Technical Guidelines for

PLASTICS AND RESIN PELLETS LEAKAGE PREVENTION FROM PLASTIC RECYCLING FACILITIES

MANILA CITY AND ILOILO CITY, PHILIPPINES

RRC.AP
Regional Resource Centre for Asia and the Pacific

Regional Knowledge Centre for Marine Plastic Debris

ERIA
Economic Research Institute for ASEAN and East Asia

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Section 1

Introduction

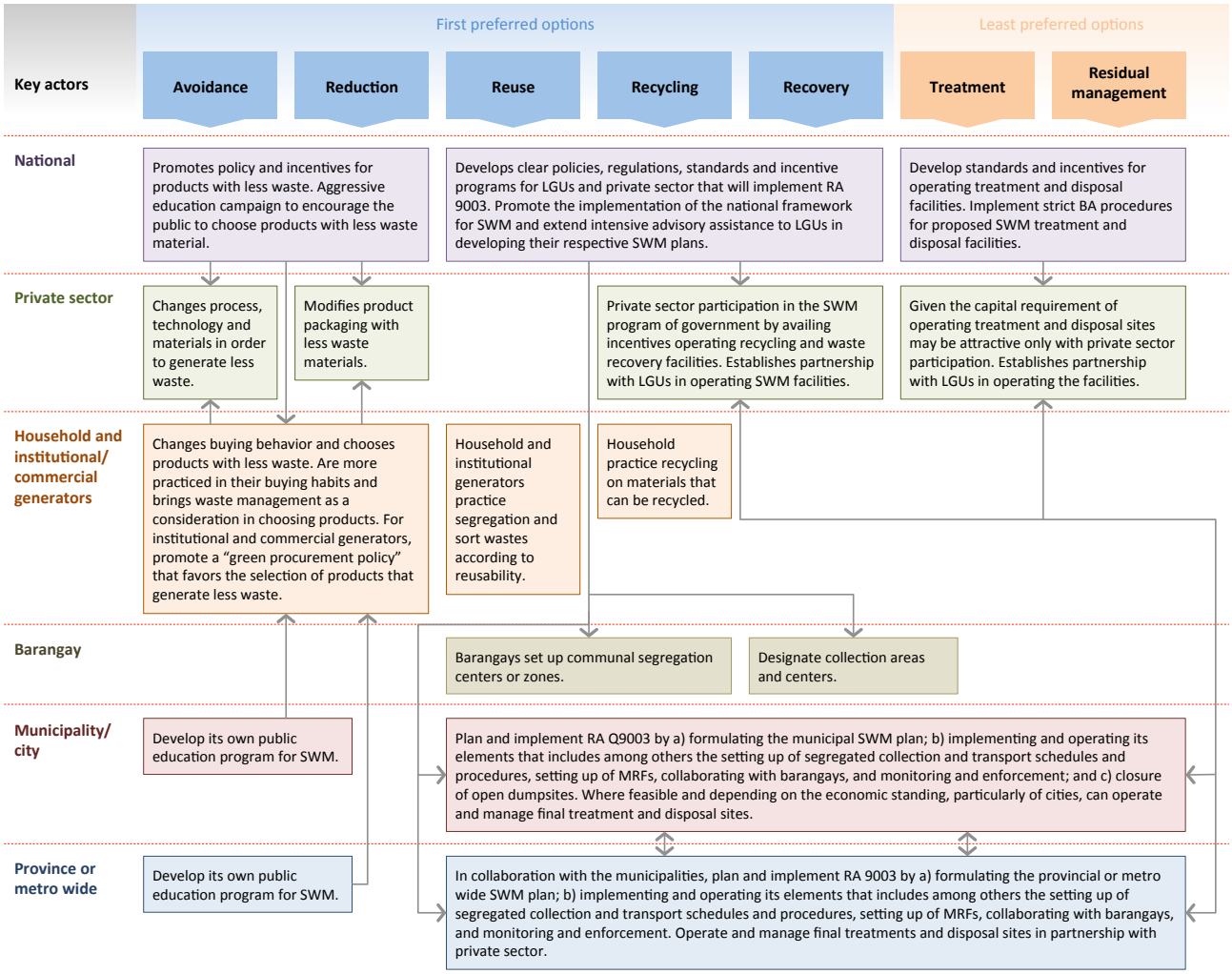
Marine litter has a direct negative impact on coastal and marine ecosystems, as well as economic prosperity and human well-being. Among the array of marine litter, abandoned, lost, or discarded fishing gear (ALDFG) stands out as a particularly menacing threat, posing grave dangers to marine life through entanglement. This entrapment often leads to severe consequences such as restricted movement, starvation, suffocation, lacerations, infections, and, ultimately, mortality. As a result, the economic gains derived from maritime and coastal endeavors like shipping, fishing, aquaculture, and tourism may dwindle, while the expenses associated with cleanup efforts, vessel and equipment repairs, debris removal, and workforce downtime may escalate for communities. According to the National Solid Waste Status Report 2008–2018 (DENR-EMB, 2018), the Philippines is anticipated to produce approximately 1.75 million metric tons (MMT) of plastic waste by 2020. Although the National Plan of Action on Marine Litter (NPOA-ML) highlights the absence of a definitive and comprehensive baseline study on the extent and impact of waste leakage into marine environments, various initiatives have attempted to gauge the country's contribution to the global marine litter crisis.

According to a study conducted on five focus countries, including the Philippines, less than 20% of leakage originates from ocean-based sources such as fisheries and fishing vessels, while more than 80% of ocean plastic originates from land-based sources. Around 75% of the leakage from land-based sources comes from uncollected waste, with the remaining 25% coming from within the waste management system itself. Improper dumping, as well as formal and informal dumpsites that are poorly located or lack proper controls, can all contribute to post-collection leakage (Ocean Conservancy and McKinsey, 2017).

