Sustainability & Eco-Friendly Practices: Waste Management

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Abstract

Like any other city in the Asian region, Kathmandu Metropolitan City (KMC) faces tremendous challenges in solid waste management. In general, the broad sources of the municipal wastes in the city contain domestic, industrial, medical, commercial, institutional, agriculture, construction or demolished materials. The major components in domestic wastes are food residue, fruit or vegetable peels, meat or fish, milk wastes, plastic or plastic products, glass, paper, metal and fabric, of which 60-70% are biodegradables, 20 % are recyclable and rest of the 10% is disposable. In the changing socio-economic context and rapid urbanization, there are more inorganic items in the residential wastes such as gift or food wrap or boxes, heavy grocery packaging, aluminum foil, cardboards, paper products, fiber, rubber, and plastic. Old pots and pans, electric and electronic products, sharp knives or needles are another set of wastes that require more careful disposal methods due to associated public health risks to waste handlers and impacts on the environment. In specific reference to the Nepali community, characteristics and management of such wastes depends on, but is not limited to, the traditional and/or cultural practices, level of awareness, food habits, types of grocery packaging, climate condition and geographic context. Lately, domestic waste has become a concerning factor to degrading environment and public health hazards in the municipal population. On the other hand, the challenge lies on lack of space to dispose such wastes due to rapid urbanization, shortage of appropriate space for managing a sanitary landfill site and lack of efforts in reducing the wet and dry wastes at source. The challenge is likely to continue with the rate of population increase in the urban centers, importantly in the Kathmandu municipality. In this article, the significance of the reduce, reuse and recycle (3R) approach is presented, which is in use in Nepali context, though at micro level. It also shares the selected replicable personal or institutional stories on the 3R approach to waste management. The article further summarizes the suggested way forward to the matters related to waste management.

Keywords: solid waste, types, 3R, techniques, challenges, handling, space, landfill, public health, risks

Background

Solid waste management is a global issue, as a substantial part of environment management that most countries have signed international treaties to address it in a more sustainable manner. Nepal is not separate from the commitments. For the 2024 conference in Busan, South Korea kick started negotiations in managing plastic pollution, one of the most harmful litters that is ringing the bell as the largest environmental crisis related to protection of people and planet (Associated Press, 2024).

According to the report, plastic waste is projected to increase by 736 million tons by 2040 and it is high time for Nepal to check the alerts and act accordingly. The waste-generated environmental pollution and associated risks to human settlement in KMC has been a long- standing and larger public health concern, recognized as one of the global issues (Pathak & Mainali, 2018).

According to the Asian Development Bank (ADB) analysis (2013), the volume of waste generated in Kathmandu city alone is inclusive of 66% organic wastes, plastic and related 12%, paper and paper products 6%, glass 3% and others 5%. Of the total non-organic wastes, an estimated 29% is reusable or recyclable, as per the analysis. The USAID clean air project report 2021 reveals that KMC disposes 516 tons of wastes per day of which 326.22 tons include organic wastes, 55.72 tons of plastic, 46.54 tons paper, 27.96 tons glass, 23.22 textile, 6.19 tons rubber 2.17 tons metals and 16.07 other wastes. The report of a JICA's Data Collection Survey of Waste Management in Nepal 2024 shows per capita waste generation in the Kathmandu city is estimated at 0.490kg/person/day (FHI 360, 2025). All above data shows that the major portion of the waste is organic, which can be reduced by segregating and composting at household level before going to the collection centre and transfer stations. In other words, the given data suggests the 3R method as the most appropriate solution to minimize the wastes in order to increase the life of the landfill, thereby saving costs for final disposal and reducing public health and environmental risks. At the same time, the large proportion of plastic, paper, glass and other materials provide an attractive business opportunity of reuse and recycling. Unfortunately, the KMC is neither issuing public directives nor substantially operating the compost plant for reducing organic waste at source (Karki et al., 2008).

Similarly, the KMC does not have the system of recycling plastic, paper, glass etc. within its institutional mechanism. After closure of the composting plant at Teku Transfer Station in 1990, the KMC was compelled to dump more waste in the scarce landfill station at Sisdol. On the other hand, public awareness on segregation of waste at source seems one of the key missing links in the system. Operation of composting and recycling plants in municipal and community level is not feasible under the current municipal capacity, thus calls for a private partnership.

In general, waste disposal and management is a multi-dimensional issue that seeks attention of scientists, geo-technicians and policy makers at macro level. It is also a concern of the general public, individual households, waste or scrap collectors, including recycling units at the community level. For urban centers of Nepal, a strong policy formulation and strategic framework for solid waste management (SWM) is lacking, as revealed by several consultations and literature review (Bank, 2013). A concerted effort in making arrangement of the specific institutional set up, initiation for public consultation and participation, enforcement of prevailing laws on implementation of 3R approach, public awareness campaigns, promotion of public private partnership, recovering cost from services, building capacity of local bodies and key actors and formal recognition of relevant association or non-profits are necessary.

The Informal Waste Workers' (IWW) Health Status also is one of the concerns of the municipality, as suggested by the MDM study on the IWW. According to the study report, 73% of the IWW view that working in waste is a highly vulnerable job due to non-use of preparatory equipment. Due to vastness and complexity of the agenda, this article summarizes the status of Kathmandu City's SWM in general and recommends solutions for addressing those in a more integrated manner. The article also show-cases selected good stories that are active and replicable at community levels, especially reinforcing the significance of the 3R approach.

Methodology

Preliminary interview questionnaire survey, formal and informal discussion and key informant consultations were conducted in the KMC area. The interviews were conducted with over 100 city dwellers and stakeholders in the urban centers using a questionnaire on knowledge and practice on managing domestic waste. Discussions were carried out with the recycling units, compost developers and SWM professionals. Other major interviews included with scrap dealers' association, restaurants, compost practitioners and recycling business entrepreneurs. Some secondary data and information have been gathered by desk study and literature reviews of published articles, survey analysis and more formal institutional studies.

The major reference documents were publications of the ADB, USAID and JICA, IWW study report, National Environment Agency guidebook for Singapore on 3R, Practical Action report on best practices on SWM including several online articles and blogs. Other methods included collection of selected case studies on good practices of 3R, based on both institutional and personal stories, such as DOKO Recyclers, Bottle House, Neha Craft, Phool Prasad and Vermi Composting (Biocomp Nepal, 2023). Consultation meetings with the Environment Department of the KMC remained the key source of information on the issue. The interview with Maarten Nijhof the head of the BioComp was also an important learning on the values of recycling as a professional business and employment generation. Online interview with Dr. Bhushan Tuladhar, the Environmental Engineer in Nepal is one of the key sources of information. The social media posting from the Mayor, Kathmandu City, khalisisi and purano kagaj remained key information, in addition to interviews and consultations (Admin & Admin, 2024). In addition, the author's experience and knowledge on the 3R implementation is also shared in the article.

