Kulon Progo Regency (Eco Enzyme Kulon Progo 2023, 3). The coordinator of Omah Eco Enzyme Kulon

Progo is Purwanto and the chairwoman is Atiek Mariati, my main informant (Eco Enzyme Kulon Progo 2023, 8).

The vision of Eco Enzyme Nusantara is to "make the earth beautiful and sustainable again for the survival of people and all living creatures" (Eco Enzyme Kulon Progo n. d., visi & misi; unless otherwise noted, all translations from Indonesian to English of the source Eco Enzyme Kulon Progo n. d. come from the author of this article). To achieve its vision, Eco Enzyme pursues the following five missions:

a) carrying out educational and socialization work in the community
b) creating public awareness and love for nature and motivating the public to process organic waste
c) education and training of volunteers across Indonesia
d) cooperation in the processing of organic waste with the central government, local and regional governments, private institutions, groups, individuals
e) development of research on eco-enzymes (Eco Enzyme Kulon Progo n. d. , visi & misi)

When talking about Eco Enzyme, we are not only talking about the organization itself, but also about the product at the center of the organization. The multi-purpose liquid is made by mixing 10 shares of clean water with 1 share of red sugar or molasses and 3 shares of organic food waste, such as the peel of fruits and vegetables. This mixture needs to ferment for three months in an airtight plastic container. A detailed recipe can be found in the appendix of this anthology. The purposes of use are manifold and range from personal hygiene and natural medical products to soaking fruits and vegetables, natural fertilizers, water and air purifiers, and disinfectants (Eco Enzyme Kulon Progo n. d., 6).

A Grassroots International NGO

Before going into more depth about the interplay of vegetal agency and Eco Enzyme as well as the fields of action of Omah Eco Enzyme Kulon Progo, it seems crucial to me to elaborate a bit more on the terms 'NGO' and 'grassroot' and their relevance in a decentralized country like Indonesia.

In the online version of the Dictionary of Social Sciences, an NGO is defined as a "not-for-profit organization that is institutionally separate from the

state" (Calhoun, nongovernmental organization (NGO), Oxford Reference). NGOs pursue different goals and have different sources of support. However, what most NGOs have in common is the goal of influencing government policies through various actions such as setting agendas, participating in negotiations, and implementing programs. On the one side of the scale, some NGOs are closely involved with business interests. On the other side of the spectrum, there are NGOs worried about social change. These organizations follow goals which range from the protection of human rights to the preservation of biodiversity and the environment (Calhoun, nongovernmental organization (NGO), Oxford Reference). Eco Enzyme can be assigned to the latter. NGOs are usually financially independent from the state and get their financial resources through philanthropic foundations, donations, membership fees, and mass solicitations. The hybrid form of NGOs is partly funded by the state but remains independent from it (Calhoun, nongovernmental organization (NGO), Oxford Reference).

Compared to NGOs, Grassroots International NGOs (GINGOs) are defined as small-scale organizations, heavily reliant on private, individual donations. They are characterized by their low budget and operating costs and are usually invented by people with no formalized practice or professional development experience. They are often sustained by volunteers, not by the paid employees (Appe, and Telch 2020, 31; Contreras, and Roudbari 2022, 570). GINGOs are usually affiliated with developmental topics which often include a prevalent focus on "providing relief and welfare services through the provision of goods and services" (570). Since GINGOs are active in areas that do not require a lot of investment and financing, they are typically more effective in specific development fields rather than focusing on large-scale development topics and changing comprehensive development agendas (570). Nonetheless, according to Contreras and Roudbari, GINGOs "are able to have a unique influence in the areas where they do work" (570). Due to their independence from established international development structures, they are flexible in organizing exchanges with local communities.

