Organic wastes, black-soldier flies, and environmental problems through the lens of the stock market

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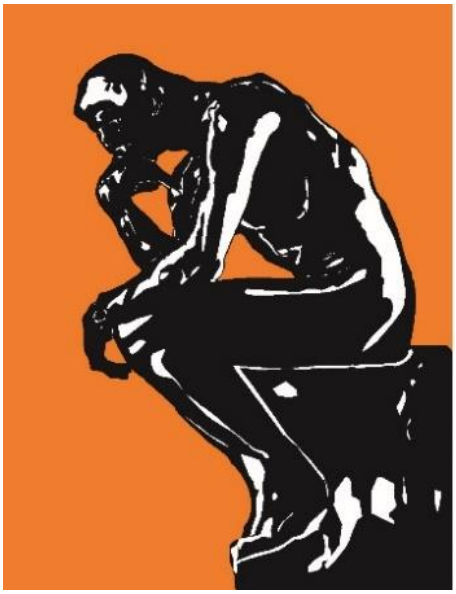

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Are humans in a toxic, abusive relationship with nature? Love is strange.

—In "Glands of love"; *Meandering Sobriety* (2023a)

Abstract

As the world's population grows and urbanization continues, the global waste crisis is becoming more severe, especially in developing countries. Without proper waste management, they may encounter various environmental and health risks. Biological technologies are regarded as promising waste management and recycling approaches in developing countries due to their cost-effectiveness and capability to handle diverse waste categories. One prominent technology in this aspect is the vermicomposting of organic waste utilizing the black soldier fly larvae. Nevertheless, significant financial resources are still necessary to advance and expand biological waste treatment, which requires the participation of businesses. By examining waste management companies listed on the Vietnamese stock market, we highlight two challenges that hinder the adoption and scaling of the waste treatment system using black soldier flies and potentially other biological technologies in Vietnam. Specifically, the business regards the environmental services they offer primarily as a means to generate profit rather than as a genuine commitment to environmental preservation, and the values of companies operating in the environmental sector, particularly in waste management, have been significantly undervalued by the Vietnamese investing public. Therefore, we advocate for societal shifts toward the eco-surplus culture and apply the semiconducting principle of monetary and environmental values exchange to address the problem.

Keywords: stock market; business; waste treatment; culture; biological methods; black soldier fly; organic waste; recycling

1. Dumping problems and potentials of biological waste management methods

Dumping waste is a global problem. More than 2 billion tons of municipal solid waste are generated worldwide annually, which is expected to grow to 3.4 billion tons by 2050 (Kaza et al., 2018). If waste disposal is not managed properly, it can result in various environmental and health risks. For example, open dumping in uncontrolled sites can contaminate the groundwater, water bodies, and agricultural products, emit greenhouse gases and other landfill gases, and increase risks of diseases transferred to surrounding residents through rodents and insects, while open burning can release a wide range of hazardous air pollutants that cause illnesses and climate change (Ferronato & Torretta, 2019). According to the World Bank, despite the risks associated with improper waste management, at least one-third of the global waste, estimated highly conservatively, is not treated in an environmentally safe manner (Kaza et al., 2018).

The problem is even more critical in developing countries where the populations, economic growth, urbanization, and industrialization are increasing rapidly, but the waste management systems are insufficient (Ferronato & Torretta, 2019; Mmereki et al., 2016). The waste

collection rates in low-income and lower-middle-income countries are only 39% and 51%, respectively, much lower than those in upper-middle-income and high-income countries (82% and 96%, respectively) (Kaza et al., 2018). However, the predominant disposal methods are uncontrolled dumping, open-air incinerators, and landfills with inadequate leachate or gas collection systems (Abubakar et al., 2022; Bundhoo, 2018). Moreover, there is environmental inequality in waste dumping between developed and developing countries. While high-income countries only account for 16% of the world's population, their amount of produced waste accounts for around 34% of the global waste (approximately 683 million tons) (Kaza et al., 2018). Although waste treatment and recycling systems in these countries are well designed, they still export their waste, especially plastic waste, to developing countries to reduce the cost of disposal (Abalansa et al., 2021; Bourtsalas et al., 2023; Varkkey, 2019).