Legal Provisions

Solid Waste Management was introduced in 1996 and the Solid Waste Management Rules came in 2013. Environment Protection Act of 2017 and the Environment Protection Rules of 1998 recognized the importance of public health concerns associated with the waste management. The Local Self Governance Act of 1999 entrusted the local institutions to take responsibilities in managing solid waste at local level in the country (Bikash & Ichihashi, 2022). The Solid Waste Management Act 2011 was enforced with the view of maintaining a robust healthy and clean environment and minimizing effects of pollution on public health (Lohani et al., 2025). As spelled out in Section 5 of the SWM Act 2011, any individual, organization or body shall be responsible for reducing the production of solid waste by making arrangement for disposal on its own area or reuse of solid waste, as far as possible (Khatoon, 2020).

Similarly, the Section 10 of the Act has mentioned that the Local Body, referred as KMC here, may take necessary steps to encourage the reduction, reuse and recycling use of solid waste, by issuing necessary directives by coordinating with the concerned industry for its effective implementation. However, the challenges in enforcement of the prevailing laws remain due to a number of factors including lack of high- level political commitment in prioritizing the issues related to SWM. Dr. Tuladhar states that one of the key factors of non-compliance of legal provision is the absence of any technical institution to support the municipality, following the dissolution of the Solid Waste Management Technical Centre.

He further mentions that lack of coordination across the neighboring municipalities and within the concerned Ministries or Departments of the federal government is equally problematic in implementation of the legal frameworks. Lack of long- term strategic plan is a hindering factor in giving a direction to the municipality on various aspects of waste management. In addition, the unwillingness of the municipality in engaging the private sector or any community- based organization in sharing responsibilities and associated challenges leaves the waste management issues nobody's business. Lack of initiative in recognizing the scope of recycling business and more focus on dumping contradicts the prevailing laws. Lack of regular government funding support is an ongoing problem whereas most external initiatives are project centric and they end with the phase out of the project.

Specific Interventions

As an economic, cultural, educational and social hub of the country, the KMC attracts tourists throughout the year, with over one million visiting annually (NTB 2023). Similarly, KMC draws attention of various international development agencies in different periods in time for its improvement in waste management and related sectors. Between 1980-90, the GTZ worked with the Ministry of Works and Transport with the idea of introducing new brooms and push carts in Kathmandu valley. In 1986, a landfill site in Gokarna was initiated with external support. In 1998, the German company BGR supported the government of Nepal that produced a map entitled Potential Areas for Waste Disposal in Kathmandu Valley (Rayamajhee et al., 2021).

The map, first of its kind, was introduced after rigorous efforts and detailed investigation of hydro-geology, soil and other related aspects required for the solid waste management in scientific manner (Y. Dahal & Adhikari, 2018). In 2000, USAID supported KMC through a Regional Environment Project that experimented with the 3R technology in selected wards of the city, as a pilot project (Khanal, 2023). Activities also integrated the medical waste management through designated medical institutions. In 2012/13, the Asian Development Bank commissioned a study in 58 municipalities including KMC to assess the status of solid waste management. In 2020, the City Planning Commission of the KMC also conducted a study for updating the SWM data in the municipality. Between 2004-05, the KMC in support of JICA, conducted a study on Solid Waste Management in Kathmandu Valley (Biswakarma et al., 2023). As a result, an action plan was framed between four municipalities, namely Kathmandu, Lalitpur, Bhaktapur and Kirtipur on implementation of the SWM strategy. Most of the interventions under any of such cooperation included survey and data analysis, stakeholders training and awareness and distribution of blue bins with tools and manuals. KMC has been implementing the Clean Air project with USAID support.

In addition, MDM France and KMC collaborates on solid waste management and workers health system strengthening project (Thapaliya et al., 2024). Despite several interventions and experimentations, the Kathmandu City's solid waste management issues are further complicated with problems related to collection, partnering, ownership and political differences. It is also a high time to learn lessons from these past experiences. Based on a long period of experience and studies on the waste management issues, Dr. Tuladhar clearly reiterates that external partners can provide technical or financial support, but they cannot solve the problems. He puts more emphasis on a high- level political commitment and clear guidance and framework for partnership in particular with the private sector, consultation with stakeholders at all levels and ownership of locales for succeeding the SWM tasks. Other key lessons learnt from the past experience are the over-dependence on the external development partners, absence of broad strategic planning, lack of effort in capacity building of local government cadre, lack of mass awareness, politicization over waste and corrupt practices.

Reducing Waste is a Common Sense

Due to rapid urbanization, rate of increase in population and loss of traditional methods of waste management, the Kathmandu city is increasingly bearing the volume of domestic wastes in public spaces. This has created institutional challenges to the concerned agencies as well as public health associated risks to the city dwellers. Non attended wastes or unscientific dumping tend to breakdown or decompose into other secondary harmful substance through biodegradation. Unplanned management might not only affect the immediate public health concerns but also a longer-term liability to the society by creating a contaminated surface and groundwater. Solid waste has a large organic content, constituting 66% of household waste, which is looked as a burden to the economy, environment, social and technological aspects of the city's wellbeing.

The key to successful waste management would be the segregation of waste at source by creating a deeper understanding and knowledge of the 3R approach at all levels, which requires rigorous public awareness campaigns. Each household should be sensitized to create less amount of wet waste from the kitchen so that the segregation process is eased and landfill disposal gets the minimum of wastes. Reduction of wastes at source is also considered as prevention from waste creation, which is a part of responsible citizens behavior to the community. The enforcement of prevailing legal provisions is equally important along with the awareness in order to significantly reduce the amount of waste to be disposed off at the final landfill stations. It also helps in saving institutional costs for disposal and minimizing public health and environmental hazards. The promotion of organic composting would also improve the government's balance of payments, by replacement of the compost to the imported chemical fertilizers (Sustainableholly, 2022). At the same time, farmers receive added value due to organic quality of the products.