Although Eco Enzyme works together with the local government, when it comes to socialization programs, financial resources only come partly from the state. The supplies needed for any events are, according to Atiek Mariati, paid for by the volunteers of the organization (Atiek Mariati, informal talk, 6th May 2023). According to Andre Moedanton, there have been cases where the local government of Kulon Progo has received money from the state to pay Eco Enzyme volunteers before lectures and socialization events. However, this money

never reached them but remained in the corrupt hands of local politicians (Andre Moedanton, informal talk, 8th May 2023). Nowadays, Atiek Mariati also does not want to be paid when she gives lectures about Eco Enzyme because she is afraid that people will think that she only does it out of self-interest and for money (Atiek Mariati, informal talk, 8th May 2023). Due to the low costs, the flexibility in organizing exchanges with the population, the activity in an area that requires relatively low investments and is being upheld by unpaid volunteers, Eco Enzyme can be defined more as a GINGO than an NGO. As is typical for a GINGO, Eco Enzyme has various impacts on the areas it is working in as well. After briefly discussing the relevance of GINGOs in decentralized countries such as Indonesia in the following paragraphs, I take up some of these areas of influence of Eco Enzyme in chapter four.

When the decentralization laws came into force in 2001, wide-ranging areas of responsibility, such as regional development, budget, agriculture, education, culture, social affairs, and financial resources were transferred from the central government to the cities (*kota*) and regencies (*kabupaten*). Since then, the regions themselves have had the right to decide which priorities are set and where the budget is used. However, in many cases, there is a lack of human capital because implementation assistants of the central authority became decision-makers overnight. Hidajat argues that in Indonesia the local population is often suspicious of political decision-makers because they frequently act in their own interests rather than in the interests of the population (2008, 369–370). While Hidajat writes about disaster management, I argue that this can also be applied to waste management and to the responsibility of maintaining the environment. As already mentioned, cases of cooperation were also known in which employees of the Cooperative Service for Small and Medium-Sized Enterprises in Kulon Progo Regency stole financial resources (*Dinas Koperasi, Usaha Kecil Menengah Kabupaten Kulon Progo*) for themselves instead of using them to, for example, finance community services of Eco Enzyme which promote the development of the region. This led to skepticism towards the authorities and to the independent implementation of various services. The bottom-up approach became more popular (Andre Moedanton, informal talk, 8th May 2023).

In the following chapter, I shed light on vegetal agency to then link it to Eco Enzyme.

Vegetal Agency acting upon Eco Enzyme

In the 1980s, the actor-network theory crystallized at the *Centre de Sociologie de l'Innovation* at the *Écoles de Mines* in Paris, which is based on the premise that action can be traced back to a network of actors, not just singular individuals (Gertenbach, and Laux 2019, 87). According to Bruno Latour, in the same way as actors on a stage are rarely, acting alone, "we are [also] never alone in carrying out a course of actions" (2005, 44). Similarly, actions are never carried out under the full control of consciousness. Rather, they should be understood "as a node, a knot, and a conglomerate of many surprising sets of agencies that have to be slowly disentangled" (44). Thus, in actor-network theory, an actor is not simply the origin of an action, but a dynamic target of numerous influences. Latour clarifies the role of non-human beings, which as agents can exert a force on other entities and are not to be understood as subordinate to the will of humankind, but as resistant, complex, and controversial beings (Latour 2005 as cited in Gertenbach, and Laux 2019, 124). The actor-network theory thus overcomes the long-standing dichotomy of nature/culture and object/subject and creates space for "power relations" between the two domains (Hinderlich 2023, 2). Once one realizes that action and agency are not limited to the human experience, the symmetry of people being acted upon in the same way as they themselves act becomes clear (Cooren 2010, 22).

