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Research Article

Junkshops as Recycling Chain Actors in the Recovery of Waste Resources from a Highly Urbanized City in the Philippines

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Abstract

This study was performed in order to identify the role and work mechanism of the 33 junkshops in the recovery of valuable recyclable materials for further processing by the next level hierarchy of recycling chain actors in Iloilo City, Philippines. Results revealed that more than 65% of the junkshops operate at 7 to 8 hours per day, hire 1 to 4 male workers, operate at an area of 50 to 1000 m^2 with structures made of light materials, and with a capital outlay of ≤USD 1,818.18. The recyclables (paper, plastics, glass, ferrous and non-ferrous metals, and waste from electrical and electronic wastes or WEEE) recovered per month by all junkshops amounted to 1,584.83 metric tons (MT) and 115,470 pieces for glass bottles with an industry worth of USD 338,400.00. Ferrous metals have the highest monthly recovery weight at 608.26 MT or equivalent to USD 150,199 followed by papers and plastics. For plastic recyclables, high density polyethylene (HDPE) amounted to 110.68 MT per month equivalent to USD 34,383. Further analysis revealed that the junkshops assessed can recover valuable waste resources equivalent to 10.65% of the city's daily waste generation or an equivalent amount of 33.49 MT d^{-1}. In countries having similar conditions as that of the Philippines, recognition of their role and function can complement existing solid waste management (SWM) laws, including the national frameworks on extended producer responsibility in which junkshops and related SWM facilities can become part of product waste recovery programs. If junkshop operations and their existence are regularly monitored and capacitated with skills training, including the geographical presence of recycling industries, their impact on waste management could have been more essential for sustainable development and the conservation of resources.

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Introduction

Iloilo City, being the capital of the Province of Iloilo, is classified as a highly urbanized metropolis. In the Philippine map, it is strategically located at the center of the country and it has a thriving economy in the Western Visayas region driven by agribusiness, tourism, business process outsourcing offices, trade, and commerce [1–2]. With 180 barangays located in its seven districts, the city has a growing population of 457,626 based on the 2020 census data [3]. In the Philippines, barangays are the lowest political administrative unit of the government [4]. When population and economic activity grow, it can also be expected that the daily generated waste will increase, especially for developing countries such as the Philippines. In addition, the increasing reliance on the use of packaging materials, mostly made of plastics, for preserving and transporting food has created negative impacts associated mostly

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with pollution from unmanaged and improperly disposed waste. Cities located in Southeast Asia have specifically been associated as a major source of plastic pollution [5–7].

With the city's aim to become one of the country's most livable cities by 2028, managing waste properly is essential for building sustainable and resilient cities [8]. A sustainable way of managing municipal solid waste is a prerequisite for achieving circular economy due to its positive impacts in terms of promoting environmental and human health protection. In addition, a properly managed waste system can boost the economic productivity of an area through resource recovery from waste [9]. Based on the data shared by the city government, Iloilo City generates around 400 tons of solid waste per day as compared to that of Metro Manila at 5,742 tons per day, and to reduce that amount, residents are urged to manage their organic and recyclable wastes [10–12]. Effective management, however, remains a challenge, especially in terms of how key players and sectors can be tapped in the system. In many Southeast Asian cities, efficient municipal solid waste management programs are still lacking [13].

In the past 20 years, the Philippines has implemented various initiatives from the national down to the local level to improve its solid waste systems. The Republic Act 9003 - Ecological Solid Waste Management Act (ESWMA) of 2000 mandates every local government unit in the country to have systematic, comprehensive, and ecological approaches and strategies in implementing a solid waste management (SWM) program. It shall be based on the hierarchy of waste management promoting practices of source reduction, reuse, recycling, and resource recovery (3Rs) of materials. This law not only emphasizes the significant contributions of the informal sector, especially in recovering generated waste [14], but it also mandates that solid waste be reduced at source and recyclable materials be recovered while the remaining waste (i.e., residuals) are to be disposed of properly. Despite the existence of a law, the overall implementation of SWM in the country remains a challenge, a critical social challenge when no behavioral and institutional changes occur [15–16].

ESWMA defines the term "recovery" as the collection, extraction, or recovery of valuable materials from the waste stream for recycling purposes, generating energy, or creating products suitable for beneficial use. In the waste separation process, they are considered vital in effectively implementing an integrated waste collection system [17]. The absence of segregation or separation of valuable waste such as plastics is the cause of ineffectiveness in recycling activities of this specific material [18]. Recycling, likewise, is concerned with the treatment of waste to make it ideal for beneficial use and the transformation of waste materials into new products. These new products could then be tapped as raw materials for the production of other goods and services. With the recycling of solid waste, it would not only protect the environment and produce health benefits but it would also generate economic advantages [19].

An effective system of managing waste with recycling components is considered essential for sustainable development and the conservation of resources [20]. Supplementing and amending the purpose of the existing law (ESWMA) in adopting comprehensive and ecological solid waste management initiatives is the approval of Republic Act 11898 (RA 11898), which is also known as the Extended Producer Responsibility (EPR) Act of 2022. Under this new law, EPR is considered an environmental policy approach and practice that encourages plastic waste reduction especially the retrieval of plastic packaging materials from the trash for reusing and/or recycling them back into the production process [21]. Recovery of these valuable waste after generation is an important initial step in attaining a circular economy. With the circular economy concept, the traditional production and economic activities, which are considered linear systems, will shift into circular dynamics, not an end goal but a means leading to sustainable development [22]. A closed-loop system is applied with a circular economy or the cradle-to-cradle model [23]. For example, the raw materials collected and converted into usable products by various consumers will be linked to sectors that could utilize them for resource use and production to decrease waste that may end up in the environment [24–25]. To realize this transition, private businesses such as junkshops are pivotal stakeholders in commanding the most resources and capabilities.