The interview responses and the consultations showed that even though there is knowledge on how to manage domestic wastes, only 10% said they practice segregation and composting of the organic wastes. A few practical methods reported of reducing wastes from the trash are to donate extra foods to the needy, store foods properly for the second use and use leftovers creatively. In the interviews many restaurants noted that their wasted foods are taken by the farmers for pig feed. The waste reduction actions also take into account other aspects of common sense, such as purchasing less as far as possible, conservation of natural resources, contributions to pollution free environment and saving cost from disposal. Most kitchen waste, after reduction, is good for composting, in which the individual household,

community, local institutions and policy makers are expected to contribute. There are a number of composting methods that are in use traditionally and some improvised techniques are increasingly gaining popularity. At micro level, pit composting in farming communities has been a part of daily chores in the countryside, and is still practiced in urban based kitchen gardens, as interviews showed. Such composting methods seem more sustainable requiring no modern technology and additional costs. In the city centers of Kathmandu, the Saga method was in practice, in which the community in clusters pile up the kitchen waste in one heap for a long period of time and extract after it is matured. When vermi composting was introduced in the 90s, the method spread across the community using terrace gardening (OYR Frugal & Sustainable Organic Gardening, 2014). Vermi composting also does not require much space or technology, it is just grown in card board boxes, fiber containers and wasted plastic buckets. All of the composting methods are better for soil aeration, water percolation and increasing plant nutrients (Polo et al., 2024). They also contribute to improved taste and flavor of plant products, minimize risks of plant toxicants and assist in microbial production for the soil, thus keeping the soil alive. The crux of the matter here is that waste should not be treated as something to ignore or dumped, but as a resource for creative ventures. Composting plants can be developed in communities or municipalities depending upon the local capacity, volume of waste and population density. Once successfully tested and installed, composting practices can be gradually scaled up with due attention to the product quality and marketing strategies. The author's knowledge and practice over 25 years in reducing the kitchen wastes is shared in the table 1:

Table 1: Examples of reducing the organic waste at source

Types of waste	Methods	Usage
Banana peel	Soak peel in water for 2-3 days Chop peel into pieces Sun dry chopped peel Boil peel with egg shell Soak peel in apple cider vinegar	Create new recipes out of banana peels (pickle, fries, fermented beverage) Feed plants potassium, magnesium, calcium Apply directly in the soil bed Apply mixing with compost Spray liquid compost to plants Use for repelling flies
Potato peel	Finely chop and soak peel/skin in water for 7-10 days to decompose Boil the peel and let it cool	Feed plants potassium, phosphorus, nitrogen Spray as a liquid fertilizer to plants Directly apply solids in the soil
Egg shell	Collect, crush and dry shells Soak shells in water for 2-3 days	Feed protein and calcium to plants Use as fertilizer to plants
Onion/garlic peel	Collect, dry and crush peels Soak peel in water for 3-4 days	Mix dried peels in soil Spray in plants as antiseptic and antioxidant
Old yogurt or buttermilk	Mix in water and fill in a sprayer	Use as insect repellent Spray for protection from mold, shrinkage and harmful bacteria
Orange peel	Dry, powder and store	Use in face masks for cleansing and glowing Sell to beauty salons for income
Green soya or bean peels	Dump under the trees and plants	Feed nitrogen to plants
Wasted lentils and beans	Put in the fruit tree roots	Feed protein and nitrogen to trees
Melon peel	Create new recipes	Salad, pickle or curry recipes
Tea/coffee residues	Mix in the soil	Use as compost to plants Source of magnesium, zinc and nitrogen
Carrot peel	Peel and soak in water for a few days	Feed potassium and calcium to plants
Lemon peel	Save peels with salt to pickle Save peels in sugar for jam Boil in water for cleaning spray Rub with sugar Dehydrate with spices	Turn into pickle Make jam with sugar Wash oily utensils of floor Cleansing craked skin Making candy
All raw or cooked food wastes	Collect and feed vermis	Food to worms to produce compost

Source: Based on the author's experience and selected online information

Reuse and Recycle for Turning Trash to Cash

Definition of reusing waste material is to use it one or two more times from its primary form. Reuse of household materials is one of the most sustainable methods to protect the environment from damages. Reusing unwanted domestic material by second or third hand is one of the most common traditional practices in Nepali households. Operation of thrift shops is a new trend in the city of Kathmandu, thus turning it into a professional business (Thapa et al., 2008). On the other hand, recycling involves collection of used or wasteful materials, processing them by hand or machine with the help of chemicals or without and manufacturing the ingredients to newer products. Recycling not only protects the environment, it also saves resources, prevents identity theft, increases office or home spaces, saves time and energy and provides enjoyment from new products. The process also saves money for buying fresh raw materials and minimizes the trash that goes into the municipal landfill. Most pots and pans in the Nepali kitchen are made of specific metals, such as earthen, brass, copper, iron or aluminum, all of which are recyclable.

Recycling is an excellent no-cost opportunity of turning trash to cash. Historically, the local government institutions in Kathmandu valley have experienced mobilization of scrap (Kabaddi) dealers in the valley. According to a study of scrap waste in Kathmandu valley in 2010, the Kabaddis tend to process over 50% of the wastes per their convenience and transport to the industrial units as raw materials. The study further reveals that the kabaddi units are able to generate a significant level of employment in the urban centers. The data shows 18% of the kabaddi shops have employed more than 10 workers. As per a discussion with the kabaddi dealer's association, Mr. Ram Kewal Gupta, as of January 2025, there are 2000 scrape shops in Kathmandu valley, each unit deploys 40-50 persons, generating employment for over 80,000 in total. Recently, the municipality has terminated the role of such Kabaddi units and mobilized private sector to pick the wastes from door steps. On the other hand, the recycling business has been flourishing as start-ups as social enterprise for managing dry wastes and electric and electronic based scrap in the urban centers. There are selected non-profit or cooperative organizations working for women empowerment, the major activity being management of wasteful plastic materials and composting organic items as an input to terrace farming. While there are several informal sector businesses on recycling goods in the valley and across the country, there are emerging enterprises as formal business set up based on the concept. For instance, scraped plastic bags are now being used as a resource for producing table tops and other household items by Bio- Comp Nepal.

The Bio-comp also produces compost fertilizer, from a formal industrial setting using the Dutch technology, providing jobs to 40 people 42% of which are women. The social enterprise Phool Prasad transforms wasteful floral products into organic incense, thus directly contributing to environment protection and sustainable development (Luitel & Khanal, 2010). The initiatives of the DOKO recylers, Purano Kagaj, Khaalisisi Nepal and likewise have good stories to share on how they created the ideas of recycling business with the dry wastes. Together, they manage approximately 100 tons of dry waste per year in Kathmandu city alone, as known by interviews. The large proportion of reusable and recyclable materials provides a great opportunity for generating income by reuse and recycling technologies. Skills training on recycling process on regular basis backed by policy support would benefit larger strata of the urban poor and business enthusiasts, contributing to their sources of income.