Ever since Aristotle compared animals with plants and, in a hierarchy of life, placed the latter at the very bottom due to their ostensible lack in intelligence and sensing abilities, this hierarchy has persisted in European minds (Hall 2011, 7). As already mentioned in the previous paragraph, however, many disciplines are now attempting to transcend this juxtaposition of object and subject, and consequently plants are increasingly being understood as agents and subjects rather than passive objects. Elton observes that despite their quiet and stationary traits, plants "participate in highly political and even violent acts such as colonizing territory" (2021, 93). Especially in the Anthropocene, the role of plants must not be underestimated as they not only guarantee human survival, but are also important players in many other environmental issues such as food security and carbon economies (Head et al. 2014b, 861). Research has shown that humans and plants are involved in a complex interplay when it comes to agency. Although it is often still assumed and seems to be anchored in the minds of the broader population, humans are not in power over plants – not even when they plant and cultivate them in places that appear to be man-made. Rather, they are in a dynamic relationship that requires the mutual exchange

of agency (Elton 2021, 94). Head et al. define this as vegetal politics, referring to "collaborative and conflictual relationships between humans, plants and others" (2014b, 861). Plants and people are politically intertwined, from which their agencies derive. According to Elton,

> the relational agency of plants in human society is the expression of an ability to exercise power through relationships with humans. […] Agency is expressed when something happens because of – or as a result of – relationships, because things and beings are interdependent and in constant interaction. (2021, 107)

The political nature of this interaction between humankind and plants can be well demonstrated by the case of Eco Enzyme: As a result of the interplay between the methane-emitting quality of composing organic food waste and a lack of measures for the sustainable handling of organic waste on behalf of the Indonesian local governments, the GINGO Eco Enzyme decided to take the controlled processing of the organic waste into its own hands. Thus, plants are equipped with agency which allows them to exert a force. This force influences human actions and makes people do things, albeit the latter not being aware of being acted upon.

When it comes to vegetal agency, one term I find crucial to shed light on is *plant time*. According to Elton, plant time refers to the temporal framework in which plants exist and grow, and it differs from the fast-paced, capitalist-driven schedules of human life (2021, 98–99). It encompasses the slower, often imperceptible rhythms of plant growth and development that require altered human perception to fully comprehend. Although plants generally move slowly, they usually do not stop moving and growing which sometimes requires rapid human action (100). This highlights the dynamic and variable nature of plant time, depending on the circumstances experienced by the human interacting with the plant (102) and vice versa. Plant time also becomes apparent when it comes to the emission of decomposing organic waste. Although there are also more comprehensive methods for estimating methane emissions, in its report "2006 IPCC Guidelines for National Greenhouse Gas Inventories" the Intergovernmental Panel on Climate Change (IPCC) refers to the first order decay method, according to which the degradable organic carbon in waste is slowly decomposed over a period of a few decades. In this process, methane (CH_4) and carbon dioxide (CO_2) are released into the atmosphere. If the external influences remain constant, CH_4 production is only dependent on the re-

maining carbon content in the waste. Therefore, CH_4 emissions from landfill waste are highest in the first few years after disposal and then decrease progressively as the degradable carbon in the waste is gradually consumed by the bacteria that can be blamed for the decay (IPCC 2006, 3.6). Although plants, in this particular case decaying organic waste, emit methane over a period of decades, they are urging environmentally conscious people such as members of Eco Enzyme to take immediate action to reduce their greenhouse gas emissions in the near future in order to slow down global warming. The concept of plant time can also be applied to the fermentation process of the Eco Enzyme liquid. While in tropical regions it takes around three months to derive the finished Eco Enzyme liquid from the fermentation process, in the sub-tropics the fruit residues must remain sealed in a plastic container together with molasses or sugar and water under anaerobe conditions for twice as long. These temporal differences, dependent on climatic and geographical parameters, illustrate the dynamic and conditional components of plant time.

Vegetal agency is expressed particularly in negative situations when plants do something undesirable to humans – for instance, when weeds growing in a vegetable garden motivate gardeners to use herbicides. In the same sense, vegetal agency is also evident in my research context. Through their methane emissions during decomposing, plants prompt environmentally conscious people to take action. Both humans and plants are integral parts of the biosphere, and their continued existence depends on joint cooperation on different levels (Head et al. 2014a, 399). By activating the members of the Eco Enzyme organization to produce the fermented liquid and subsequently the derived products, the vegetal agency of organic food waste not only brings the obvious benefit of reducing greenhouse gas emissions and a positive impact on the climate, but is also responsible for a number of other advantages that benefit people and the region and will be outlined in more detail in the following chapter.