Junkshops are part of the waste recycling chain. In the hierarchy, registered or unregistered medium and small junkshops and big junkshops are above the informal waste sector, such as waste reclaimers, jumpers, garbage crews, itinerant waste buyers or waste collectors [14, 26]. They are also stakeholders of the recycling network who are involved in sorting and reprocessing secondary raw materials. They could be the same or different, and they may sell their secondary commodities to brokers or directly to new product manufacturers at local, regional, and national enterprises and individuals that are connected by waste relationships [9, 27–28].

Junkshops as significant players are necessary in helping these materials not end up in drainage canals, open disposal facilities, or worse, in riverine and marine environments. They are involved in the trading process by buying and selling materials for next level operation and markets [9]. Their business, however, is less con-

sidered by many since the quality of traded materials is unclean and soiled [29–30]. Though the contribution of the informal sector in emerging economies plays an important role in achieving high recycling rates, they are not fully recognized due to the lack of reliable information on the volume and quality of recyclable waste materials collected, sorted, and managed [9].

As a sector involved in SWM, junkshops are being recognized for their large contribution to recycling activities and waste recovery [30]. In the 2008–2018 National Solid Waste Management Status Report of the Philippines' Environmental Management Bureau of the Department of Environment and Natural Resources [31], recyclables particularly those with high commercial value like paper, scrap metals, and plastics are typically sold to junkshops passing through a business chain of middlemen and wholesale for use by the industry, mainly outside the country. Similar data was also highlighted by the National Solid Waste Management Commission (NSWMC), in which the 1,940 junkshops and recycling facilities listed are buying materials like plastics, glass, papers, metals, textiles, and electronic waste, including residuals with potential for recycling [32].

In a study conducted at selected cities in the Philippines, the participating junkshops were found to have lucrative business operations and could help support economic development through the materials they accommodate, such as all types of plastics, whole or broken glasses, papers, metals, and batteries, amounting to a traded value of 100 to 5,000 kg per week [33–34].

However, due to the direct handling and exposure to various unsorted waste in their operation, junkshops have been stereotyped as not glamorous. Despite the unsanitary conditions practiced by some small business junkshop enterprises, it is still implied that the collective efforts of this industry can earn millions of dollars while also contributing to the recycling sector and the economic development of a city [33].

Just like in any developing country, recovery of recyclable waste materials also often relies on labor-intensive and informal recycling operations. Junkshops would rely on independent waste reclaimers (i.e., waste pickers) who would collect and sell them as recyclables for their living. They serve as facilities in the collection and sorting of waste for processing and as marketplaces for the different levels of recycling chain actors to sell their collected recyclables [35–36]. South Korea, even with a developed economy, still adheres to the networks of local junkshops and waste reclaimers in the informal recycling chain. Using the geographic information system, they interviewed respondents like junkshop owners to determine the factors that caused the co-existence of the formal and the informal systems in their waste management and how these junkshops have progressed in their operations over time [37].

A sustainable management of generated solid wastes can boost economic productivity via resource recovery from waste, thereby, creating an effective supply and demand market [9]. It has been seen as a possible solution towards sustainable development [38]. Numerous sustainable development goals (SDGs) can also be addressed, such as poverty reduction (SDG 1), good health and well-being (SDG 3), decent work spaces and a growing economy (SDG 8), cities and communities that are sustainable and livable (SDG 11), responsible consumption and production (SDG 12), and climate action (SDG 13) [39–40].

What is happening currently, however, is that not all consumers and generators segregate waste and recyclables are not completely recovered. Low- and middle-income cities have a considerable presence of the informal recycling sector; in its formal collection systems, recovery of recyclable materials is yet fully developed due to unsegregated waste at source, no separate trucks for specific types of waste, and improvements needed in the efficiency and the living and working conditions of those involved [16, 41].

With the recycling chain component of the Rethinking Plastics Project implemented in Iloilo City, Philippines by Central Philippine University, the reduction in the generation of plastic waste that may end up in marine waters through sustainable consumption, production, and improved waste management of plastics and its alternatives is aimed. To find solutions to the decades-long concerns in waste generated by different sources and its management by government and private authorities, one of the key objectives of the project is to strengthen the dialogue on the efficiency and mechanism of the recycling chains in Iloilo City with more emphasis on the existing presence of junkshops as traders for scrap and recyclable materials. The results of this study are valuable in addressing the lack of reliable information on the quantity and quality of recyclable waste materials collected, sorted, and managed by informal stakeholders, and on how well recycling chains promote circularity in recyclable waste materials management globally [9, 42].

This study gathered and analyzed valuable information about junkshops, such as their business profile, computed quantity and assessment of the quality of recycling materials, identified machinery and equipment available, process flow operation evaluated, hazards encountered, value chain linkages, and community presence. We aimed at providing visually and economically additional baseline information on solid waste management systems with similar conditions to those of a highly urbanized city in a developing country.

Materials and methods

1) Study Area

Having 7,107 islands, the tropical country of the Philippines has a total land area of 300,000 km^2. Based on the 2020 Census of Population and Housing [43], the total population of the country is 109,035,343, with an annual population growth rate of 1.63%. The country is divided into three island groups, called Luzon, Visayas, and Mindanao, composed of 17 administrative subdivisions known as regions.

Iloilo City, the commercial center and the capital of the Province of Iloilo, belongs to Region VI or the Western Visayas region. According to the same 2020 census, Iloilo City has a total population of 457,626 [3]. It is composed of seven districts with 180 urban barangays. The 26 junkshops that participated in the one-shot survey using a structured questionnaire [44] for baseline information covered six of the seven districts in Iloilo City, indicating comprehensive coverage in terms of area distribution. As presented in Figures 1 and 2, more junkshops proliferated and were interviewed in the Mandurriao district since that is also where the city's sanitary landfill (SLF) is located.