1.1 Relevant International and National Policies, Plans, Programs, and Initiatives

Global and regional agreements and declarations encourage the active involvement of countries, cities, and various sectors in combating marine litter, particularly plastic waste, originating from both terrestrial and maritime sources, as well as that already polluting marine ecosystems. These initiatives encompass a range of frameworks including the Sustainable Development Goals (SDGs) for 2030, the International Convention for the Prevention of Pollution from Ships (MARPOL), the New Plastics Economy Global Commitment, the East Asia Summit Leaders' Statement on Combating Marine Plastic Debris and the Osaka Blue Ocean Vision, the Bangkok Declaration on Combating Marine Debris in the Association of Southeast Asian Nations (ASEAN) Region, the ASEAN Framework of Action on Marine Debris, and the United Nations Environmental Assembly's (UNEA) Ministerial Declaration on securing a global commitment to reduce single-use plastics. In the Philippines, the Republic Act (RA) 9003, also known as the "Ecological Solid Waste Management Act of 2000" (depicted in Figure 1), was promulgated to address the escalating issue of solid waste in the country. This legislation provides a legal framework for the systematic, comprehensive, and ecological management of solid waste. It mandates a minimum waste diversion rate of 25%, which is to be incrementally increased and requires the safe closure and rehabilitation of all dumpsites. Additionally, in accordance with RA 7160, or the Local Government Code of 1990, Local Government Units (LGUs) are obliged to furnish basic services and facilities, including solid waste disposal systems and environmental management systems, as well as services related to general hygiene and sanitation. Section 10 of RA 9003 underscores the primary responsibility of LGUs in implementing and enforcing the law within their respective jurisdictions.

Figure 1. The Philippines ESWM Framework.



Commonly referred to as the Clean Water Act of 2004, RA 9275 shares a similar provision with RA 9003. Section 27 of RA 9275 prohibits the unauthorized transportation or dumping of sewage sludge or solid waste into seawater, mirroring Section 48 of RA 9003, which prohibits littering, throwing, or dumping waste materials in public spaces such as roads, sidewalks, canals, esteros, parks, and establishments, or allowing such actions to occur. Additionally, the National Framework Plan for the Informal Sector in Solid Waste Management, published in 2009, acknowledges the informal waste sector as a partner of public and private entities in promoting and implementing the principles of ecological solid waste management (SWM) in the Philippines. This collaboration aims to alleviate poverty by engaging informal waste workers in sustainable waste management practices. Moreover, Executive Order (EO) 533, issued in June 2006, established the national strategy of Integrated Coastal Management (ICM) to ensure the sustainable development of the country's coastal and marine environment and resources. This order also outlines support mechanisms for ICM implementation, recognizing it as an effective approach to fostering economic growth, protecting ecosystems, and promoting social equity along coastal and marine areas.

In addition, the release of the Philippine Biodiversity Strategy and Action Plan (PBSAP) 2015–2028 identified direct and enabling interventions to reduce the five major pressures on biodiversity loss, which include habitat loss and degradation, as well as pollution. Following the success of the inter-governmental efforts to rehabilitate Boracay Island, the Department of Environment and Natural Resources (DENR) launched the "Manila Bay Coastal Strategy 2017–2022" in January 2019, which includes the following activities: clean up

for improved water quality, rehabilitation and resettlement, and education and sustainability. This strategy is in accordance with the Supreme Court's Continuing Mandamus, which directs relevant government agencies to spearhead the cleanup of Manila Bay. Similarly, the National Economic Development Authority (NEDA) has led the development of the Philippine Action Plan for Sustainable Consumption and Production (PAP4SCP), serving as a guide to influence and steer sustainable behavior and practices across sectors and levels of government, contributing to the Philippine Development Plan 2017–2022 targets.

1.2 The Philippines National Plan of Action on Marine Litter (NPOA-ML)

The DENR spearheaded the development of the Philippines' National Plan of Action on Marine Litter (NPOA-ML), designed to serve as a comprehensive framework for enhancing the nation's current endeavors in resource and waste management. The NPOA-ML aims to shed additional light on marine litter issues and control further leakage of waste into aquatic environments. Subsequently, the National Solid Waste Management Commission (NSWMC) adopted the NPOA-ML on May 12, 2021, through NSWMC Resolution No. 1441, officially endorsed by DENR Secretary Roy A. Cimatu on July 1, 2021, via DENR Memorandum Circular No. 2021-10. Guided by the vision of achieving "A Philippines free of marine litter through shared responsibility, accountability, and participatory governance," and with the overarching goal of achieving "Zero waste to Philippine waters by 2040," the NPOA-ML outlines measures for the prevention, reduction, and management of marine litter. These measures are organized into programmatic clusters, consisting of six strategies, and enabling or cross-cutting clusters, comprising four strategies. Each strategy delineates its primary activities, along with suggested sub-activities, serving as a future guide for the leading and cooperating agencies entrusted with their implementation.

A. Programmatic Cluster of Actions

Strategy 1: Establish science- and evidence-based baseline information on marine litter

Strategy 2: Mainstream circular economy and sustainable consumption and production initiatives

Strategy 3: Enhance recovery and recycling coverage and markets

Strategy 4: Prevent leakage from collected or disposed of waste

Strategy 5: Reduce maritime sources of marine litter

Strategy 6: Manage litter already existing in the riverine and marine environments.