Effects of Eco Enzyme on the Region and the Local Population

Apart from the main goal of reusing organic waste and thus reducing methane emissions with the ultimate goal of mitigating climate change, Eco Enzyme provides further opportunities on the Kulon Progo region and its local population. These positive repercussions are briefly explained in the following section of this article and will also be linked to vegetal agency.

Socialization Events

Even if this is not consciously perceived by the local population and it becomes clear that the actions are not carried out under full cognitive control (Latour 2005, 44), the vegetal agency of organic food waste motivates volunteers from the organization Eco Enzyme to organize socialization events in which detailed information about the product, its production, and further processing is provided. Subsequently, the vegetal agency of organic food waste encourages the local population to participate in such events and socialize with like-minded people with similar values. Participation in such events is free of charge and every participant receives free drinks and food, which makes such events even more attractive. The events where the information is conveyed are accompanied by practical learning units. The participants produce the Eco Enzyme liquid and derived products themselves after receiving a demonstration of how to do it. In addition to the participants, there are also volunteers from the organization who give the lecture and help with any preparations and support with the practical exercises (Research Diary 2023).

In cooperation with the Cooperative Service for Small and Medium-Sized Enterprises in Kulon Progo Regency, Eco Enzyme organized a socialization event in Nanggulan from 15th to 17th May 2023, in which 29 people participated. The participants were people working in small businesses, household industries, and agriculture, as well as students of Muslim dormitories. Also present were three representatives from the Cooperative Service for Small and Medium-Sized Enterprises and seven volunteers from Eco Enzyme. Together, the group produced the liquid itself as well as a face mask made from rice flour and Eco Enzyme, homemade soaps, and cooling and heating pads made from the leftover fruit residue. Figure one shows on the left the products made on the second day of the workshop. The participants were allowed to take the self-made products home with them (Research Diary 2023).

Community Building

The practical exercise during the socialization events takes place in group work. As the right hand side of figure one shows, the products are manufactured in groups consisting of four to five people (Research Diary 2023). This is not only more financially effective as fewer utensils are required, but also enables social exchange between participants. It was evident that the participants had a lot of fun making the products. One participant confirmed this to me: "Aku belum membuat sabun sendiri sebelumnya, tapi aku menyukainya",

translated: "I have never made soap myself but I enjoy it" (Informant 2, informal talk, 17th May 2023).

Apart from the group work, the following statement was shouted monotonously at the end of the workshop: "Aku bisa, kamu bisa, Bersama kita bisa! Yes, yes, yes", translated: "I can, you can, together we can! Yes, yes, yes" (Research Diary 2023). This statement not only conveys the message that everyone can process their organic waste into Eco Enzyme, but above all the word 'together' implements a feeling of community among the participants. This statement also illustrates the bottom-up approach, i. e. the management of waste by the population instead of the local authorities and government. The fact that everyone is motivated to act by the same force, the vegetal agency, reinforces this sense of community.

Fig. 1: Airtight container with the prepared product, finished Eco Enzyme, and the cooling and warming pads made from the fruit residue that remains after the fermentation process (left)
Fig. 2: A group of five women collectively producing Eco Enzyme soap with the help of an Eco Enzyme volunteer (right)

Source: Own photography

Knowledge Transfer

Animating the population of Kulon Progo to live zero-waste is, according to Atiek Mariati, the organization's main focus, as this approach reduces organic waste in landfills and subsequently methane emissions. Atiek Mariati was pleased to say: "I feel happy when they produce Eco Enzyme themselves" (Atiek

Mariati, informal talk, 6th May 2023). However, to motivate the population to process their household waste, it is essential to educate them about the product and the advantages of its production as well as its intended uses. Also, in order for the vegetal agency of decaying plants to have an effect on the public and to prompt them to act, it is crucial to make them aware of the methane emitting properties of food waste under uncontrolled conditions and the respective impacts on climate change as well as the consequences and future living conditions. Socialization events provide the main focus of knowledge transfer.