A non-experimental type one-shot survey using a structured questionnaire [44–45] was administered face-to-face in order to collect and verify primary qualitative and quantitative information about the different junkshops in Iloilo City, Philippines. Prior to engaging the participants for questions, the researchers adhered to the ethical guidelines outlined in the American Evaluation's (AEA) Guiding Principles for Evaluators. These guidelines covered informed consent, systematic inquiry, competence, integrity/honesty, respect for people, and responsibilities for general and public welfare [46].

Figure 1 Number of junkshop participants involved in the study per city district.

Figure 2 Location of surveyed junkshops seen in Iloilo City, Philippines map.

Junkshops included in this study were initially based on the 17 registered number of junkshops provided by the Iloilo City Government's (ICG) General Services Office (GSO). But when the site was validated, some junkshops in the list ceased to operate. Additional participants were included according to the referral of the other interviewed junkshops as the study progressed. There were five others, however, who opted not to participate. Overall, 33 junkshops were involved in this study, where 26 were interviewed with their consent using the one-shot survey questionnaire administered through actual observation on-site to validate the physical structure and ongoing operation of the junkshops. Additionally, seven (7) participated further with other recycling chain actors during the business forum activity. Out of the 33 junkshop participants, 25 joined the said business forum, and 72% of them were identified to have business permits. In contrast, 76% of the same number have a Department of Trade and Industry (DTI) registration. DTI is a Philippine government agency responsible for regulating the registration and issuance of the name of businesses for legal identity [47]. Figure 3 presents the dropdown of the number of junkshops involved in the study.

Figure 3 The number of junkshop participants involved in the study.

2) Interviews

Throughout the study, the junkshop respondents, who were mostly owners and operators, were interviewed using a set of structured questionnaires that focused on their business information, recycling materials bought and sold, machinery and equipment used, process flow operation, recycling stream analysis, environmental management practices, value chain linkages, and community presence.

3) Data analysis

The data collected were encoded and tabulated for analyses using frequency, percentage, and weighted mean.

Results and discussion

1) Recycling chain in Iloilo City, Philippines

As presented in Figure 4, the solid waste management (SWM) system has four main elements. It starts when waste is generated by different sources like households, commercial establishments, and institutional facilities. The generated waste, either segregated at the source or mixed, are then collected by the city government and its contracted collection hauler. Other wastes with scrap value are collected by the assigned barangay eco-aides and private haulers to be brought to storage and processing facilities like the barangay's materials recovery facility (MRF), while some are delivered to junkshops for direct selling. The remaining materials would be collected back by the city collection vehicle, while some junkshops would directly haul their rejects to the sanitary landfill for final disposal.

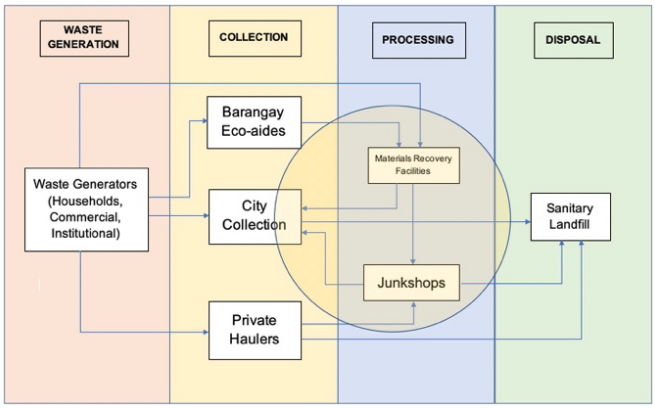

Figure 4 Recycling chain in Iloilo City, Philippines' solid waste management system.

As seen in the same figure, the circle placed between collection and processing highlights the role of the junkshops and other actors, such as the barangay eco-aides, city collectors, and private haulers in the recycling chain sector. They play a substantial role in the recovery of recyclables for next-level processing instead of being dumped in landfills. The latter scenario is a strong possibility, especially since no segregation at the source is appropriately in place. In the figure, there was no indication of segregation at source and during collection because further processing of valuable waste like recovery of paper, plastics, glass, ferrous and non-ferrous metals, and waste from electrical and electronic equipment (WEEE) are performed at the MRF and junkshop spaces.

Just like in Singapore [48] and in Vietnam [49], junkshops can complement the Philippines' national framework on EPR in which they and the related SWM facilities available can become a part of waste recovery programs. Intended at preventing waste from leaking into the terrestrial and aquatic environments, junkshops can be capacitated to recover waste through activities such as redemption, buy-back, offsetting, or any initiative or strategy that will efficiently result in the high retrievability of valuable waste for the succeeding more advanced method of processing of recyclable materials. Their

recovered waste would allow the identified obliged enterprises and other industry players, as indicated in the EPR law, to fund enhanced collection and processing.

Regardless of political subdivisions, properly monitored waste production is considered an initial step in implementing waste management strategies. Other countries have already developed and integrated start-of-the-art monitoring technologies such as ultrasonic sensors, geographic information systems (GISs), general radio packet service, and radio-frequency identification (RFID) to improve waste collection from bins and trucks. However, these high-end devices and technologies are mostly not applicable in low-income countries due to high investment costs [50–51]. This is the same scenario for lower-middle income countries where the inclusion of this sector remains a problematic issue that needs considerable attention when it is targeted to be integrated into formal SWM systems [41]. Nevertheless, despite differences in the use of new technologies, the most critical considerations affecting the scale of recycling are considered significant concerns both for developed and developing countries [52]. The Philippines, as a developing country, particularly the junkshops in Iloilo City, have collection systems for recyclable materials that are still not systematized for regular monitoring. A properly developed monitoring system for Iloilo City's collected recyclable chain, including the recovered volume of valuable materials by the junkshops and other aggregators, will play a vital role in developing its urban economy [53].