B. Enabling/Cross-Cutting Cluster of Actions

Strategy 7: Enhance policy support and enforcement for marine litter prevention and management

Strategy 8: Develop and implement strategic and targeted social marketing and communications campaigns using various media

Strategy 9: Enable sufficient and cost-effective financing and other institutional resource requirements for the implementation of the NPOA-ML

Strategy 10: Strengthen local government unit capacities and local-level implementation of NPOA-ML

The strategies and activities outlined in the NPOA-ML were meticulously proposed and evaluated in accordance with precise guiding principles. Marine litter stakeholders played a pivotal role in identifying key merits to prioritize strategies and actions. These include ensuring that strategies and actions are feasible, relevant, and suitable; grounded in scientific knowledge; implemented progressively or in phases; supported by operational resources; and consistently funded to guarantee the successful implementation of the NPOA-ML. Additionally, other crucial considerations encompass principles of integration, prevention, precaution, sustainable consumption and production (SCP), polluter pays, public participation, stakeholder engagement, as well as ecosystem- and science-based approaches. These guiding principles collectively reinforce the comprehensive and sustainable

approach taken toward addressing marine litter issues in the Philippines.

Strategy 10 emphasizes the importance of local governments in implementing the NPOA-ML. It specifies the requirement for an NPOA-ML localization guide or framework to aid local-level implementation. UN-Habitat and its partners are taking the lead in demonstrating how this can be accomplished through the Japan-funded HOCCI Project.

Manila City and Iloilo City, Philippines

Section 2

Localizing the National Plan of Action on Marine Litter NPOA-ML

Additional marine litter must be avoided or reduced through appropriate local measures to reduce the leakage of MSW from land-based sources into waterways and bodies. This can be addressed by incorporating the circular economy (CE) and 3R approaches into the overall SWM program, as well as campaigns and training to increase awareness and positive behavioral change in individuals, communities, and businesses.

2.1 Establishment and Operation of a Materials Recovery Facility

The establishment and operation of a materials recovery facility (MRF) specified in RA9003 accord with the strategy and guidelines outlined in the city ISWM plan. Similarly, the minimum requirements for establishment and operation in RA 9003 and its IRR must be met. MRFs will be established in all barangays and schools in addition to the city/municipal MRF. The establishment and operation of MRFs in barangays and schools should be in accordance with the city/municipal ISWM plan's strategy and guidelines.

Diagrams of a manual MRF and a fully mechanized facility are shown in Figure 2. Manually operated MRFs with capacities of less than 2 tons per day (tpd) usually have roofed floor areas of at least 50 square meters (m^2), containing only the receiving, processing, and storage areas. Semi-automated to fully mechanized facilities would require areas ranging from 150 m^2 to 1,500 m^2, excluding parking and buffer zones. The Material Recovery Facility Handbook of the Recycling Marketing Cooperative of Tennessee (2003) suggests a building area not exceeding 1,400 m^2 for MRFs processing less than 10 tons of recyclable waste per day and about 1,800 m2 of floor area for facilities handling waste not exceeding 100 tpd.

The basic equipment, even for a manual operation, includes sorting tables, weighing scales, a baler, and a payloader. Semi-automated MRFs make use of a conveyor system that could be aided by a loader

Figure 2. Diagram of an automated material recovery facility (ADB, 2013)