Table 2: Examples of reusing and recycling domestic waste

Types of waste	Methods	Usage
Paper (newspaper, paper products)	Donate to pet shop or clinics Donate to vermi composting plant Donate to paper bag making factories Shred and turn to pulp Donate to school children for craft works Donate or sell to craft producers	Create new products like printed boxes, egg trays, poly-mailer Clean window shields As bed or food to vermis Create new crafts School children benefitted
Books/note books	Donate to schools or community libraries Donate to new readers	The end users read or add to their collection
Card board	Unfold and save for packing Donate to shops Donate to compost makers	Use for home shifting Use as store room container Use for composting
Heavy gauge plastic bag	Save for future use Donate to retail shops Donate to street vendors	Re-use for packing
Electric/electronic wastes/ kitchen appliances	Sell to repair shops or recycling units Exchange offers	Re-use repaired items Parts for new products

Old carpets, sheets	Clean and donate	Re use by needy people m
Used fabric	Sell or donate to craft producers or designers Donate to needy people or factories	Old fabric as cleaning rags Pet bedding New styled clothing created Turn to yarn
Mattress, quilts	Donate to charity homes Sell to scrap picker	Use for needy Recycled to new quilts or mattress
Old furniture	Donate to charity organizations Sell in thrift shop or donate to needy people	Remodeling, repair and re use
Plastic goods	Planter for herbs and flowers Melted or re-shaped	Build small community structures Cut and hang in trees as a watering vessel or nutrient feeder Recycle to new products: table tops, fuel, Asphalt
Flowers	Dehydrate rose petal, hibiscus, marigold, jasmine, lotus, basil Donate or sell to factories	Produce massage oil, insane, crafts, tealeaf, bath water flavoring
Metal (brass, copper, aluminum, iron)	Sell to scrap collectors or factories	Transform to new products Transform to improved items
Leather goods	Collect and send to leather manufacturing or recycling companies	Recycled into new products

Source: Based on discussions with the recycling companies and SWM professionals

Local and Global Good Practices in Waste Management

Zero-Waste Policies and Practices

Some instances of international zero waste and recycling good practices and policies are noteworthy. Recycling and remanufacturing alone creates at least one million jobs and generates 100 billion dollars revenue in USA (D. Peter N. King 2011). India, under its Swachha Bharat Mission-Urban 2.0 aims for 'garbage free' cities by using 3R principles of circular economy reducing, reusing and recycling of wastes to ensure maximization of resources. The first and foremost commitment under this principle is applying 'zero waste' approach in all the public events. A standard operating procedure has been developed to implement this principle (MHUA, Government of India). More developed countries like Japan incinerates 78% of its solid waste, as shared by the zerowaste.com.

In Taiwan, 50% of the waste is recycled and 70% of the food waste goes to the farm. Belgium achieved a recycling rate of 60% already in 2000. The 'pay-as-you-throw' fee helped achieve 90% of waste diverted from the landfill in Italy. Austria, Denmark, The Netherland, Switzerland, Germany, Norway are some of the European countries with successful 'zero waste' policies. Taking into consideration its significance and supporting the promotion, the UN observes 30 March as the Zero-Waste Day, as proclaimed on 14 December 2022 (UN)

Singapore Guidebook on 3R

Sustainable Singapore Blueprint (SSB) 2015 came with the vision of more livable, vibrant and sustainable city by leading to a Zero Waste Nation and Green Economy targeting recycling 70% of wastes by 2030. In order to materialize the goal, the National Environment Agency (NEA) introduced a 3R Guidebook, updated in January 2017, for offices to promote 3R practices in organizations in Singapore. Waste management companies and recycling agencies can also refer to this guidebook to tailor their services to clients. However, it does not provide 'one-size-fits-all' solutions, but considers contextual circumstances. The NEA also promotes public private partnership in the 3R approach and more importantly takes it as a way of life. It has suggested eight basic steps to the 3R approach including top management commitment and support, appointment of 3R team, conduct waste audit, identify opportunities in 3R, engage recycling service providers, develop a 3R program, implement 3R activities, and finally monitor, evaluate and improve the 3R initiatives.

Swachha Bharat Mission-Urban 2.0

The Swachha Bharat Mission-Urban 2.0 of the Government of India provides a high-level commitment and multi stakeholder engagement strategy in solid waste management. This refers to a national framework of the Ministry of Housing and Urban Affairs of the Government of India launched on October 2, 2014. One of the key missions of this framework is the 'garbage free cities' in India. The

important pillar of this mission is strengthening capacity of state and municipal cadres in waste management. The plan also includes mass awareness, leagues or camps for keeping the urban areas clean. It ensures open defecation free community, which is claimed as 100% successful mainly due to the senior level political support. Sustainable sanitation practices and waste management to contribute to circular economy are other important agenda of the Mission. In addition, provision of financial assistance to the States for setting up various plants, such as waste to compost, waste to energy, material recovery facilities, construction and demolition of waste, sewerage and slug treatment plants are important features of the Mission.

Digital Application in Waste Management

With increasing use of modern technology, application of digital systems has become an important tool in managing waste across the globe. A self-paced, interactive and e-learning module has been launched under the Swachha Bharat framework, where 90,000 staff members successfully completed the course to date in India. A review of use of artificial intelligence (AI) in waste management in smart cities reveals that New Zealand, UK, USA, Japan, Switzerland, Canada, South Korea, Singapore have already started using the technology in waste management. Evidence has shown that the AI has been useful in particular collection, sorting and treating wastes, which in turn contributes to the 'zero waste circular economy'.

The review further states that technology of AI can be applied in introduction of intelligent garbage bins, mobilization of waste sorting robots, sensor -based waste monitoring, development of models to predict waste generation, tracking waste materials and chemical analysis of waste to convert to energy, all of which will bring a revolution in the waste management system. The journal on cleaner production published an article on blockchain technology application in waste management (Overview, Challenges and Opportunities, October 1, 2023) which interprets the blockchain as another emerging digital system, currently spreading in the smart governance, circular economy, industrial database, supply chain mechanism, information sharing, smart energy system and other sectors as appropriate.

As far as waste management, the blockchain technology can be utilized for separating categories of wastes such as plastic, hospital waste, textile etc. The blockchain technology is specifically useful in waste tracking, compliance of regulations, waste governance, resource management, documentation and logistics systems. The Geen.Org (2024) claims that there are a number of benefits in use of robotic systems in waste collection, segregation and recycling. It increases efficiency, reduces labour cost and ensures workers' safety in hazardous tasks. UK, France, Germany and Italy are increasingly using robotic technology in recycling. AI powered waste sorting has been showcased in international fairs (Recycle CEO Victor Dewulf ref: IFAT 2022). The Sagarmatha Pollution Control Committee (SPCC), Pasang Lhamu Rural Municipality and Airlift Pvt. Ltd. collaborated to lift 234 kg of waste from the Everest region via its 15 test flights using advanced drone technology. Similar initiative in Ama Dablam collected 641 waste from an altitude of 6,812 meters peak (The Himalayan Times, March 20, 2025).