Currently, biological methods are considered highly promising approaches for developing countries to address waste management challenges because of their ability to handle various types of difficult-to-treat waste, such as plastic, and because of their low cost. Scientists have discovered that wax moth larvae (*Galleria mellonella*) have the capability to rapidly degrade Polyethylene, the most common packaging plastic, thanks to two enzymes in their saliva (Bombelli et al., 2017; Sanluis-Verdes et al., 2022). Zhu et al. (2021) also confirm the biodegradation capability of the wax moth larvae against waste electrical and electronic equipment. Meanwhile, by using microorganisms to break down organic matter, composting and anaerobic digestion are the two most adequate methods to treat organic waste and recycle it into nutrient-dense fertilizer and biogas (Aleluia & Ferrão, 2017; Bengtsson et al., 2012; Cucina, 2023; Shekdar, 2009; Tanaka et al., 2014). According to Aleluia and Ferrão (2017), biological treatment methods are the most appropriate for the context of developing Asian countries, as they are among the most economically viable options and can be leveraged by the economies of scale, especially composting.

The conversion of organic refuse by saprophage (CORS) systems can enhance composting effectiveness by feeding decaying organic waste to organisms. A widely recognized form of CORS is vermicomposting, which involves worms and microorganisms converting organic waste into nutrient-rich humus (Diener et al., 2009). Due to the black soldier fly larvae's (*Hermetia illucens*) voracious consumption of various types of organic wastes, waste treatment using this type of species is increasingly considered an effective organic waste converter and a potentially cost-effective alternative for recycling biological waste (Amrul et al., 2022; da Silva & Hesselberg, 2020).

In Vietnam, vermicomposting utilizing the black soldier fly larvae has appeared in recent years, but its implementation is fragmented and at a very small scale within household settings (Đáng, 2023; Thùy, 2023; Vũ, 2021). Fueled by rapid population growth, economic development, and urbanization, Vietnam is among Southeast Asia's top five leading waste-producing countries. It is ranked third after Indonesia and Thailand, with 22 million tons/year (or more than 60,000 tons/day) (Arumdani et al., 2021). Approximately 55% of

such amount is municipal solid waste, of which 51.6%-78.95% is organic waste (Dũng, 2023; Phuong et al., 2021; Verma & Borongan, 2022). The government has issued Decision No. 687/QD-TTg 2022 to develop the circular economy in Vietnam, intending to recycle 100% of urban organic waste and 70% of rural organic waste.

Although biological waste management methods, specifically using black soldier fly larvae for composting organic waste, are cost-effective, substantial finance is still required to develop and scale up the waste treatment. Listing on the stock market is one of the common ways to enable waste management companies to access a significant amount of capital (through equity financing or the sale of its share to public investors). In Vietnam, 23 companies working in the waste management sector are currently being listed on the stock market. Soc Trang Urban Construction Joint Stock Company (USD) has experimented with and constructed an organic waste processing plant since 2018. Thus, this biotechnology can potentially spill over to other companies, supporting the country in accomplishing the national goal of recycling 100% of urban organic waste and 70% of rural organic waste.

Figure 1: Black soldier flies are being experimented on by Soc Trang Urban Construction Joint Stock Company (USD) (Công ty Cổ phần Công trình Đô thị Sóc Trăng, 2023)

Nevertheless, some underlying issues exist, hampering the application and scalability of biological technologies in the national waste treatment systems. Without addressing these problems, companies established for environmental protection will risk falling into the downward spiral of damaging the environment for the sake of profit.

The current paper aims to overview the potential of biological waste management methods, represented by the CORS system utilizing black soldier fly larvae, discuss the existing problems of waste management companies listed on the stock market, and call for cultural changes to address the issues.