Iloilo City, a highly urbanized metropolis outside the Philippine capital was observed to have similarities in terms of the recycling chain as compared to the SWM value chain documented in selected barangays in Metro Manila and its nearby communities where recovery and movement of recyclables are taking place because there are MRFs and junkshop presence in the area [34]. Junkshops in Iloilo City as a recycling chain fits in the definition as being the chain of processes and structures of formal/informal networks of stakeholders created and shaped by their relations across the value chain. They are aimed at connecting production with the management of recyclable waste resources [9].

2) Business profile of junkshops

Table 1 presents the summarized results of the 26 junkshops surveyed regarding their business profile. The 26 junkshops interviewed for their baseline information covered six of the seven districts of Iloilo City or 85.57% of the city's administrative area. The respondents were either owners, managers, or operators of junkshops. Both at 38.50% of the junkshops have been operating for one to five years and six to 15 years. The same percentage, at 11.60%, has been in the business for more than 16 years, while others opened only during the COVID-19 period, which was in March 2021. The junkshops in the city operate at 6 days a week, covering Monday to Saturday (69.23%), while the rest operate from Monday until half day or the whole day of Sunday (30.77%). In terms of business hours, close to 81% of them operate at 7 to 8 hours per day. Almost 75% of the workers hired in junkshops are men, while women (25.64%) are also hired by some junkshops. As to land area, the junkshops occupy a space of 50 to a maximum of 1,000 m^2 (96.14%), with more than half (65.38%) operating in a rented space. Their structure is constructed using light materials (88.46%).

Almost 81% of the 26 junkshops surveyed had a capital outlay of less than or equal to PHP 100,000 (USD 1,818.18), and the remaining 19.23% started their business with a capital between PHP 100,001 and PHP 250,000 (USD 1,818.20 to USD 1,454.55).

In terms of their estimated average monthly income, 76% declared earning between PHP 8,000 to PHP 80,000 (USD 145.45 to USD 1,454.55) while 20% are at the PHP 100,000 to PHP 400,000 (USD 1,818.18 to USD 7,272.73) range. Four percent (4%) earn more than PHP 1 million (M) (USD 18,181.82) every month for the recyclables they recover.

Comparing these results in terms of gender participation, a similar trend was also observed in Indonesia and India [54], in which the male workers hired were at 60% while women's participation ranged from 17% to 35%. This shows that the junkshop industry predominantly hires male workers given the nature of their work.

The same findings were also observed in the study conducted [33–34] wherein the junkshops located in Luzon Island of the Philippines, were also constructed mostly of light materials (75%) and operated in a less than 1,000 m^2 lot area (65%). Adopting the same observations that using light materials in its building structure may pose threats to its workers and close-in facilities, these junkshops need upgrading and reviewing whether they follow the minimum requirements against hazards. The less than the 2,000 m^2 minimum lot area requirement for junkshops in Iloilo City also means they may not have been monitored prior to operation. Less lot area for operation will indicate negative implications regarding the more effortless movement of workers and the need for substantial spaces for filing stacked recyclables to minimize the chances of accidents [33].

A similar capital outlay value was also documented in the study conducted in the Philippines [33], where 80% of the 20 junkshop respondents had less than PHP 200,000 (USD 4,000) in) capital investment.

Table 1 Business profile of junkshops in Iloilo City, Philippines

Business Information		
Junkshops visited and surveyed	26	
Districts covered	6 out of the 7 districts of Iloilo City, Philippines	85.57%
Respondents	Owners and managers of junkshops	100%
Years in operation	One year to 5 years	38.50%
	6 to 15 years	38.50%
	16 to above 40 years	11.60%
	newly opened since March 2021	11.60%
Hours and days of operation	7 to 8 hours per day	80.77%
	9 to 10 hours per day	19.23%
	$\leq$ 6 days per week	69.23%
	$\geq$ 6 days to 7 days per week	30.77%
Classification of workers	Hired male workers (1 to 14)	74.36%
	Hired female workers (1 to 5)	25.64%
Business area	50 to 1,000 m^2	96.14%
	1,001 to 4,000 m^2	3.85%
Area ownership	Rented	65.38%
	Owned	34.62%
Type of business structure	Light materials	88.46%
	Permanent	11.54%
Capital outlay	≤PHP 100,000 (USD 1,818.18*)	80.77%
	PHP 100,001 to PHP 250,000 (USD 1,818.20 to USD 4,545.45)	19.23%
Average monthly income per junkshop	PHP 8,000 to PHP 8 0,000 (USD 145.45 to USD 1,454.55)	76%
	PHP 100,000 to PHP 400,000 (USD 1,818.18 to USD 7,272.73)	20%
	above PHP 1 M (USD18,181.82)	4%
Association membership	None	100%

Remark: *USD 1 = PHP 55

3) Junkshop process flow

As seen in Figure 5, when materials from the sellers (both from the formal and informal waste collectors) arrive at the junkshop, they are sorted and classified first whether they would be considered recyclables or rejects. Initial rejects are returned to the seller for transfer and transport to the sanitary landfill. Recyclables, on the other hand, are weighed, and price negotiation takes place. This data generated is new information regarding the current knowledge on the role of waste recovery in junkshops: depending on the volume of materials delivered, both parties – the seller and the buyer – discuss and negotiate the prices for each recyclable. That is why when asked if the junkshop owners/operators were willing to place price signages outside their business establishment, many opted not to, because negotiation may take place depending on the current price of the materials, quantity delivered, and good financial standing of the seller. As part of the process flow, this valuable activity painted a clear picture of the business-mindedness of the personnel involved in junkshop operations. After price negotiation, the buyer pays the seller in cash. Once payment has been made, some materials are bagged and stored directly for the next-level actors who are mainly the bigger junkshops and consolidators. Some recyclables would undergo further cleaning and sorting for bagging and storage. Rejects in this process are transferred and transported to the sanitary landfill.