Use of Appropriate Composing Technique

One of the good practices at the local level is Madhyapur Thimi Municipality in Bhaktapur district of Nepal is the choice of right composting technology. The suitable technology based on traditional practices, locally accepted and satisfactory testing is the key to success and sustainability of the waste reduction drive. A Japanese technology known as "CNBM" meaning carbon, nitrogen, bacteria and minerals, is used in composting. This technology is based on fermentation with the help of microorganism at a temperature of 60-80 degrees celcius (Moktan P. and Lal Ajaya Chandra) 2023). The CNBM is prepared by mixing bran, husk, leaves and red mud called as Tokozai that prevents foul odor from the wastes.

Out of total domestic waste generated in the Municipality, 70% includes organic in nature. The institution follows the process by distributing the composting agent door to door. Value addition to the successful application of this technology is the strong institutional mechanism and stakeholder coordination. Major actors in this initiative include local bodies, district coordination committee, village coordination committee, government owned business, donor partners, non -profit organizations, community service providers, community- based organizations, individual consumers and volunteers.

The study also identified a number of other critical success factors in managing waste in this municipality, e.g. technological feasibility, detailed project planning, transparent procurement process, public awareness, commitment and responsibility of project stakeholders, capacity building of staff, competent private sector partners, good governance, waste segregation at source, public engagement, political support, risk sharing approach, appropriate tariff and adequate financing. Being relatively small in geographic area and increasing population density of the urban center, one of the key solutions of Madhyapur municipality is the reduction of waste at source and composting.

Multi Stakeholder Partnering Approach

In Nepal different varieties of partnership approach have been tried according to a study commissioned by Practical Action Nepal in 2008. The study findings reveal examples and selected contextual and replicable waste management practices across urban centers of Nepal. In Bhaktapur district, selection of the staff and the group contractors from the specific service areas make the process more effective and accountable. The local knowledge, language and skill in collection, segregation, transportation and recycling steps are highly successful

and sustainable in this case. There has been a long-time partnership between GIZ, NGOs and CBOs in Bhaktapur. Tribhuwan Nagar municipality in Mid-Western Nepal displays an effective waste management process mainly in recycling and safe disposal. The major players in this municipality are GIZ, UDLE, UNDP, GON, TLOs and NGOs. This is one of the good examples of income generation from recycling by selling grass and firewood from the landfill site and planning to sell fruits in future. Bharatpur and Biratnagar municipalities are examples of a private sector led initiative in waste collection and recycling. They are a replicable instance where a number of jobs created on the waste management business without adding cost to the municipal institution. Hetauda, Bharatpur and Kirtipur municipalities are good examples of Suiro (needle) campaign where plastic pollutant is minimized by community mobilization. Nepal Pollution Control and

Environment Management Centre works in various urban centers in waste collection, awareness, recycling and handling. The Urban Environment Management Society is engaged in selected urban areas in providing technical assistance to households in composting, handling of organic waste and grievance redress initiatives. The Women's Environment Preservation Committee works with school children on awareness of 3R. Partnering with business companies, the NGO provides education in the target areas on composting, recycling and kitchen gardening.

The NGO already has a composting and vermicompost facilities in its premises in Lalitpur district. The key lessons learned from these cases are minimize the waste at source, identify appropriate sanitary landfill site, initial management infrastructure, participation of local communities, support from private sector, involvement of local recycling business, tax waiver from recycling enterprise, financial sources, recognize role of household and community composting and honor a good waste handler. All of these aspects should be backed by regular awareness, immediate and long- term planning and ongoing studies and research.

Replicable Modern Composting Plants

The 3R approach does not limit its process to household level composting, but calls for scaling up in response to the space crunch, increasing rate of population in urban centers and the busy schedule of the individual residence. Introduction of SWM handling rules in 2000, India is mandated to scientific treatment of waste. Accordingly, the Excel Industries Ltd. have set up 12 plants across the Indian States for converting urban waste to compost and supporting the sub urban farming communities (Sthapit et. al). It mobilizes a cost effective and efficient machine for processing of waste that produces a high- quality compost. Over 25 years of Excel's experience has shown that the plants are capable of treating 100-500 MT of waste on a daily basis. Marikana city in The Philippines is a center of excellence in South East Asia in terms of managing the city wastes (author's observation visit). The Ecological Solid Waste Management Act 2000 mandated the Municipality to structure its SMW plans (livablecity.org) starting with enforcement segregation at source. The SWM is looked at from the larger perspective of healthy air, clean water, open space, clean household and community, mental wellness and clean future. A community- based composting plant uses 1-tonner government accredited bioreactor machine and one rotary composter. Considering waste as a resource, the Marikana city stakeholders fully understand the value of the circular economy.

Selected Case Stories on 3R in Kathmandu Valley

Story 1

Bottle House: A Sense of Pride

About 18 km drive from Kathmandu is Pharping, where there is a bottle house that comes across as a symbol of creativity and positivity in the community. One of the good practices of its kind in Nepal in the 3R concept, the bottle house attracts several visitors a year. As an eco-friendly and earthquake resistant structure, the bottle house demonstrates a brilliant example of how we can reduce, reuse and recycle waste materials and turn them to meaningful products for human use. Niroj Shrestha, a Social Worker and Promoter of the house, in his interview describes it as a matter of pride for the user community, building such a useful house using the scraped bottles. As he calls it, 'A School for Community' (ASC), the bottle house has two units–a big meeting hall and an office space. The hall accommodates meetings, training, ceremonies, indoor picnics and larger community events while the office space is in use for the ASC purpose. In addition to the used bottles, other construction materials include sand, mud, bamboo and hay, all the natural resources available at locales (Sahas & Desk, 2024).

Uniquely, human hair is said to mix in the plastering substance for durability of the structure and at the same time minimizing waste to the landfill. Those taking care of the house are named as eco-volunteers, thus adding a valued title to their career. Interestingly, the management has added a solar cooking facility and eco-san toilet to the system that displays a packaged environment friendly system in place. The system also manufactures briquette out of waste papers generated from the school by simply soaking paper in the water drums and pressing in a basic mold. The PRAXIS magazine in its May-June 2003 edition included, "So On and So Forth-We can Speak the Bottle House," by Shristi Bajracharya, which attracted larger public interest on the subject, locally and among its global network. Republica daily newspaper published an article entitled "A community of Creative Chain Reactions," by Nitya Pandey (May 10, 2013), which testified the concept of integrated approach to environment is sustainable. The bottle house, demonstrates a very practical approach to integrated waste management and sustainable

mobilization of the local resources. For a long time, this structure has been a useful resource center for agriculture school, farmers, mothers, adults and school dropouts. The bottle house, designed by American architect Bill Hutchins, is built in a Nepalese design of thatched roofing.