2. Black soldier flies and their capabilities of recycling organic waste

Black soldier fly (*Hermetia illucens*) is a true fly species (Diptera) that belongs to the family *Stratiomyidae*. This species can be found omnipresent in tropical, subtropical, and temperate regions. Due to its ability to feed voraciously on a wide range of organic materials such as manure, rice straw, food waste, distillers' grains, fecal sludge, animal offal, kitchen waste, and so on (Wang & Shelomi, 2017), the black soldier fly has a great potential to treat and recycle organic waste. Besides that, the species also has a high efficiency in converting organic waste into various kinds of stable and valuable products, like animal feedstuff, organic fertilizer, and biodiesel. When compared with conventional composting methods, black soldier fly larvae can reduce the initial waste of organic waste by about 50% in a shorter period (Amrul et al., 2022). The larvae also exhibit superior feed conversion ratios than both crickets and mealworms (Wang & Shelomi, 2017). Especially, the adult black soldier flies are non-pathogenic as they consume solely water (they do not have a stinger, mouthpart, or digestive organs), avoid human contact, do not exhibit biting or stinging behavior (Čičková et al., 2015; Sheppard et al., 2002). The black soldier fly larvae can produce antibacterial compounds that inhibit house flies from laying eggs and reduce the presence of foodborne pathogens like *Escherichia coli* and *Salmonella enterica* (Amrul et al., 2022). Consequently, there are no significant concerns regarding disease transmission associated with industrial farming of black soldier flies for large-scale waste management.

The CORS systems utilizing the black soldier flies consist of four primary stages (Amrul et al., 2022):

1) Waste pre-processing (e.g., particle size reduction, dewatering, and inorganic waste removal)
2) Treating the organic waste using black soldier fly larvae
3) Separating black soldier fly larvae from the process's residue
4) Refining the larvae and residue into marketable products

Within this system, the larvero, where the larvae feed and grow, and the fly house, where the adult flies live and reproduce, are two main components. Maintaining a healthy environment for adult and larval flies is crucial to ensure a consistent supply of offspring for organic waste management.

To treat the organic waste using the black soldier fly larvae, the first step is acquiring the eggs either from the market or by capturing them in the wild. The eggs typically hatch into neonate larvae after approximately four days. Then, the larvae grow by feeding on various organic materials such as manure, food waste, municipal waste, and decomposed plant matter. The larvae can grow up to lengths of up to 27 mm, widths of approximately 6 mm, and weigh as much as 220 mg in the final larval stage. As prepupae, the last larval stage before pupation, they clear their digestive tract and depart from the food source to seek a dry and secure location for pupation. At this stage, the larvae have reached their maximum size and boast a protein content of 36–48% and fat content of 33%. If not harvested, the

larvae will develop into adult flies in around 14 days and produce a residue called frass. If the adult flies continue to breed on a large scale, a secondary waste of dead flies will be generated besides eggs, leading to a significant amount of biomass. This kind of biomass has the potential to be recycled into a valuable renewable source of pigments like melanin and ommochrome (Ushakova et al., 2019). Normally, the life cycle of the black soldier fly, from egg to adult, will take approximately 40-43 days in tropical areas, but it is subject to change depending on food availability and other conditions (Furman et al., 1959; Tomberlin et al., 2002).

By the end of the treatment process, larvae and their waste (frass) are generated as by-products, which can be converted into animal feed and organic fertilizer. In the traditional black soldier fly bioconversion method, organic waste is directly supplied to the larvae without any moisture adjustment. While this approach is simple and time-efficient, separating the residue from the generated biomass becomes challenging if the residue is overly wet, with a moisture content ranging from 82% to 86%. Such high moisture levels make the residue too thick for effective sieving. However, this issue can be addressed through proper moisture regulation. It is recommended that a drainage system be installed to remove excess leachate and include a ramp for the prepupae to exit the larval area, facilitating both their departure from waste and the easy separation of the pupae from the frass. In other words, this method enables the “self-harvesting” behavior of the fly larvae, which removes an otherwise labor-intensive step from the treatment system (Diener et al., 2011; Sheppard et al., 1994). In addition, Dortmans et al. (2017) proposed a harvesting technique separating the larvae from the residue using manual or automated shaking sieves. This process is recommended after 12 days of BSFL waste treatment; at this point, the larvae have attained their peak weight and nutritional value but have not yet progressed to the prepupal stage.