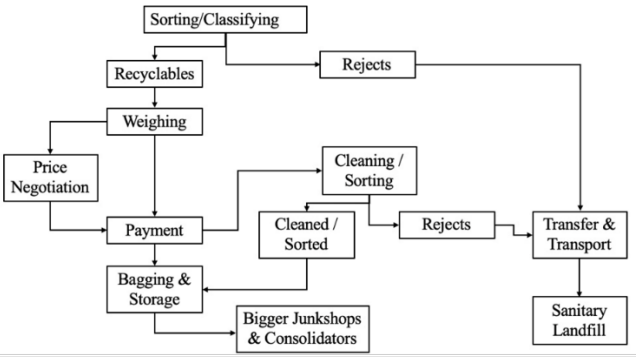

Figure 5 Flow, processes, and quality of recyclables assessed by the junkshops in Iloilo City, Philippines.

A similar waste material and service value chain study was found in particular barangays of Metro Manila and the Provinces of Rizal and Bulacan in the Philippines in which the process starts with manual sorting of the different recyclables like paper, plastics, metals, glass, textiles, and electronic wastes. These materials were re-sorted again for processing (e.g., grinding and pelleting) until they were ready to be sold to next-level recyclers.

Non-recyclables or rejects are brought to dumpsites [34]. A generic waste material flow chart from generators to junkshops, recyclers, and landfills from selected countries in Asia was highlighted [54] in which, from the households and bulk generators, the informal sector (street scavengers, recycling pickers, and itinerant buyers) and formal sector (large- and small-scale waste collectors) are sources of materials brought to the junkshops. After which, these materials are processed for recyclers, while unclassified materials are brought to landfills [54].

4) Quantity and quality of recyclable materials recovered

The values of the different recyclables bought by the 26 junkshops surveyed in Iloilo City are presented in Figure 6. There are six materials recovered by junkshops with high recyclable potentials, namely: 1) paper (newspaper, cartons, assorted and shredded), 2) plastics (polyethylene terephthalate or PET, high-density polyethylene or HDPE, low-density polyethylene or LDPE, polypropylene or PP, and polystyrene or PS), 3) glass (clear and broken), 4) ferrous metals (steel bars, tin cans, galvanized iron or GI sheets), 5) non-ferrous metals (aluminum, copper, and brass) and, 6) waste from electrical and electronic equipment or WEEE (batteries and appliances).

Among the total recyclables received every month, ferrous metals have the highest value in terms of weight at 608.26 metric tons (MT) (38.38%) and in terms of market value at USD 150,199 or PHP 8.3 M (44.39%), followed by papers at 394.44 MT (24.89%) with a value of USD 27,144 or PHP 1.5 M. Plastics came in at third with an amount recovery of 310.33 MT (19.58%) or an equivalent value worth USD 57,908 or PHP 3.2 M followed by glass (13.19%), WEEE (2.43%) and non-ferrous metals (1.53%). The total amount of recyclables that can be recovered by the 26 junkshops alone was 1,584.83 MT, and 115,470 pieces for glass bottles amounting to an industry worth of USD 338,400 or PHP 18.7 M per month. These incomes generated by junkshops, whether classified as small, medium, or consolidators, have contributed to the SWM knowledge that there is money in the recovery of recyclable materials. The jobs created by this sector have helped to address one of the SDGs in reducing poverty.

When analyzed further, the amount recovered by these junkshops from the waste stream is equivalent to 10.65% of Iloilo City's daily waste generation or an equivalent amount of 33.49 MT d^{-1}. This was computed according to the results of the survey, which established that 63.40% of waste brought to junkshops was from Iloilo City and was analyzed using the 314.46 MT d^{-1} total waste generation of the city [55]. Similarly, in Cambodia, the 692 junkshops operating in the whole country were able to buy 16,811 tons of recyclable waste per month, which was about 5% of the total municipal solid waste generation or 9% of the collected waste. Metals also shared the highest proportion in terms of weight at 46.76%, followed by paper (33.16%) and plastics (17.82%) [56]. In order to improve the recovery and recycling participation of junkshops, the city government needs to create a participative sector that would be instrumental in raising awareness of the benefits derived from the recycling of products.