Story 2

Recycling Business: Trash to Cash

A 58 years old college graduate, Sarita Joshi Bajracharya from Kilagal, Kathmandu has been in the recycling business for the past 34 years. Sarita is a great enthusiast in managing waste by creatively turning rags to cash. Her major creations emerge out of trending styles and consumer demands. For instance, she utilizes used jeans to make hand bags, pouches, cushion covers, laptop covers, cell phone holders and it goes on. She designs baskets or carry bags out of plastic containers, transforms wasteful hay into floor cushion, mattress or wallets, and utilizes the remaining trash to create several decoration or gift items. She usually receives orders from government institutions, non-profits and individuals. Interviewing with Sarita has been a matter of superb enthusiasm, which directly passes to the person she meets. The way she describes the unending ideas of how trash is equal to cash is an inspiration. Sarita's words with sparkling eyes speak to how much of her heart and mind she has put into the venture.

There are two parts of her initiative, first recycling of household trash and creating direct and indirect employment for urban poor. The second part of her initiative is more sustainable, i.e. the skill training on the same with the purpose of transfer of technology to the newer generation (S. P. Lohani et al., 2021). In her long period of investment on the matter, Sarita thinks it is high time to transfer the skills to younger generation, so that the idea of recycling does not end. Sarita sells recycled products worth Rs. 60-70 thousand a month which leaves with her a profit of estimated 50%. One of Sarita's proud outcomes is her city-based residence built by contributions of her recycling business. She has employed 16 staff in this period of time, four full time and 12 home- based workers. She has provided training to around 10,000 trainees from across the country, of which 25% are already in some form of profitable business.

Other participants gained knowledge and skill to manage their own household trash. Sarita is connected with some formal institutions, e.g. Rado Nepal, Blue Waste Value, Prism, Clean Up Nepal, all of which collaborate with her for skill training, marketing of products and knowledge sharing. Under Clean Air project previously supported by USAID with the Kathmandu municipality, she is currently involved in training of new entrepreneurs. Sarita is an honored recipient of Positive Planet Award in Paris in 2015, for which she also wants to give credit to her family members for their unconditional support and encouragement throughout her journey. She operates online portals such as website and TikTok for information and business. The key take-away from Sarita's story is that there is a wide scope of recycling business in the urban centers. Not only is it a sustainable approach to waste management but it also meaningfully supports urban poor in livelihood.

Story 3

Vermi Composting: A Passion to Profession

Engaged in SWM for over 25 years, Sanu Maiya Maharjan from Marutole, Kathmandu is a passionate farmer rearing vermis for composting. One of the good community practices of composting technique, she herself is a senior staff member at the Kathmandu Municipal Office and serves as a role model to her extended family and community at large in terms of managing kitchen waste. In the interview she stated that she collects wastes from tea shops, fruit vendors and the vegetable market, and feeds to the worms. Total amount of waste collected per year accounts for approximately 10 tons, which produces the compost equal to 1 ton. She sells compost in Rs 50 per kg that gives her Rs 50,000 worth of income. Additional source of income is by selling worms in Rs 3000 per kg, the sale of which remains 30-50 kg per year. Other bi-product of the composting is terrace gardening in which an estimated 20-25% of vegetable need is served in her kitchen.

Her excitement listing down the benefits of vermi composting is beyond description, as she puts "I am self- sufficient in turmeric, green chili and other daily used spices from my terrace garden". She adds "It can be a great source of enjoyment, pass time and small pocket money for the caretaker". For public information, she has installed Google information where people access to reach her home either for the compost or the worm itself. An unexpected benefit from this project Sanu Maiya thinks is a very engaging family chore that helps bring all levels of family members together.

She feels extremely happy about her family cohesion, support to each other and garnering help in need such as collection of trash and delivery of final products, as necessary. More importantly, she states it as an excellent pass time for the senior citizen in the family and a good source of income for them. Sanu Maiya is grateful to digital facilities in the country, which has enormously helped strengthen her network and link with the interest groups. She can be reached via social media, Facebook, for supplies and information. One can learn a lesson from Sanu's project that specific focus to a smaller part of the waste management may bring such a tangible outcome, provided how much passion and interest is laid to the process. It is equally important to lay emphasis on regular public awareness, technical training and incentive for continuation of the process.

Story 4

Phool Prasad- Waste to Worth

Kathmandu is known as a city of temples and monasteries,

including world heritage sites, and the population consumes a significant amount of flower and floral products for offerings to temples throughout the year. In addition, plenty of flowers are used in ceremonies, festivals and formal or official events in the country. Likewise, there is traditional practice of lighting incense in the temples as well as domestic puja rituals on a daily basis. Sharp observations show that temple peripheries are littered with floral items all the time. On the other hand, hospital reports reveal that the person using chemically treated incense are increasingly being infected with chronic obstructive pulmonary diseases (COPD), though empirical data on this is not available (Siddharthan et al., 2018). Data from The Clinic One, a reputed pathology lab in Kathmandu, shows the causes of high prevalence of COPD is smoking, burning of chemically treated products including fossil fuel and exposure to toxic and harmful particles (Team & Team, 2022).

This finding suggests a study on impact of use of chemically infused incense on lungs. Using her conscience and believing every challenge comes with opportunity, Ms. Sushma Sharma founded Phool Prasad, in 2018, with the view of managing floral wastes to meaningful upscale the venture in Nepal. Phool Prasad, which translates as 'flower offered to God' emerges as a unique and innovative idea of transforming the floral waste into precious incense, thus serving a parallel purpose of managing floral wastes from temples and yielding industrial product in the form of incense at the same time. As a woman-led initiative, the company also supports directly to women empowerment and independence through skill building and income generation. The company mobilizes over 150 women in direct and indirect employment for collection of floral wastes, separation of external particles, making of incense, packaging of final products, including administration of the business.

The final residue turns into vermi-compost, as an important bi-product to the farming community. The products are sold in both local and international markets, making meaningful contribution to economic upliftment of the country as well as community, as per discussion with Ms. Sharma. Phool Prasad products find their way to five countries as a niche export item from Nepal. With the mission to reduce floral waste and promote environment sustainability, the core objective is to transform floral waste from different area into ecofriendly incense and preservation of cultural heritage (Shakya et al., 2008). Some other proxy indicators of success of this venture include public awareness on health hazards as compared to the use of other adulterated incense, policy advocacy and sensitization in particular taxation or custom duties on recycled items and a positive recognition of such recycling enterprise at industrial sector.