Not only within public events but also in private structures, such as at family- and friendship level, the transfer of knowledge takes place. Yatono, who is active in the Social Disaster Response Section (*Seksi Sosial Tanggap Bencana*) of Eco Enzyme Kulon Progo, told me in an informal talk on 11th May that his friends also produce Eco Enzyme for personal use on the household level (Yatono, informal talk, 11th May 2023). Likewise, Pak Andre stated that a friend of his living in Switzerland also produces Eco Enzymes (Research Diary 2023). However, this shows that in times of digitalization, distances of several thousand kilometers do not have to be a barrier to knowledge transfer. Because of this, anyone with adequate digital devices and a stable internet connection can obtain information via social media such as Instagram and YouTube. Eco Enzyme uses both platforms to educate the population:

https://www.instagram.com/ecoenzyme.jogja/?igsh=em0yeGwoNndnN3ly and https://www.youtube.com/channel/UCyro3padktpjnTvUTLiu5-g.

In addition to knowledge transfer in the digital space, personal knowledge transfer with direct exchange is also important. Pustaka Merdesa is a particularly important place for face-to-face interaction. Due to its great relevance not only for Eco Enzyme but for the entire region, I will discuss it in more detail in the following sub-chapter.

Pustaka Merdesa

The Pustaka Merdesa is a library and a central place for not only Eco Enzyme, but also the local population of Kulon Progo. The name is made up of the two words *Pustaka*, which in Bahasa Indonesia means library, and *Merdesa*, which translated to English has several meanings, such as decent, polite, appropriate, orderly, prosperous, and civilized (Pustaka & Komunitas Merdesa n. d., 1). The Pustaka Merdesa is located on the property of Atiek Mariati and Andre Moedanton and has two main functions. On the one hand, it is the office of Omah Eco Enzyme Kulon Progo in which the organic food residues produced

by Atiek Mariati and Andre Moedanton's household are further processed to the Eco Enzyme liquid, as can be seen in figure two. The library serves as a location for socialization events, in which the local population, especially women, learn about the benefits and production of Eco Enzyme and how to further process it into derived products such as soap which can be sold. Furthermore, stakeholders and politicians from the local government as well as other partners Eco Enzyme cooperates with are frequently invited to visit the Pustaka Merdesa to gain information about Eco Enzyme and its benefits (Research Diary 2023). However, the Pustaka Merdesa is not only important in connection with Eco Enzyme, but also as a stand-alone institution.

Fig. 3: The Pustaka Merdesa also serves as an office for Omah Eco Enzyme Kulon Progo. In the foreground you can see the containers in which fermentation takes place, as well as the bottled liquid and organic food waste.

Source: Own photography

The library was founded out of Atiek Mariati's and Andre Moedanton's love for reading which they wanted to share with the wider population after their arrival in Kulon Progo (Research Diary 2023). According to Atiek Mariati (informal talk, 19th May 2023), Kulon Progo is still very rural and education did not have a high priority twenty years ago. Thus, the population of Kulon Progo is not the target audience for a library. However, when Atiek Mariati moved and settled in the Special Region of Yogyakarta, she felt that her new living environment needed to be improved because there was not only a persistent lack of interest in reading but also a lack of commitment to the environment (informal talk, 19th May 2023).

The library is in particular frequented by children and adolescents who borrow comics and novels but also by adults who regularly borrow books with practical topics such as cooking, crafts, and knitting (Research Diary 2023). The Pustaka Merdesa is a future-oriented collaborative learning space where everyone is given the opportunity to learn freely to contribute ideas and intentions. This collaborative learning space strives for an ideal model of civil society in the information age. According to Atiek Mariati, villagers are expected to solve both local and global problems. Such a village can learn together, build relationships, revitalize the power of its culture, develop empathy, and change for a single reason: to respond to the steady progress of development (Pustaka & Komunitas Merdesa n. d., 2). Thus, one topic often addressed in not only the workshops held but also in the books, is climate change.