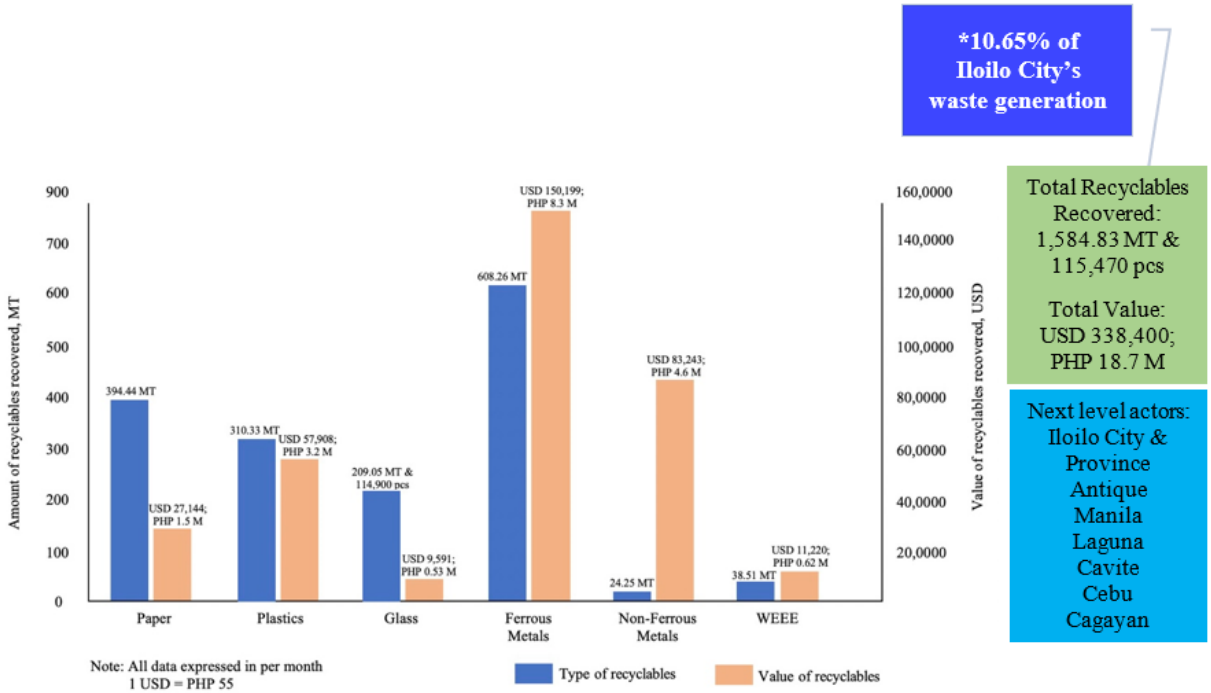

Figure 6 Quality and the equivalent value of all recyclables recovered by the junkshops in Iloilo City, Philippines.

For plastic waste (Figure 7), results reveal that HDPEs (hard plastics like detergent bottles, milk jugs, crates) have the highest recovery value equivalent to 110.68 MT (35.67% in terms of weight) or worth USD 34,383 or PHP 1.9 M, followed by LDPEs ("sando" bags, plastic bags) having a total weight of 75.60 MT (24.36%) with a market worth of USD 3,619 or PHP 0.20 M. The third highest recovered plastic wastes are PETs (water and soft drink bottles) at 58.61 MT (18.89%) with a market worth of USD 6,876 or PHP 0.38 M. Imagine this monthly amount of 310.32 MT of plastics, equivalent to USD 57,908 or PHP 3.2 M, all goes to waste in landfills and bodies of water if they were not recovered by junkshops. These specific materials can take centuries to break down.

The high amount of plastic waste recovered by the junkshops in their operation for the next level hierarchy of the recycling chain helps to ensure an efficient waste management. Aside from reducing its environmental impact, the volume of waste recovered has indicated economic opportunities [57]. The findings in this study also followed the same international classification of six types of non-biodegradable plastics recovered by junkshops [58–60].

Table 2 presents the average buying price of recyclables in Iloilo City, Philippines, based on the data obtained in August 2021. They are categorized as paper, plastics, glass, and metals. Among the 26 junkshops surveyed, 13 (50%) buy all of these types of recyclables. There are junkshops focused only on buying one type of recyclable, like glass or plastics. There were also junkshops that included paper in their recovery.

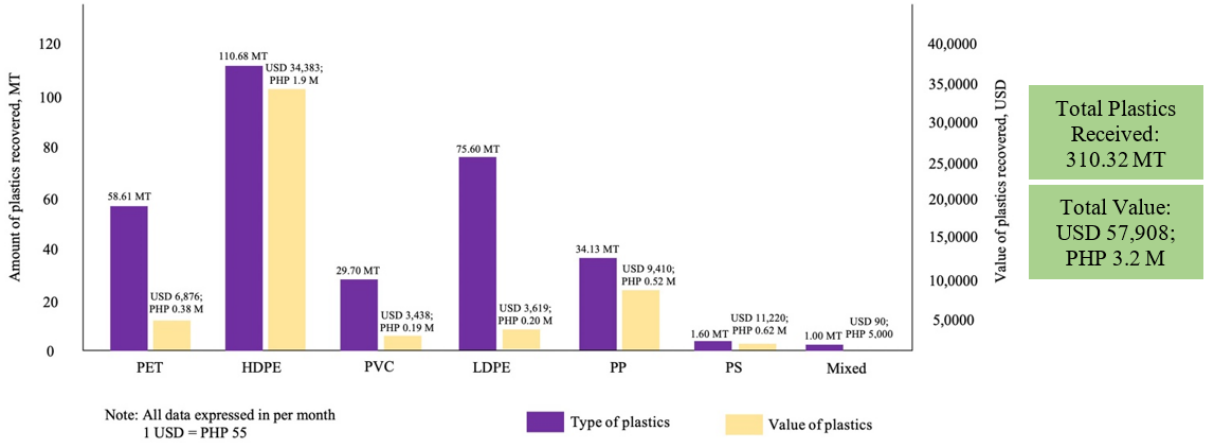

Figure 7 Quality and equivalent value of plastics recovered by the junkshops in Iloilo City, Philippines.