In a recent study, Grau et al. (2022) analyzed costs associated with waste treatment using black soldier fly based on an existing plant and the example of the solid waste system of Surabaya, Indonesia. Specifically, the analysis suggests that $147,451 of early capital investment, 1,544 m^2 of land, and 56 staff are required to establish a centralized waste processing plant (integrating the larvae nursery, waste pre-processing, waste treatment, harvesting, post-processing, and residue processing units) that can treat 10 tons of organic waste per day. The total operating cost of the plant in five years will be approximately $200,000, while its net present value, the difference between the present values of all costs and potential revenues, is around $325,000. The corresponding capital costs, operating costs, and net present value of a decentralized plant system with similar waste treatment capacity are $151,991, $280,026, and 333,296$, respectively (Grau et al., 2022).

Although the net present value seems promising and the calculated capital and operating costs are much lower than that of other waste treatment systems, like incineration (Aleluia & Ferrão, 2017), the financial investment needed for adequately treating more than 30,000-

45,000 tons/day in Vietnam (assuming that 50%-75% of waste is organic) is still overwhelming for the existing waste treatment companies in Vietnam.

3. Issues of waste treatment companies as viewed through the lens of the stock market

In Vietnam, there are technically three stock markets:

- Ho Chi Minh Stock Exchange (HOSE): The largest and most prestigious stock exchange in Vietnam, which focuses on listing large, established, and profitable companies.
- Hanoi Stock Exchange (HNX): The stock exchange for mid-sized companies with growth potential.
- Unlisted Public Companies Market (UPCOM): A market within the HNX for companies that do not yet meet the listing requirements of HNX and HOSE. It is sometimes referred to as a "pre-IPO" market.

As of April 16, 2024, 23 companies operating in the waste management and recycling sector are recorded to be listed on the stock market. However, none of them has been listed on the HOSE or HNX stock exchanges, hinting at the lack of authorized capital or other listing requirements (e.g., profitability, a record of stable and sustainable operations, share distribution, disclosure and transparency, etc.). Indeed, the capitals of these countries are relatively low, with only 11 companies (48%) acquiring assets greater than $5 million (see Table 1). Even when we combine all these companies, their collective total assets are only approximately $169 million. Such capital is still largely insufficient to establish black soldier fly processing plants to treat 30,000 tons of organic waste/day, which hypothetically requires an initial investment of $442.4 million (equivalent to 3000 centralized waste processing plants with the capacity of 10 tons/day).

Not to mention, waste management companies in Vietnam do not concentrate solely on waste management but tend to take care of a wide range of environment-related businesses, such as urban greenery and landscape management, urban lighting and traffic signal system management, urban drainage and water supply system management, cemetery management, etc. These companies can only use a proportion of their limited capital to invest in new waste treatment technologies. Consequently, they need to rely on low-cost methods of landfill disposal and incineration. According to the General Department of Environment, 75% of collected solid waste was disposed of in landfills in 2020, of which more than 80% were unsanitary landfills (Minh, 2020). Meanwhile, 14% of the total waste is treated by incinerators that fail to meet environmental and technical standards (Trinh et al., 2021).

To raise capital for new treatment technology investment, companies listed on the stock market can expand the development and investment funds (DIFs) through retained earnings and conduct equity financing through secondary offerings. However, most companies in the waste management sector tend to have no plan of raising capital for development and

investment. They (83% of the companies) allocate less than 20% of their profit for the fund, which significantly limits the amount of capital that can be utilized for the application and scalability of new biological methods in waste treatment. Moreover, out of 21 companies paying dividends to shareholders, only one company (MQN) chose to pay by stock to raise more capital from the profit for future use. The cash dividends paid by these companies are relatively high; 12 companies paid more than 50% of their profit for cash dividends.

More notably, even if the company allocates a high rate of its retained earnings to the DIF, its capital is still inadequate because its profit is relatively low compared to the capital costs of adopting new technology and constructing a new waste treatment plant. For example, Quang Ngai Urban Environment Joint Stock Company (MQN), the company with the highest rate of retained earnings allocated to DIF (41.93%), could only have around $291.42 thousand of capital for investment.

From a financial investment perspective, the prioritization of cash dividends at a very high rate by companies is normal, not to say overly positive, because these companies can generate good and steady profits for investors. However, given the fact that these companies are environmentally focused, the high and regular payment of cash dividends is unusual for several reasons. If all profits are consistently used to pay dividends to shareholders, then where will the money come from to expand the scale and improve the waste treatment technology? If investors are accustomed to such high profit margins, would they agree with the technological improvements and expansion proposals, which usually require a significant amount of capital invested?