The Pustaka Merdesa can also be seen as a social meeting point for the local population of Kulon Progo where children and teenagers are given the opportunity to take part in various events and workshops to broaden their horizons. These workshops range from cooking classes to language courses to music and dance workshops. During my fieldwork in May 2023, I was allowed to playfully tell the children about Austria and Vienna as well as Austrian music and cuisine and answer their questions about Europe and Austria. After the presentation, I observed the children engaging with the books with great interest by going through the shelves, taking out books, looking through them, and sometimes borrowing and taking them home. The library is frequently visited by the children of Kulon Progo. Once a month, a joint library visit for kids of the nearby kindergarten is organized for them to support the development of their reading ability (Research Diary 2023). From a future-oriented perspective, the commitment of Pustaka Merdesa can promote engagement with environmentally relevant issues and open up a space for plant-human networks in which vegetal agency can impact human actions.

Economic Benefits

Vegetal agency and Eco Enzyme have their benefits for the economic state of the region Kulon Progo, as well. The liquid itself is not sold. According to Atiek Mariati, this measure encourages the population to process the households' organic waste themselves which is Atiek Mariati's main goal. Since the liquid itself is not sold, but still has many areas of application, the vegetal agency has greater scope to encourage households that produce organic waste to produce the Eco Enzyme themselves. However, as can be seen in figure three on the left, the products derived from the liquid, such as hand soaps, do-it-yourself sets for producing soaps, face masks, or dishwashing liquids, are for sale. While the environmental aspect is paramount for Atiek Mariati and the organization Eco Enzyme itself, according to a member, the main motivation of the Cooperative Service for Small and Medium-Sized Enterprises in Kulon Progo Regency for working with Eco Enzyme is the prospects for economic growth of the Kulon Progo region. This should be promoted by training individuals and small businesses to produce the liquid Eco Enzyme and to further process it so that more sellable products can be on the market and offered for sale online as well as in areas such as hotels or at the airport which is located in Kulon Progo (Informant 1, informal talk, 16th May 2023; Research Diary 2023).

Female Empowerment

Closely intertwined with the economic benefits for the region and the socialization events is the aspect of female empowerment. The majority of the participants of the socialization event are female. An example for this female predominance is the three-day workshop in Nanggulan, Kulon Progo where out of a total of 29 participants only seven were male and 22 were female. The right hand side of figure three shows the participants of this workshop on the second day, while Atiek Mariati is giving a speech on Eco Enzyme. This high proportion of women is due to the gender-based division of labor in Indonesia. Thus, women are more likely to work in the home sector and in *warungs*, small restaurants and places with a lot of food waste (Research Diary 2023).

Fig.4: The picture shows the unsellable liquid Eco Enzyme in bottles as well as the derived products for sale. The products for sale presented here are different kinds of soaps (charcoal, aloe vera, olive oil, minyak papua [oil from Papua]) and DIY sets for producing homemade soap (left).
Fig. 5: Participants of the three-day workshop on how to produce Eco Enzyme and derived products such as face masks and soap (right)

Source: Own photography

The large female preponderance of participants can also be observed in the posts of the Instagram account @ecoenzyme.jogja, which mostly feature women taking part in such workshops. The population in Java is structured bilaterally. While men are shown a lot of respect because of their potency and power and properties are assigned to them purely based on their sex, women have a special economic role (White, and Schweizer 1998, 41). In many cases women earn at least as much, if not more than men by working in the agricultural sector, in craft manufacturing, or in businesses (Brenner 1998, 139). Nevertheless, it is often argued that men are responsible for providing for the family. Women often manage financial resources, but according to their husbands' wishes (Sullivan 1994 as cited in Riyani 2021, 28). The high rate of female participants in the Eco Enzyme workshops to some extent ensures the independence of women from their husbands. However, this is still a long way from equal rights between men and women in Java. As a result of the gender-based division of labor, the plant-human network in this context is particularly strong between plants, or organic waste, and Indonesian women. Thus, vegetal agency has a notably strong effect on women. Since women are more often in contact with organic waste, they are more likely to form a symbiotic relationship with plants than men and by supporting each other, building a network, and taking part in economics, they actively counteract the patriarchy. This shows that