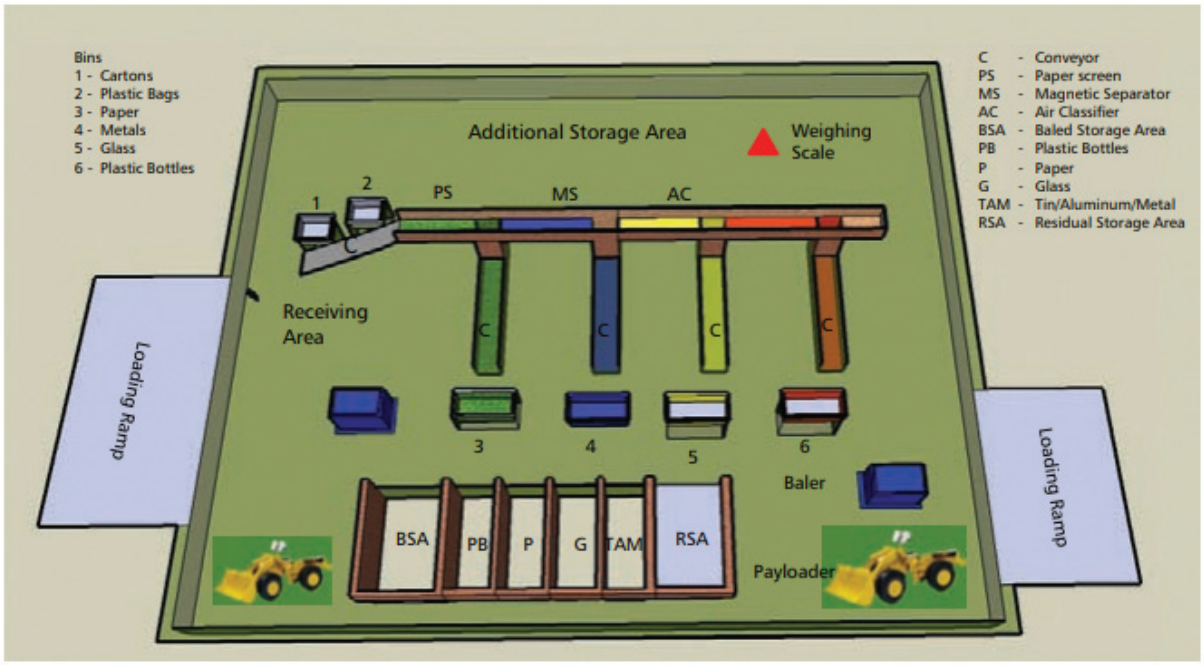
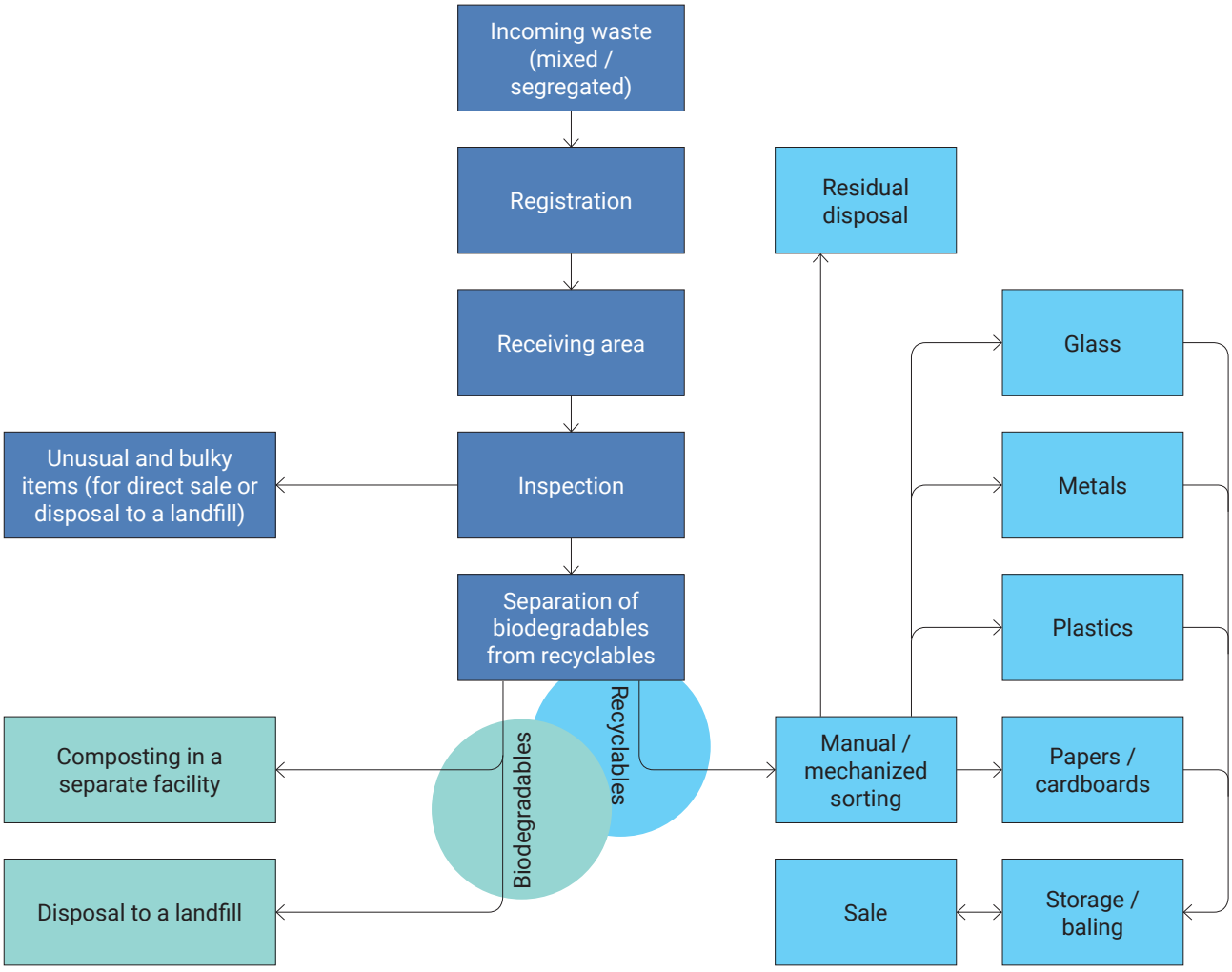


Figure 3. MRF Flow Chart. Source: ADB, 2013



MRF = materials recovery facility
Source: Modified from KfW-CLSWM Project. 2008. *Technical Evaluation Manual, Philippines.*

to facilitate sorting. Automated facilities utilize a combination of screens, magnetic separators, air classifiers, and conveyor systems with options for more than one processing line. The choice of equipment will depend on the target capacity and the nature and composition of incoming waste.

All consolidators, junkshop owners, and junk buyers operating in the city/municipality shall secure the necessary permit/accreditation from the CENRO/MENRO prior to operation. LGU regulates the activities of junkshops and junk buyers. LGUs can come up with policies on junkshops as may be applicable to the situation or conditions in the LGU/city. These policies can be included in the SWM ordinance since they are relevant to materials recovery and processing, which is a material component of the SWM plan.

2.2 Waste Diversion Initiatives in the City of Manila

Collaborations for waste diversion initiatives with plastic manufacturers and national government agencies were also established by the City of Manila. Among the projects initiated (initiatives for the Incentivized Collection Program to Recover Plastic Wastes) are the following:

1. *Kolek Kilo Kita Para Sa Walastik Na Maynila*

Through an innovative initiative facilitated by Unilever Philippines and with the support of accredited junkshops in the City of Manila, a rewarding program has been established to encourage the collection of flexible plastic waste, thereby empowering

Weight of Plastics Collected (mt) in 2020	Weight of Plastics Collected (mt) in 2021	Weight of Plastics Collected (mt) in 2022
24.24 mt	28.69 mt	16 mt
GRAND TOTAL = 68.93 metric tons		

communities to actively participate in keeping plastic pollution at bay. Under this incentivized scheme, individuals can exchange every kilogram of soft plastics for PHP 3 pesos. Since its inception in October 2019, this program has successfully diverted a substantial volume of flexible plastics from entering the environment, with a total of 700 metric tons or 700,000 kilograms collected to date.

2. *Alaskalikasan Wrapper Redemption Project*

The Alaska Milk Corporation has initiated a program with the dual purpose of diminishing the volume of residual plastics entering waterways and landfills while concurrently addressing nutritional needs at the grassroots level. Under this program, partners from various barangays in the city are encouraged to participate by exchanging 3 kilograms of flexible plastics for 165 grams of Alaska-fortified milk. A total of 98 barangays have actively engaged in the Alaskalikasan Wrapper Redemption Project, contributing to both environmental conservation efforts and the promotion of community nutrition.