Another notable aspect is the discrepancy wherein, despite the companies' significantly high profit margins (as illustrated by their EPS and P/E ratio) compared to their market peers, their market valuation remains disproportionately low. Specifically, the average earning per share (EPS) of all companies listed on UPCOM is around 0.061 USD, and their average price-earning ratio (P/E) is 17.7. Meanwhile, although the EPS of companies in the waste management sector is relatively equal to the average EPS of UPCOM-listed companies, their P/E ratios are substantially lower, with most companies' P/E ratios (65%) being lower than 10. As explained above, these companies in the waste management sector have low amounts of assets and low levels of technology. Their operations are labor-intensive. Despite the remarkably low P/E ratios compared to other companies in the stock market, the annual income of these workers is still relatively similar to the average income of Vietnamese workers at around $3500 per year.

Table 1: Details of waste treatment companies listed on the stock market

Stock	Market price	Number of shares	Assets (Million USD)	Liabilities (Million USD)	Equities (Million USD)	Profit 2022 (Million USD)	Dividend 2022 (Million USD)	Dividend type	Dividend/Profit	DIF 2022 (Thousand USD)	DIF/Profit	Worker	Worker salary (Thousand USD)	EPS	P/E
BMD	0.51	2,753,280	2.84	1.37	1.48	0.24	0.10	Cash	41.23%	4.66	1.96%	416	3.51	0.09	5.84
BTU	0.63	3,600,000	3.50	1.21	2.29	0.28	0.14	Cash	51.54%	-	0.00%	231	4.66	0.09	6.74
CDH	0.08	2,000,000	3.01	1.52	1.49	0.14	0.04	Cash	27.65%	-	0.00%	264	4.01	0.08	1.07
DNE	0.36	5,773,600	6.23	3.20	3.02	0.28	0.11	Cash	40.45%	45.42	16.10%	1131	3.23	0.04	9.29
DTB	0.49	1,558,248	1.43	0.65	0.77	0.12	0.08	Cash	68.72%	12.25	10.25%	175	3.75	0.07	7.51
DUS	0.51	5,601,200	6.52	3.91	2.61	0.49	0.27	Cash	54.74%	35.65	7.35%	407	3.98	-0.02	--
HEP	0.57	6,000,000	23.97	1.38	22.60	0.45	0.21	Cash	45.84%	83.32	18.32%	565	7.17	0.08	6.97
MBN	0.31	5,750,000	6.83	1.27	5.56	0.01	-	-	-	1.66	15.73%	645	3.46	0.01	34.08
MDA	0.36	1,200,000	1.92	1.04	0.88	0.03	-	-	-	-	0.00%	178	3.23	0.07	4.93
MLC	0.67	4,171,175	3.83	1.44	2.39	0.43	0.21	Cash	49.39%	88.70	20.44%	616	5.11	0.12	5.62
MND	0.40	2,194,475	1.77	0.77	1.00	0.09	0.06	Cash	66.64%	9.29	10.00%	369	4.10	0.04	9.33
MPY	0.32	6,143,000	4.46	1.61	2.85	0.28	0.15	Cash	52.43%	23.00	8.28%	460	3.52	0.05	6.04
MQB	0.36	3,675,675	3.25	0.84	2.42	0.12	0.05	Cash	42.06%	12.53	10.36%	224	3.94	0.03	10.82
MQN	0.91	5,800,882	18.16	8.85	9.32	0.70	0.26	Stock	37.94%	291.42	41.93%	1128	4.24	0.26	3.52
MTB	0.39	6,278,259	3.36	0.85	2.51	0.03	0.02	Cash	91%	-	0.00%	375	3.23	0.00	96.66
MTH	0.57	4,787,910	6.47	1.29	5.18	0.28	0.19	Cash	68%	81.15	29.11%	438	3.56	0.09	6.48
MTV	0.62	5,400,000	4.68	0.77	3.90	0.34	0.15	Cash	44%	-	0.00%	536	4.06	0.07	8.53
NAU	0.28	3,669,999	8.37	2.65	5.72	0.06	0.03	Cash	50%	-	0.00%	488	4.13	0.02	14.28
NUE	0.39	6,000,000	5.45	2.61	2.83	0.24	0.18	Cash	73%	12.02	4.97%	957	4.64	0.04	9.25
SDV	1.28	5,000,000	17.37	11.66	5.70	1.17	0.59	Cash	51%	342.57	29.35%	227	-	0.12	10.34
SZE	0.52	30,000,000	24.76	10.56	14.20	1.09	0.95	Cash	87%	-	0.00%	588	5.81	0.04	13.49
USD	0.75	5,600,000	7.69	4.52	3.17	0.73	0.47	Cash	65%	90.67	12.49%	357	3.38	0.14	5.58
VLP	3.95	3,536,222	2.75	0.69	2.06	0.22	0.07	Cash	32%	35.65	16.50%	263	3.75	0.05	72.99