the context of the relationships and the social and societal conditions in which the investigation of vegetable agency takes place plays an important role and has a strong impact on the people who are brought to action by plants. For instance, in the context of this specific study, environmentally conscious women in particular are addressed and animated to act by the vegetable agency of decomposing and methane emitting plants.

Environmental and Community Services

Apart from economic benefits for the region and the effects on its inhabitants, vegetal agency and the resulting actions by Eco Enzyme bring favorable deeds that benefit both the preservation of the environment and the health and well-being of the local society. While the former is the motivating reason for the organization to operate, the latter should not be neglected. As already mentioned, the coexistence of plants and humankind in the biosphere depends on their mutual cooperation (Head et al. 2014a, 399). In this sense, plants play their part insofar as they, with their vegetal agency, encourage humans to act, and humans can play their part by consciously noticing that they are being influenced by the vegetal world and by taking action themselves. Through the controlled processing of organic waste, better environmental conditions can be provided that allow both entities to continue to (co-)exist on earth. I briefly present these environmental and community services in the following subchapter.

Reduction of Methane Emissions

In the introduction to this paper, I have already made clear the effectiveness of methane as a greenhouse gas on the warming of the climate and the earth. For this reason, it is necessary to return to it in this chapter. According to Kaza et al., Indonesia is committed to making its nationally determined contributions to the Paris Climate Agreement (2018, 119). These primarily consist of reducing the country's greenhouse gas emissions (119). By reducing organic waste in landfills and in the environment itself and by the controlled processing of organic waste, the organization Eco Enzyme can make its contribution to achieving the goals set in the Paris Climate Agreement. This reduction of the methane gases emitted by ineffectively managed food scraps increases proportionally to the number of people who live the zero-waste approach. That is why it is so important for Atiek Mariati to educate the general population about the practice: "The more people do Eco Enzyme, the more we [Atiek Mariati and Andre

Moedanton] can relax" (Atiek Mariati, informal talk, 8th May 2023; Research Diary 2023).

Reduction of Plastic Waste

After food waste, plastic is the second most pertinent contributor to solid waste in Indonesia with 17.8% (Direktorat Pengelolaan Sampah – Kementerian Lingkungan Hidup dan Kehutaan, Capaian Kinerja Pengelolaan Sampah, SIPSN). Eco Enzyme counteracts this problem: The product can be set for fertilization in plastic bottles which are not thrown away after the product is emptied, but instead are given a new life. Furthermore, the production and use of homemade cleaning or personal hygiene products prevent the need to purchase these products in plastic containers after every emptying (Research Diary 2023). This is how the use of single-use plastic can be significantly reduced.

Improvement in Living Conditions

According to Schlehe and Yulianto, power structures in the population are created and strengthened through waste and the way it is dealt with in Indonesia (2019, 40–59). Garbage dumps, which are not only accompanied by strong smells but also often by toxic and harmful substances, are usually located in the immediate vicinity of poorer residential areas (46). Furthermore, it is mostly people with low incomes who take care of the garbage and clear it away. In contrast, richer families are often accountable for careless pollution (46–47). By reducing the amount of waste that ends up in such landfills, the quality of life of poorer families and households can be significantly improved. Thus, the effects of vegetal agency on human actions also help reduce social inequalities and class differences at least to some degree.