Story 5

Doko: Recycling for Zero Waste Future

Founded by a group of five members, who were studying environmental science abroad, the DOKO Recycler laid its legal foundation in Nepal in 2017 as a for-profit institution. Uniquely conceived and first of its kind of social enterprise in the country, the DOKO Recycler specializes in collection and recycling of dry wastes, e.g. plastic, paper and metal of all types and qualities and e-wastes in any forms of electric and electronic wastes from households or corporate units. DOKO implements PLEASE (Plastic Free Rivers and Seas in South Asia) project with the joint financial assistance from South Asia Cooperative Environment Program, The World Bank and UNOPS. The plastic recycling starts from sorting of all types and qualities of dry waste, segregation for grouping, compacted and transported to the recycling stations as a resource material for manufacturing new products. Interestingly, Sabitra Karki, the Operational Manager says "transfer of knowledge and skills to the new generation could be one of the best achievements of the current venture of DOKO".

Asked about a most satisfying moment, she remembers the awareness campaign around Se Phoksundo area, a very popular tourist destination, the immediate change of behavior of the local citizens in terms of managing waste was a tangible result. DOKO establishes partnership with corporate units for organizing campaigns, collection of dry wastes and training of staff or clients. Discussion with the CEO, Mr. Pankaj Panjiyar revealed that the DOKO continues to set up close linkage with informal sector like scrap collectors and upcycling and recycling industries, which has resulted into absorption of estimated 95% of the dry wastes in the country.

Mr. Panjiyar also stated that a few items are sent to India for processing and about 5% of the residue is transported to the municipal dumping stations. DOKO, like any other private sector, operates with many challenges, the major being imposition of taxes at all levels and costly transportation management. DOKO office runs with 55-60 staff members, all enthusiastic about the issue. It also mobilizes volunteers throughout the country. One of the findings of the story is that managing waste, either wet or dry, not only requires technology but it is also a matter of soft skills such as partnership, networking and co-working environment. The expected outcomes also depend on a sound government policy back up and regular monitoring of the processes.

Key Recommendation

Landfill Management

Scientific sanitary landfill is non-existence in Nepal. First, an efficient waste disposal management should follow identification of a proper sanitary landfill. The second step is leveling and layering, preferably with red soil. Red soil has quality of absorbing heavy metal ions contents from the lichet or environment (Sthapit N. Et al) Layering process also facilitates faster decomposition of solid waste (SOLID WASTE MANAGEMENT OF KATHMANDU METROPOLITAN C NRead, n.d.). A lichet management

is another important step requiring a lichet tank about 15-20 meters downstream of the waste disposal. Then the lichet should be treated with a proper treatment plant and clean water released to the stream. In the landfill, preferably organic spray is needed to get rid of the foul smell. Bad smell not only irritates the dwellers around the place, but it also attracts flies, harmful virus and bacteria affecting the public health of the dwellers. Such conditions also cause health hazards to the workers. In addition to the technicalities of the landfill site, there are also certain software parts to take into consideration. For instance, proper management of the system to minimize source of conflict, mobilization of locales to ensure ownership and support and skill training of the community to assist in maintenance and monitoring. Awareness of policy makers about the difference between the dumping site and scientific landfill is necessary at the same time.

Public Private Partnership (PPP)

Partnership with concerned stakeholders or institutional linkage, not limited to government or non-government organizations, but also with business groups, health or education institutes, community-based organizations or individual households is important in order to smoothen the waste management process.

The waste management involves a hierarchy of activities e.g. prevention, reduction, segregation, collection, recycling, recovery, transportation, treatment and disposal, where various players perform the given task by mobilizing available resources, knowledge, skills and technology. The PPP mechanism should be considered as a priority agenda for the Ministry of Environment or Health and Education along with local bodies to ensure awareness and skills. The municipalities should also be closely working with the Ministry of Agriculture in promoting compost fertilizer by giving subsidy, tax rebate or buy back guarantee for the producers (Teal House Farm, 2024).

Organic compost production should be also recognized as a local enterprise under the Ministry of Industry. Partnering with the local non-government organizations cannot be ignored with the purpose of service related to training, skill transfer, monitoring and introduction of new technology. Business community or private sector including restaurants make very viable partners for the municipality with the purpose of leveraging resources for infrastructure development, improving quality of life of the common citizen, beautification of the city and many more under the CRS activities. Provision of legal identity to the scrap collecting association, partnering with them for streamlining the collection and segregation process helps facilitate the duties of the municipality. Collaboration and partnership with recycling units by giving them subsidies, rental facilities or display rooms will create a positive and demonstrative effect in the society (Koutsogiannis, 2023). Working hand in hand with the federal government for using the recycled papers or other products in the official business for sustainability of recycling works also makes sense. As per a seminar presentation of Binita Acharya at the Faculty of Health Science of Pokhara University in 2019, Kathmandu municipality has a separate community mobilization unit which plans the activities engaging children and environment, city volunteers, community participation, training and mass education. There is a need to review how far these initiatives are contributing to the 3R approach.

Community Centric Approach

Mobilization of community user groups at the grass root level eases the municipal tasks and shares ownership while minimizing the local conflict at the same time. At the ward level, they can aid in door-to-door campaigning, facilitate community meetings, liaison with ward offices, education institutes, grocery stores, restaurants and others as appropriate. The community training of locals on 3R approach, household level composting, monitoring of household in segregation and reduction of waste at source and door to door dissemination of municipal guidance are some of the key activities that the bottom-up responsibilities call for.

Such community groups in the landfill site also help assist in training and awareness on the waste management techniques, monitoring of lichet management and treatment plant. In addition, they can also be prepared for assisting in local level conflict management and complaint handling related to matters with wastes. Such groups collaborate with the local NGOs for expertise and skills and aid in organizing training events and activities. Community mobilization approach not only creates ownership but also secures accountability, inter-groups trust and sustainable management of the solid wastes (Alam et al., 2007).

Recognition and Incentives

Recognizing the role of informal sector such as scrap collectors, their institutional arrangement and a robust regulation should be taken as a priority in the process, so that they take ownership and serve as a meaningful partner to the municipality. They should be provided with a proper identity card, uniform and entitled health insurance policy including access to banking service in order to facilitate in their respectful survival and quality of life. The individual citizen engaged on the reduce, recycle and other innovations be recognized as a responsible member of the society and provided with appreciation and honor.