* VND was converted to USD using the following exchange rate: 1 USD = 25,300 VND

4. A need for social transition from eco-deficit to eco-surplus culture

Organic waste treatment using the black soldier fly is a promising approach for Vietnam due to its high waste recycling efficiency, cost-effectiveness, value generation, and existing technology in Vietnam. However, some problems hinder such a method and even other biological technologies in waste management in Vietnam. As reflected through companies listed on the Vietnamese stock market, there are two major issues.

First, the business considers the environmental services they provide as a pathway to earn profit, but not for the sake of the environment. This tendency is reflected in their capital allocation strategies. The strategies are directed to maximize the profit for the shareholders but not to raise capital for later development and scaling of companies' operations. Paying high cash dividends to shareholders is almost similar, or not to say identical, to high-interest rate loans, which increase the financial burden and limit growth opportunities. In the long term, this action can create an eco-deficit culture in which the boards of directors will prioritize profit over the true environmental values they are meant to produce to avoid the dividend pressure from companies' shareholders (Vuong et al., 2021). What if the pressure from the shareholder is tremendous? Will the board of directors determine to conduct some activities that can harmfully affect the environment for profits, such as open and ocean dumping?

Second, the Vietnamese public underestimates the value of companies working in the environmental sector, specifically waste management. Despite the high EPS and cash dividend/profit in the waste management sector, their market value is relatively low compared to companies in other sectors (as reflected in the low P/E ratio). With such a low valuation, equity financing from public investors will encounter the risks of limited investment capital and high interest rates. As beliefs play a pivotal role in determining values, investment decisions, and stock prices (Coibion et al., 2018; Gennaioli et al., 2016; Gennaioli & Shleifer, 2018; Vuong, 2023b; Vuong et al., 2022), the undervalue of these companies could potentially originate from Vietnamese cultural beliefs of devaluing individuals engaged in the environmental sector in Vietnam. This devaluation can be exemplified by the prevalent portrayal of sanitation workers as emblematic of failure in child education.

Additionally, the underestimation of waste management by the Vietnamese public is also implied through the public's spending on waste treatment. According to the World Bank, Vietnam only spends 0.23% of its GDP on domestic waste treatment, which is less than half the global rate at 0.5% (Chinh, 2023). The public only needs to pay 25% of the spending on waste treatment, while the state budgets cover the remaining 75%. This practice contributes to the Vietnamese public's unawareness of the actual costs of environmental quality assurance through waste treatment and the undervalue of waste treatment companies.

In general, the two problems observed through the stock market hint at an eco-deficit dilemma: society simultaneously aspires towards environmental sustainability and consumerism—often a source of waste—but still deems those engaged in waste management as socially inferior and unwilling to pay more for the environmental values they produce. To address this problem, we call for societal transitions toward an eco-surplus culture, where pro-environmental attitudes, values, beliefs, and behaviors are shared among the public (Nguyen & Jones, 2022; Vuong & Nguyen, 2023, 2024). Within a society with eco-surplus cultural values, companies in the environmental sector, specifically waste management, will receive higher revenue and premium market prices as a remuneration for the environmental surplus values they produce. Subsequently, such companies will acquire more opportunities to raise capital from public investors. The semiconducting principle of monetary and environmental values exchange should also be applied to prevent companies from using monetary values to pay for the eco-deficits that they create (e.g., water, soil, air, and plastic pollution and greenhouse gas emissions) (Ferronato & Torretta, 2019; Vuong, 2021).

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