Other Community and Environmental Services

Apart from the already listed advantages for the region and the inhabitants, the Eco Enzyme liquid can also be applied in various areas due to its many possible uses. Because of its water and air purifying properties, the liquid can be poured into waterways or sprayed in landfills to purge the water and extract bad smells from the air (Atiek Mariati, informal talk, 16th May 2023; Research Diary 2023). This reduces the use of chemical agents. For example, the Banyuroto final disposal site, consisting of about 70% organic waste, was sprayed by Eco Enzyme volunteers in collaboration with the Regency Government of Kulon Progo, and a significant reduction in the odor was

noticed (Humas DLH Kulon Progo, Tekan Bau Sampah: Relawan Bersama Bupati Semprot Tpa Banjuroto Dengan Eco Enzyme, Dinas Linkungan Hidup Kabupaten Kulon Progo). Due to its properties, Eco Enzyme was used for fertilization after rice fields were flooded. Apart from that, it can also be used for disinfection for instance in animal enclosures where hygiene is often poor due to a lack of financial resources (Atiek Mariati, informal talk, 16th May 2023). A study showed that regular spraying with Eco Enzyme reduced the spread of *Escherichia coli* bacteria in pig stables (Ginting et al. 2021, 283–287). Since large amounts of Eco Enzyme are required for such practices, the liquid is collected from the entire Eco Enzyme community in Kulon Progo (Atiek Mariati, informal talk, 16th May 2023). Helping each other out also contributes to establishing a corporate feeling and building a community.

Conclusion

In conclusion it can be argued that the ecological crisis is not a problem of nature, but the result of the relationship between society and nature in the capitalist world, which affects both equally (Hinderlich 2023, 2). A greater understanding of human-plant relationships can help to overcome some of the current challenges, such as those relating to food security and species conservation (Head et al. 2014b, 864), and, as I argue, the reduction of greenhouse gas emissions. Humans and the increase in population are boosting the demand for food and, in further succession, food waste and methane emissions from uncontrolled organic wastage which in turn drive global warming. Both humans and nature are equally affected by climate change which manifests itself, for instance, in the loss of habitats, the extinction of species, and an increase in extreme events (extreme heat, drought, floods, gravitational mass movements) to which vulnerable population groups are particularly exposed. It can be argued that plants – once understood as agents instead of as objects to humankind – are equipped with their own agency allowing them to exert a force on humans which animates them to take action. Marder even argues that the vegetal world even holds the power to rescue our planet and humankind (Irigaray, and Marder 2016, 207–212). Due to its tendency to emit CH_4 during decomposition, the vegetal agency of organic waste prompts environmentally conscious people to become involved. Not only does the plant-human network demonstrated by Eco Enzyme reduce greenhouse gas emissions and slow down

global warming, but people can also reap further benefits in social and enomic spheres for themselves and the Kulon Progo region.

In addition to imparting knowledge and conducting social events that help strengthen communities, manufacturing Eco Enzyme has a positive impact on women's independence. Together with the socialization events, the diverse services for the environment and society boost the population's sense of community due to the necessary cooperation. The main reason for the organization's activities should not be forgotten: By processing organic waste into products with different uses, less waste ends up in landfills. Besides reducing emissions of the extremely potent greenhouse gas methane, the reduction of waste in landfills also reduces odor nuisance and enables poorer classes, often living in the vicinity of such waste dumps, to create a more homely and healthy environment. If these advantages are embedded once again into the context of human-plant studies and Latour's actor-network theory, one can argue, that the decomposing and methane emitting characteristics of plants make people act and, in further succession, profit from vegetal agency in various areas. In Indonesia, due to the lasting gender-based division of labor, especially women can benefit from vegetal agency.

Although Eco Enzyme provides many benefits for the local population and it is already a big step towards climate responsibility, the mere recognition of the vegetal agency is not enough to bring about a long-term sustainable ecological change, but must be accompanied by a political transformation. "If plants are understood as agents and subjects, we need to ask how policies and governance would and should look different" (Head et al. 2014b, 866). Maybe then, if the GINGO Eco Enzyme and the government found a common ground, more communities in Indonesia would recognize the advantages Eco Enzyme offers and the archipelago would take one step further ahead towards climate efficiency.

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