3. *Aling Tindera: A Waste to Cash Program*

4. "Aling Tindera" is a pioneering initiative by PCX designed to provide a platform for individuals to monetize plastic waste while promoting the responsible treatment of post-consumer plastics. This program is driven by the aim to curtail environmental leakage and foster awareness among future generations regarding the merits of advanced waste management processes such as co-processing and recycling. Collaborating with women micro-entrepreneurs who own sari-sari stores, the program establishes community collection points where individuals

can conveniently sell their plastics in exchange for cash, thereby incentivizing proper disposal practices. Currently, 15 container vans have been installed across the City of Manila to facilitate this endeavor. Remarkably, the program has already amassed a substantial total of 264,632.92 kilograms of plastics, marking significant progress toward its objectives.

5. *Tapon to Ipon Project (PET Bottle Collection)*

The city's barangay units have introduced another noteworthy initiative known as the Tapon to Ipon Project, focusing on the collection of PET bottles. Between June 2021 and March 2022, a commendable total of 309 kilograms of PET bottles were collected from Kartilya ng Katipunan. Additionally, community-based efforts yielded an impressive collection of 421 kilograms of PET bottles during the same period. In total, the Tapon to Ipon Project successfully gathered 730 kilograms of PET bottles, exemplifying the commitment to sustainable waste management practices at the grassroots level.

2.3 Solid Waste Management Plan (SWMP) Second Phase (2021–2025)

- Enhancement of the waste diversion strategy by the CSWMB and DPS;
- Processing of tax incentives by the CSWMB and Manila Bureau of Permits;
- Development by the City Engineering Office, Manila Health Department (MHD), and DPS of an alternative technology for special waste processing and disposal;
- Intensification by the City Social Welfare and Development Office, MHD, Division of City Schools, and the DPS of programs for the informal sector partners in SWM; and Drafting and enactment by the City Council of Manila of local laws that will provide specific health and social assistance to bona fide Manila residents in the informal sector, particularly in SWM.

Milestones achieved for almost seven (7) years of SWMP implementation include, but are not limited to, the following:

- Strict no segregation, no collection policy;
- Establishment of 11 MRFs and 686 MRS in all barangays;
- Since 2018, 2,654 IEC campaigns have been conducted in all barangays, schools, and business establishments;
- Waste Diversion Initiatives (***Alaskalikasan Wrapper Redemption project, Kolek Kilo Kita, Walastik na Junkshop para sa Walastik na Maynila, Tapon to Ipon, Trash to Cashback, Aling Tindera and Tarpaulin Mo, Ireresiklo Ko project***);
- Enactment of SWM-related City Ordinances, e.g., City Ordinance No. 8282 and City Ordinance No. 8371;
- Conduct of Waste Analysis and Characterization Study (WACS) from October to November 2021 to update the 10-Year SWMP;
- Conduct of daily Manila Bay coastal cleanups at the Baseco Beach Port Area by 20 DPS Baseco

Beach Warriors and at the Baywalk, Roxas Boulevard by 20 DPS Team Mandaragat;

- Conduct of daily estero cleanup operations in 32 esteros by DPS Estero Rangers;
- Daily garbage collection with 100% collection coverage;
- Conduct of daily flushing and sweeping as well as mopping and clearing operations by the DPS;
- Annual participation in the International Coastal Cleanup Day during the third week of September;
- Revitalization of 59 parks and plazas with a total land area of 147,330.10 m2;
- Establishment of vertical gardening and roof gardens;
- Conduct of ESWM and MPL reduction IEC campaigns in 896 barangays, 71 primary schools, 32 high schools, 6 city hospitals and medical facilities, and 70,015 listed commercial establishments for the calendar year 2015;
- Establishment of City-operated MRF; and
- Separate collection and disposal of electronic and special waste.

Manila City and Ilollo City, Philippines

Section 3

Iloilo City

This section delves into the pertinent stakeholders involved in Iloilo City's solid waste management (SWM) and recycling activities, encompassing a diverse array of actors, notably processors and consolidators.

3.1 Processors

Material Recovery Facility (MRF)

The MRFs in Iloilo City are depicted below, with some facilities equipped with mobile MRF capabilities to reach even the most inaccessible barangays using garbage trucks. Additionally, certain MRFs are outfitted with mini-garbage trucks dedicated to collecting waste from their respective barangays.

Junkshops

In Iloilo City, various junkshops exhibit a range of housekeeping standards, with some maintaining commendable practices while others require improvement. Additionally, a concern arises since some junkshops are situated in close proximity to water bodies, posing a potential risk of plastic waste leakage into the riverine environment.

Material Recovery Facility (MRF)

Junkshops

3.2 Consolidators

In certain plastic recycling/consolidation facilities in Iloilo City, the plastic recycling process entails several stages that carry a heightened risk of microplastic leakage, thereby contributing to environmental pollution. These stages encompass material reception, involving activities such as unloading, weighing, and transfer processes, as well as collections, which entail sorting/screening and aggregation. Subsequent stages include baling, grinding, washing, flake drying, packaging, loading, storage, transport, and disposal. Each of these phases presents potential points of microplastic leakage, necessitating careful management to mitigate environmental impacts.

- Considerations for consolidators include the availability of ample storage space for recyclable plastics, alongside proper insulation and ventilation to prevent the leakage of harmful substances into the environment. The facility's structure should aim to minimize dust and noise levels while also accommodating upgraded equipment and technology to ensure regulatory compliance.

Figure 4. Potential of Leakage/Losses Points of Plastic in Plastic Recycling facility (Consolidator)

Plastic material reception

Sorting

Sorting / screening

Washing / cleaning

gridning / shredding / flacjing

Sorting / storage area

Baling area

Loading / packaging / loading storage

- Recycling facility design, including machinery, equipment, and operational processes, should prioritize the maximization of usable space for recycling operations and storage areas, as well as mechanism implementation to contain plastic pollution and material loss. Minimizing or preventing material losses is crucial for the economic viability of recycling facilities.