Table 2 Analyzed buying price of recyclables by junkshops in Iloilo City, Philippines based on the data obtained in August 2021

Recyclable materials	Average buying price	
Paper	PHP	USD*
Newspaper, kg	7.33	0.13
Newsprint/colored paper, kg	1.10	0.02
Cartons, kg	3.91	0.07
White paper, kg	2.50	0.05
Assorted/mixed papers (non-shredded), kg	1.43	0.03
Shredded papers, kg	1.00	0.02
Plastics		
PET, kg	6.40	0.12
HDPE, kg	16.90	0.31
PVC, kg	6.38	0.12
LDPE, kg	2.60	0.05
PP, kg	15.22	0.28
PS, kg	10.25	0.19
Others, mixed plastics, kg	5.00	0.09

Recyclable materials	Average buying price	
Glass		
Clear, pieces	1.21	0.02
kg	3.00	0.05
Brown, pieces	0.50	0.01
Green, pieces	0.50	0.01
kg	0.63	0.01
Broken/cutlets, kg	0.75	0.01
Others, kg	1.50	0.03
Metals, Ferrous		
Steel bars, kg	14.79	0.207
Tin cans, kg	11.94	0.22
GI roofing and sheets, kg	8.70	0.16
Others, assorted metals, kg	12.00	0.22
Others, surplus in 1 tonner,	15,000	272.73
Metals, Non-ferrous		
Aluminum, kg	47.76	0.87
Copper, kg	323.81	5.89
Brass and alloys, kg	170.94	3.11

Remark: *USD 1 = PHP 55

Comparing the average buying price of these recyclables to other cities in the Philippines, it can be noted that the unit price, especially of plastics, glass, and metals, has increased. However, the price of different types of paper is varied compared to previous studies [33 - 34]. This means even in cities with close proximity to Metro Manila where recycling industries are mostly available, the prices of these materials move up and down depending on factors such as market acquisition price and recyclers' processing costs [61].

When junkshop owners and operators were asked where they would send their recyclables next, they identified bigger junkshops and consolidators located in Iloilo City and the provinces of Iloilo, Antique, Manila, Laguna, Cavite, Cebu, and Cagayan (Table 3).

As indicated in the study, the level of domestic recycling in the area is lacking, just like in Cambodia, where the recycling industries and infrastructures and the market exchange for recycled materials and products are limited [62]. To encourage more productivity in terms of waste recovery from the junkshop sector [63], the Indonesian government suggested encouraging more private sectors to develop domestic or local recycling infrastructures, such as the recovery of plastic waste for refuse-derived fuels (RDFs) and construction materials such as roads and plastic timber. Similar actions could also be considered in this part of the Philippines.

5) Assessment of value chain stakeholders

Detailed in Figure 6 is the analysis of the recycling stream of the six recyclable materials to next level hierarchy of actors like bigger junkshops and consolidators in Iloilo, Metro Manila, and other areas. At the moment, Panay Island has no waste recycling facilities. When junkshops were interviewed about the recycling industries that they hope are present in the region, they answered according to importance, to be paper and pulp, plastics, iron and steel, and glass (Table 3).

The presence of these facilities outside the big cities of the Philippines, such as Metro Manila, would ease the movement and hauling of valuable recyclables. It will further influence global recycling rates while creating employment opportunities for the marginalized sector in urban areas and economically growing cities. It shall be noted, however, that in the trading system for recyclables in urban settlements, they need to be quantified in order to enlist their contributions in areas of employment generation, livelihood income, and the amount and classification of resource recycling. More research to collect primary information and data sets involving the waste recycling network in the city is necessary [64].

In order to improve the recovery and recycling participation of junkshops, the city governments need to encourage the presence of recycling sectors, which would be instrumental in raising awareness of the benefits derived from recycling. In countries like Tunisia, which has similar behavioral patterns towards waste management, policies can be made to motivate people and private entrepreneurs to create small- and medium enterprises in the recycling sector. With more recycling industries within geographical proximity, these could lead to helping reduce waste generation and increase participation in recycling activities [52]. In addition, the role of junkshops in the recovery of valuable recyclable materials agrees with the observation that they are considered one of the most important actors in the EPR implementation. Their contribution to recovery efforts is significant as long as they have economic motivations to do so [65]. As the smallest-unit group that performs collection and sorting of wastes for the actors in the next level hierarchy of the recycling chain, the presence of junkshops in cities provides marketplaces where individual waste pickers and the informal sector can sell their collected recyclables [37]. In developing new solid waste management systems, resource recovery and the presence of recycling markets should be top priority issues [66]. Forming cooperatives and associations involving both the formal and informal sectors can aid in the improvement of their position in the hierarchy of the waste recycling chain. They can also negotiate with the local authorities and/ or the private sector and this would aid in legitimizing their activities and increase their income by circumventing or avoiding middlemen [67–68].

Table 3 Recycling stream analysis of junkshops in Iloilo City, Philippines

Location of recyclable consolidators	Iloilo City
	Iloilo Province (Pavia, Sta. Barbara, Leganes, Estancia)
	Metro Manila (Novaliches, Valenzuela City)
	Other places (Antique, Laguna, Cebu, Cavite)
	Prices demanded by consolidators and competitors
Materials when not marketed	Stored/stocked in the yard
	Disposed to sanitary landfill using own vehicles
Preferred recycling industries ideal for Panay Island	Paper and pulp, plastic, iron and steel, glass

6) Machinery and equipment of junkshop operators

Table 4 presents the main machinery and equipment used by junkshops. The standard machinery and equipment utilized by junkshops in Iloilo City, Philippines, are jumbo or extra large (XL) cement bags and plastic sacks to store materials temporarily.

It is also very common to find one to three units of weighing scales with various weight specifications (10 to 150 kg capacity). Junkshops with bigger capacities utilize compactors, cutting machines, and plastic containers for space-saving and easier handling of materials when loaded into their hauling vehicles, such as 10-wheelers and motorcycles.

If they are to be given an opportunity to use technologies to enhance their operation, they mentioned the need for crushers or pressers for paper and plastics, grinders/shredders for plastics, 50-tonner weighing scales, and forklifts for lifting heavier materials like metals and bail papers.

The materials utilized by the junkshops surveyed in Iloilo City were similar to those utilized in other countries, such as India, Indonesia, and Vietnam, such as sacks, bags, and baskets [54].

Like in many developing countries, the conventional approach to waste recovery relies on manual sorting. However, when the sorting method is enhanced through locally fabricated machinery and the rapid advancements of computer vision techniques, the burden on manual labor is reduced. This encourages modernized operation and effective recycling procedures, eventually promoting a greener and more sustainable future [20, 69].