- Many of the recycling machinery configurations in consolidator facilities are outdated and may require costly maintenance to avoid operational disruptions potentially contributing to material losses.

- Factory workers, predominantly female, spend hours sorting plastic packages or films by color and polymer. This sorting process involves separating plastics into distinct streams, often using large baskets or the floor due to granularity requirements. Proper sorting is essential for removing particle and chemical contaminants. Conveyor belt systems can increase efficiency, reduce labor-intensive tasks, and improve worker well-being.

- Shredding and grinding processes can generate microplastics if not properly contained, posing environmental risks. Similarly, washing processes can release microplastics when plastics rub against each other and equipment, potentially contaminating wastewater treatment systems.

- In summary, transit and storage can also contribute to microplastic pollution through friction between plastic materials and machinery, as well as exposure to weather conditions. Effective management strategies are needed to address these potential leakage points and mitigate microplastic pollution in the environment while considering the market dynamics and economic factors influencing plastic processing technologies.

Converting discarded plastics and waste into construction materials.

Iloilo City showcases the ECO Brick project proposed by St. Therese MTC Colleges to build housing units using ECO Bricks.

Upcycling initiatives/programs

Good practices

Converting discarded plastics and wastes into construction materials.

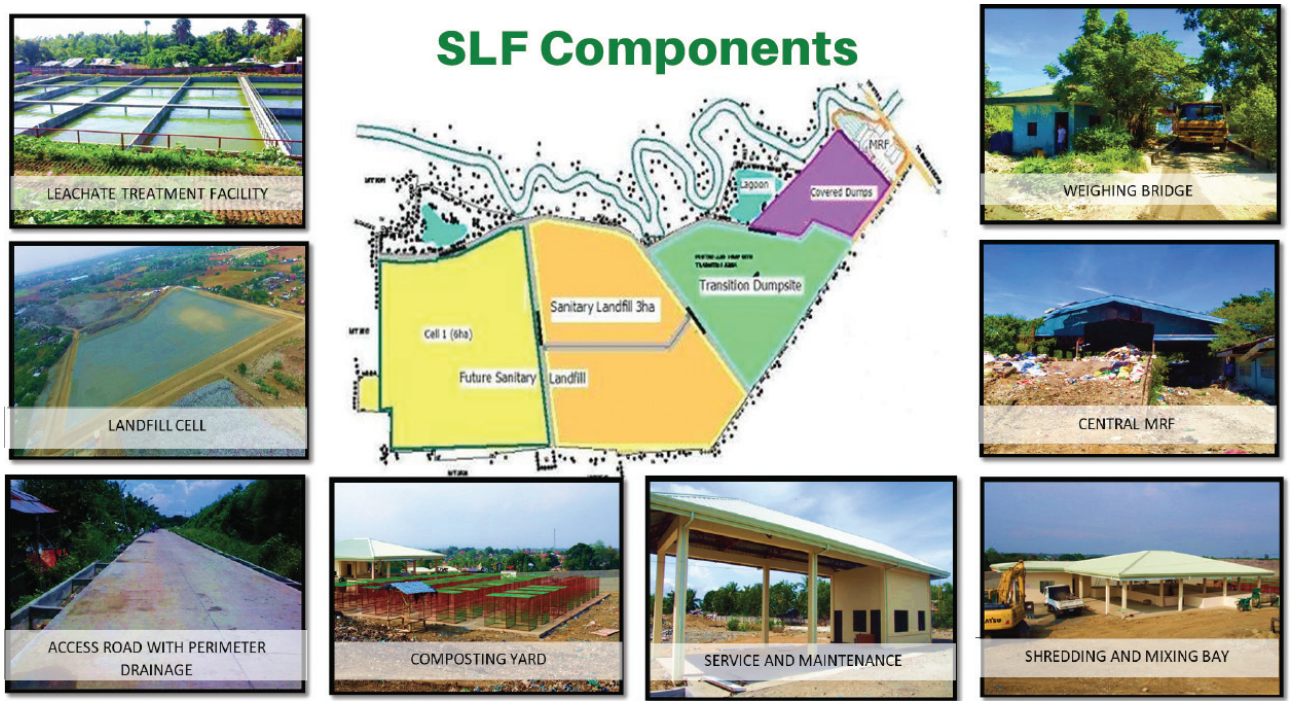
Iloilo City showcase an ECO Brick, a project of St. Therese MTC Colleges to build housing units using ECO Bricks.

Iloilo City Sanitary Landfill

The 23-hectare engineered facility located in Brgy. Calahunan, Mandurriao, serves as a secure site for the disposal of residual waste from the city and two town municipalities within Iloilo Province. Presently, the landfill is at 70% capacity. It features a solid cover system designed for odor and emission control, disease vector prevention, as well as moisture and percolation management. In the first quarter of 2023, the facility processed 16,119 tons of waste.

Technical Guidelines for the city's informal waste sector and plastic industries to prevent plastic leakage and plastic losses.

Source: Iloilo City CENRO, 2023



Section 4

Prevention of Plastic Leakage From Recycling Activities

4.1 Material Reception, Grinding, Bagging, and Storage

Pre-sorting offsite: Post-consumer plastic recyclable materials, gathered by waste pickers, scavengers, or from MRFs, often undergo pre-sorting before being sold to brokers or junkshops. Pre-sorting typically occurs offsite to enhance and classify collected recyclables based on polymers and contamination levels. Generally, pre-sorted recyclable materials command higher prices from buyers. However, the decision to pre-sort recyclable plastics before sale largely depends on market conditions or the preference of collectors. One challenge with offsite pre-sorting is the handling of low-value, contaminated plastics. The proper management and disposal of these materials are crucial for preventing illegal dumping in waterways.

4.1.1 Collections (Sorting, Aggregation)

In the city, junkshops, recycling centers, and consolidators primarily sort received recyclable plastics for profit rather than environmental considerations. Unlike advanced countries that employ sophisticated sorting technologies, these entities rely on manual and occasionally semi-mechanized methods, often in combination. Smaller junkshops with limited capacity and investment typically utilize basic and secondhand equipment for dismantling and initial sorting.

Semi-mechanized sorting, where visually identifiable recyclable plastics are handpicked from conveyor belts, is employed alongside manual sorting, which predominantly involves women sorting through heaps of recyclable plastics within the facility. Despite being reported as effective, manual sorting is challenging, time-consuming, and often inadequate due to limited space and capacity constraints.

Space limitations and speculative inventory decisions may influence the quantity and categorization of the plastics sorted. However, sorting plastics based on quality, polymer type, and color adds value and meets the specifications of recycling plants and off-takers, both locally and beyond the city.

By aligning sorted plastics with demand from off-takers, recycling centers, and junkshops, the sales value and potential marginal profit from trading recyclable plastics can be increased.

During the primary processing of recyclable plastics, residual waste is commonly generated at various stages. The extent of sorting and the type of streams produced depend on the recycling facility's business model, client requirements, demand for specific plastics, and processing capabilities.

Recyclable plastic packaging, obtained from waste pickers or purchased directly, often contains impurities, multiple material layers, and different polymer types. These materials require sorting and processing to yield pure mono-stream recyclable plastics. Rejected fractions may include certain types of plastic films, colored packaging, or other contaminants, which must be separated and disposed of appropriately.

Recycling centers receive plastic packaging of various qualities and designs, some of which may contain low-value polymers and organic impurities. These contaminants, along with oil and color-stained plastic packages, are typically removed or cleaned during the recycling process. However, improper handling of rejected plastic polymers, impurities, and contaminants can contribute to environmental pollution.

While sorting itself may be considered a low-risk source of plastic loss, inadequate handling during dismantling and improper disposal of low-value or contaminated plastic fractions pose significant risks. It is essential to take basic measures to ensure that residual or low-value plastics, as well as non-recyclable fractions, are not lost to the environment. Proper handling and environmentally

Measures for preventing plastic losses

- Plain working areas, without obstructions, must be designated for dismantling activities, weighing, and pre-sorting of plastics into polymer types, color, etc.
- Where practical, such designated areas must be paved, or tarpaulins covered areas to avoid plastic loss into soil. In situations where designated areas for dismantling sorting cannot be afforded, care must be taken to contain and collect plastic scraps from the solid regularly.
- Designated areas for plastic material reception, weighing, and pre-sorting must be far away from drains, canals, rivers and water courses or areas prone to flooding.

safe disposal of rejected polymer streams and impurities are crucial steps in mitigating environmental impact.

4.1.2 Compaction, Bailing, and Transport

Plastic losses from compaction, bailing, and transport

Compacting and baling recyclable plastics offer an efficient solution to minimize storage space usage and reduce transportation expenses. Land acquisition represents a significant initial investment for recycling facilities, while transportation costs for recyclable plastics constitute a substantial portion of their operational budget. Medium and large junkshops, as well as MRFs, handle significant quantities of recyclable plastics, making the adoption of compaction and baling techniques a justified strategy to streamline operations and manage costs effectively.

Why compact & bale?

- Optimizes space utilization for storage associated cost.
- Increases ease of transportation.
- Lowers transportation costs.
- Management of material requires less time.
- Reduces the amount of space needed for recycling containers and improves the working environment.

In the Philippines, large plastic aggregators commonly employ vertical hydraulic balers to create consolidated, freestanding cubes from individual plastic materials fed into the baling machine. However, most of the compaction and baling equipment currently in use is relatively simple and lacks the necessary advanced features for optimal functionality.

During the compaction process, hydraulic pressure compresses the materials against a plate within an enclosed compaction chamber. Whether stored externally or internally, sufficient storage space is necessary for the resulting bales. The recycling plants receiving these bales often need to conduct additional sorting based on various polymer streams and plastic colors before proceeding with the recycling process.

While compaction and baling operations themselves pose a low risk of plastic loss to the environment, failure to adhere to proper housekeeping practices can elevate this risk. The operational mechanisms of compaction and baling machines involve volume reduction through crushing and compression, which may result in plastic scraps escaping from the compression chamber.

Uncontrolled compaction and bailing processes can lead to plastic scraps being dispersed into drains, soils, and nearby vegetation, especially in unpaved working areas. Thus, maintaining proper housekeeping practices is essential for mitigating the potential environmental impacts associated with these operations.

Preventing losses from onsite secondary dismantling and sorting

- When utilizing pallets, suppliers should be aware that the weights of these pallets will be subtracted from the loads. Additionally, the reprocessing may entail extra handling requirements, potentially limiting the material's value in certain markets.
- It is crucial to conduct sorting in a designated unit and choose a location where contamination from dirt, oil, and dust is minimized.
- If the storage area has an inadequate surface, stacking bales on pallets can help prevent excessive contamination.

4.1.3 Plastics Release, Losses, and Leakage From Shredding, Washing, and Drying

In the Philippines, only a limited number of aggregators supply shredded plastic to mechanical recycling factories as recyclates, focusing on mono-stream polymers and secondary raw materials. These recyclates, marketed as high-value secondary raw materials, undergo further processing to produce plastic pellet resins.

Crushed rigid plastic packaging materials, including polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), and polystyrene (PS), are reduced in size primarily through crushers or shredders and occasionally sorted by color. Pre-processing methods vary depending on factors such as the processor's access to capital investment, market accessibility, demand specifications, and downstream market preferences.

Despite these considerations, most small-scale dealers and junkshops opt to sell to local recycling plants within the city. This is because the recycling process demands substantial capital investment, necessitating additional processing units for tasks like washing, decontamination, and high-quality sorting into color and mono-stream polymer grades, alongside the use of shredding machines.