7) Other Aspects

As presented in Table 5, small junkshops can only perform sorting and cleaning. The bigger junkshops (with wider occupied business areas) can process their recyclables through sorting, cleaning, crushing, cutting, grinding, washing, drying, and bagging, and relying heavily on manual labor and operations. These junkshops acted as facilities for collecting and sorting waste materials for further recycling processing and provided marketplaces where different stakeholders could sell their collected recyclables [37].

They practice SWM by segregating their recovered materials accordingly. However, they cannot avoid common operation problems such as stockpiling of materials outside the vicinity, including concerns about flooding.

In terms of community presence, most of the junkshops have no existing partnerships with the community, but others serve as partner junkshops of some barangays and haulers of hospitals and function as local MRFs of the barangay. For Iloilo City junkshops, prices of recyclables are not listed outside the facility.

Their plans aim to increase capital outlay, secure areas for operation, and improve physical structures. They must also increase their technical capability and business contacts with suppliers and MRFs. This information is necessary, especially when interventions are to be made by agencies and sectors concerned in the overall improvement of junkshop operations as a critical part of the SWM systems.

From the standpoint of junkshops as recycling chain actors, waste product lifespan is extended through enhanced design and relocating ways from the end of the supply chain to the beginning. This aims to utilize efficiently the resources through continual use and intends to retain the highest value of products, components, and materials at all times through sharing, leasing, reuse, refurbishment, repair, and recycling in an almost closed loop. A circular economy can significantly be important in sustainable junkshop business management (RA 11898). The activity of the informal sector, by selling their recyclables to small-scale junkshops, directly contributes to the recovery of waste resources and lessening of environmental contamination. To encourage consumers to bring their recyclables, a franchise chain collecting recyclable waste advertises the prices directly on shopfronts as well as posting them to websites [70].

By closing material loops, valuable wastes are prevented from going to final disposal facilities by being transformed into new secondary resources. Integrating the junkshop's significant role in the formal SWM system can be a crucial strategy for improving social, environmental, and economic feasibility [71–72].

Table 4 Machinery and equipment for materials recovery and disposal of junkshops in Iloilo City, Philippines

Bags	Jumbo (XL) bags for storage, sacks
Weighing scales	One to 3 units for weighing
	10 kg, 20 kg, 30 kg, 60 kg, 100 kg, 120 kg, 150 kg
Others	Compactor; cutting machines, plastic containers
Vehicles	One truck for hauling; 10-wheelers
	One motorcycle
Technologies identified for enhancement of operation	Crusher or presser (for paper, plastics)
	Grinder/shredder (for plastics)
	50-tonner weighing scales
	Forklift

Table 5 Other processes, practices, and community presence of junkshops in Iloilo City, Philippines

Processes performed	For small junkshops: sorting, cleaning
	For big junkshops: sorting, cleaning, crushing, cutting, grinding, washing, drying, bagging
Practices SWM	Yes (segregation per recyclable material), experiences common operation concerns
Value chain linkages	Others interested in building business partnerships/linkages
	Others are hesitant due to competition and loyalty to existing partners
Community presence	Mostly, there are no existing partnerships with the community; others serve as partner junkshops, haulers of hospitals, local MRF
	Does not advertise junkshop; others advertise through calendars, t-shirts, Facebook
	No price list is displayed outside
Plans	Increase capital outlay; secure area; improvement of physical structures; more trucks
	Increase technical capability
	Increase contact with suppliers and MRFs

Conclusions and recommendations

Iloilo City, as a growing, highly urbanized metropolitan, generates an increasing amount of waste. With proper solid waste management systems, materials of different types can be recovered significantly during the collection and processing operations of critical actors, such as the presence of junkshops in the different districts of the city. The results of this study were able to present in detail the profile of the different junkshops from their business background, process flow of operation, quantity and quality of recyclables recovered, average buying price of valuable materials, environmental management practices, value chain linkages and the machinery and equipment utilized. Their significant role in the recovery and initial processing of valuable recyclables that may end up in bodies of water or back in landfills when generators and other players would not have access to such facilities have been assessed and were found to be important when integrated into existing solid waste management (SWM) systems. From the local standpoint, a very clear picture was presented of the volume of recyclables that junkshops can recover from the city's waste generation. It provided potential solutions on how this sector can be improved, especially in terms of providing a properly developed monitoring system for recyclables recovered and how participative approaches can be integrated in order to increase awareness amongst different stakeholders. Nationally, the recognition of their role and function can complement the Philippines' existing solid waste management law, including the newly implemented national framework on extended producer responsibility (EPR) in which junkshops and related SWM facilities can become a part of product waste recovery programs.

Globally, for countries having similar conditions as that of the Philippines, recognition of their role and function can supplement existing SWM laws, including the national frameworks on EPR in which junkshops and related SWM facilities can become a part of product waste recovery programs. The results of this study reiterated the significance of this business entity in reducing poverty through the income earned while helping cities attain sustainability and livability through a properly in-placed waste management operation.

Whether the business classification is small, medium, or big, their inclusion in the EPR scheme is vital in the recovery efforts as long as there is economic motivation for them to do so. The income they have generated from the amount of waste recovered and longer years in the business are clear indicators of economic motivation.

It is recommended that junkshop operations and existence are regularly monitored through localized policies and encourage the establishment of recycling industries within the island to increase their impact on waste management as they are essential for sustainable development and conservation of valuable resources. To determine further the next level chain of actors in the recycling network, it is recommended to analyze the material and economic flows of each recyclable waste recovered by junkshops classified according to hierarchy.

Conflict of interest

The authors declare no conflict of interest.

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