Various crushing technologies are available, with each application chosen based on the needs and preferences of the recycler. Among the recycling facilities sampled in the city, small-scale grinders and manually fed crushers with open rotor designs are commonly used.

Plastic fragment losses occur during the crushing process within the immediate working environment, notably during the loading, crushing, and discharging phases. The release of plastic fragments and powders into the environment is most evident during agitation, particularly with open grinders. Older grinders, shredders, and open rotor designs typically exhibit higher levels of fragment release. This issue is particularly pronounced in enclosed recycling facilities lacking dust capture and filtering mechanisms, especially those with axial aspirators or ventilator fans on the roof.

Investing in advanced dust capture and filtering devices is often viewed as a secondary priority and an additional cost burden for recycling facilities. Airborne plastics released during the shredding process settle on surrounding equipment and surfaces within the recycling facilities. The primary concern is the inhalation of these fine plastic materials by workers, which can be especially severe in small enclosures with inadequate ventilation systems.

4.1.4 Bagging and Storage of Grounded Plastics

Shredded or ground plastics are typically bagged in PP woven sacks and temporarily stored before transportation for further recycling. However, in instances of poor handling, plastic fragments may unintentionally escape into the environment during bagging and storage. Measures should be in place to prevent or minimize these losses, although they may be unavoidable at times. Cleanup procedures should be implemented for the prompt removal and

Preventing the release of plastics from the shredding and grinding process

Plastics pose an environmental risk during shredding in open-end grinders due to snap breakoffs caused by agitation. Additionally, dry shredding can generate plastic dust and powders. The release of plastic may also occur during operational downtime.

The following general guidelines are useful for preventing and minimizing plastic release from shredding and shred process operations:

- Implement containment measures in the working area to capture released plastics during shredding with well-paved floors and berms.
- Maintain a clean and clear working space, ensuring it remains dry and free of water puddles, especially for wet shredding processes.
- Use nets, mesh, or tarpaulins in unpaved areas to collect plastics released during shredding.
- Install safety curtains on crusher inlet hoppers to prevent the splashing of PET flakes during operation.
- Employ conveying systems with efficient mechanisms to avoid plastic release and impact.
- Configure feed hoppers for effective delivery of recyclable plastics into the shredding chamber.
- Conduct regular maintenance, replace faulty parts, and use collection trays under discharge/ loading points.
- Securely place joints and connecting parts to prevent leakage points for microplastics and powders.
- Optimize wet shredding by reducing water flow and installing control valves for the chopper and washing tank.
- Maintain sharp cutting discs/knives/blades on shredding shafts to minimize plastic dust generation.
- Position containers at discharge outlets to capture overshoot plastic scraps effectively..

Measures to prevent, minimize, and control dust and odor release from shredding

Some housekeeping measures can be put in place to capture and contain plastic dust. Plastic recycling facilities must:

- Utilize appropriately designed dust collection equipment for all operations generating plastic dust.
- Maintain dust collection equipment as per manufacturer's recommendations.
- Use recommended filters based on the type and quantity of generated dust; clean or replace as necessary.
- Raise awareness about procedures for cleaning up plastic dust spills and settled dust in the plant.
- Implement maintenance and housekeeping procedures to minimize dust accumulation.
- Store captured plastic dust in leak-resistant containers.
- Promote employee awareness in handling plastic dust.
- Educate employees on methods for handling and processing plastic to minimize dust creation.
- Ensure compliance with national Environmental Impact Assessment (EIA) regulations for containment systems.
- Install a baghouse, where economically feasible, to reduce and control air pollution.

safe disposal of any released fragments that are not reusable.

Factors such as punctures from nearby materials, unintentional tearing of storage sacks due to human activities, or rodent interference should be controlled and eliminated where possible. Thorough sorting and separation are essential due to the quality and grade requirements of resin pellets that recyclers must meet.

Contaminants present challenges during processing, affecting the physical and chemical properties of recyclable plastics and diminishing the quality and value of the recycled material. Therefore, effective sorting and separation processes are crucial to maintaining the quality and application value of recycled plastics..

4.2 Waste Management in Junkshops and MRFs

Recycling facilities produce a variety of waste, including solid waste, electronics, and hazardous materials, which must be carefully disposed of. These facilities accept a wide range of materials such as plastics, paper, glass, and metals, initiating processes to give them a second life. Workers in these facilities, equipped with protective gear, play a crucial role in mitigating potential hazards.

Hazardous materials, particularly electronic waste (e-waste), require careful handling to extract value while ensuring the safe disposal of toxic components. This commitment extends throughout the waste stream, where recycled materials undergo thorough preparation for market consumption. Maintaining cleanliness and adhering to stringent quality standards are essential priorities.

However, recycling facilities face the challenge of waste management, striving to prevent unintended releases of plastic flakes, solid waste, dust, and hazardous residues into the environment. Proper protocols must be followed for the disposal of solid waste and hazardous materials, particularly in junkshops and MRFs.

The following measures can help address residual waste generated from MRFs and junkshops:

Solid waste management in junkshops and MRFs

- Design and implement a comprehensive solid waste management strategy for the entire recycling facility.
- Ensure waste disposal methods align with national and city-level regulatory requirements for recycling factories.
- Implement and promote waste reduction and segregation strategies for staff and operations.
- Install labeled waste segregation bins at accessible locations within the factory to encourage proper waste sorting.
- Regularly train factory workers on waste reduction and segregation practices.
- Provide training on different types of waste, including toxic and hazardous waste, as well as infectious waste handling.
- Establish a daily routine cleaning schedule to ensure the thorough cleaning of working areas and proper waste disposal.
- Institute award schemes to motivate proper waste reduction and management practices within the factory.
- Direct organic waste to material recovery facilities for compost production; consider installing a batch biogas plant for organic waste disposal.
- Strictly avoid burning waste within the factory premises.

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