Each local unit such as ward office should be empowered with adequate financial arrangement and encouraged for community level composting. The community mobilizers or volunteers should be provided with small incentives for transport or cell phone uses, tools and resource materials for training and proper identity card. School children and associated family should be considered as useful actors for waste management process. A small start-up fund should be established for the new entrepreneurs who are interested to set up composting or recycling business at community or household level.

Conclusion

The KMC has been facing a number of obstacles in dealing with the solid waste management issues for a long period of time (Dangi et al., 2010). Various attempts have been made to identify a proper landfill site, community-based awareness and training, partnering with waste collecting companies, systematic recycling technologies and so on, all without tangible results. Current strategy is led by the "golden plan" focusing on segregation at source, classification of wastes and composting at community level composting (Jeff, 2024).

Problems related to legal and political issues are equally notable. While the local government is looking for a sustainable management of the urban wastes, a concerted effort is necessary for reduction of waste at source, minimizing pressure at the landfill, creation of jobs through recycling business and ultimately creating an environment for a livable space for the citizen. In doing these, an integrated approach of developing a holistic strategic plan inclusive of a consultative policy formulation, promotion of public private partnership, creating an incentive package to the actors, selection of a scientific landfill station, community mobilization and development is necessary considerations. With advancement in the modern technology, the waste management tasks also sees potential to integrate artificial intelligence, use of robots and more innovative and convenient database and governance system, for instance.

There are several good practices and community-based 3R mechanisms wait for technical investigations, scaling up, replication or further investment to show meaningful impacts at macro level (El-Hady et al., 2022). Keeping in view the larger public interest and fulfillment of the global commitments in environment management, the primary pre-requisite is to garner a high- level political commitment and support, formulation of a robust policy framework and strategy including an apolitical horizontal and vertical linkage for a sustainable waste management.

References

Admin, & Admin. (2024, May 14). Waste to Worth: The PhoolPrasad Story - PhoolPrasad. *PhoolPrasad - From Waste to Worth*. https://phoolprasad.com/2024/05/14/waste-to-worth-the-phoolprasad-story/

Alam, R., Chowdhury, M., Hasan, G., Karanjit, B., & Shrestha, L. (2007). Generation, storage, collection and transportation of municipal solid waste – A case study in the city of Kathmandu, capital of Nepal. *Waste Management,* 28(6), 1088–1097. https://doi.org/10.1016/j.wasman.2006.12.024

Associated Press. (2024, November 30). What to know about plastic pollution crisis as treaty talks conclude. *Voice of America.* https://www.voanews.com/a/what-to-know-about-plastic-pollution-crisis-as-treaty-talks-conclude/7882600.html

Bank, A. D. (2013). *Solid waste management in Nepal: Current Status and Policy Recommendations.* Asian Development Bank.

Best practices in solid waste management in Nepalese cities (November 2008): *Practical Action Nepal with European Union under the EC Asia Pro Eco II Program.* https://www.nswai.org/docs/Best%20practices%20on%20solid%20waste%20management%20of%20Nepalese%20cities.pdf

Bikash, B., & Ichihashi, M. (2022). Household preferences for Improved Solid Waste Management (SWM) services: a randomized conjoint analysis in Kathmandu Metropolitan Ward No. 10. *Sustainability,* 14(4), 2251. https://doi.org/10.3390/su14042251

Biocomp Nepal. (2023, August 13). Biocomp Nepal. https://www.biocompnepal.com/

Biswakarma, G., Rijal, U., Thapa, S., Dhakal, S., KC, T. K., & Manandhar, T. (2023). Waste Management Policy and Practices in Mountain Expeditions in Nepal: Stakeholder's perspective on implementation of Mountaineering Expedition rules. *International Journal of Tourism & Hospitality Reviews,* 10(2), 01–14. https://doi.org/10.18510/ijthr.2023.1021

Bingbing Fang, Jiacheng Yu, Zhonghao Chen, Ahmed I. Osman, Mohamed Farghali, Ikko Ihara, Essam H. Hamza, David W. Rooney & Pow-Seng Yap (May 9, 2023) *Artificial Intelligence in Waste Management in Smart Cities: a review* https://link.springer.com/article/10.1007/s10311-023-01604-3

Blog, Lifestyle, Products (March 3, 2021): zero waste communities across the globe https://www.zerowaste.com/blog/zero-waste-communities-across-the-globe/

D. Peter N. King: (October 2011): best practices and available technologies in the 3RS-Achieving economic growth while improving resource efficiency: UNIDO Third meeting of the regional 3R Forum in Asia/Singapore: https://uncrd.un.org/sites/uncrd.un.org/files/3rd-3r_ps1_presentation.pdf

Dahal, Y., & Adhikari, B. (2018). An assessment of resource recovery potential and management of municipal solid waste in Jeetpur Simara Sub-Metropolitan City, Nepal. *Hydro Nepal Journal of Water Energy and Environment,* 23, 93–96. https://doi.org/10.3126/hn.v23i0.20831

Dangi, M. B., Pretz, C. R., Urynowicz, M. A., Gerow, K. G., & Reddy, J. (2010). Municipal solid waste generation in Kathmandu, Nepal. *Journal of Environmental Management,* 92(1), 240–249. https://doi.org/10.1016/j.jenvman.2010.09.005

El-Hady, M. a. A., Abd-Elkrem, Y. M., Rady, M. O. A., Mansour, E., El-Tarabily, K. A., AbuQamar, S. F., & El-Temsah, M. E. (2022). Impact on plant productivity under low-fertility sandy soil in arid environment by revitalization of lentil roots. *Frontiers in Plant Science,* 13. https://doi.org/10.3389/fpls.2022.937073

FHI 360. (2025, January 27). *USAID Clean Air - FHI 360.* https://www.fhi360.org/projects/usaid-clean-air/

Jeff. (2024, July 5). Can you compost uncooked soy beans? - GreenWashing Index. *GreenWashing Index.* https://www.greenwashingindex.com/can-you-compost-uncooked-soy-beans/

Karki, J., Pohl, G., Makai, P., Black, M., Lee, A. C., Kritsotakis, E., Fossier-Heckmann, A., Poudel, S., & Bernier, A. (2008). *Health Status and Occupational Risks in Informal Waste Workers in Nepal: Results From a Cross-Sectional Study Conducted in The Kathmandu Valley.* In https://www.medicinsdumonde.org. Médecins du Monde.

Khanal, A. (2023). Forecasting municipal solid waste generation using linear regression analysis: A case of Kathmandu Metropolitan City, Nepal. *Multidisciplinary Science Journal,* 5(2), 2023019. https://doi.org/10.31893/multiscience.2023019

Khatoon, A. (2020). Waste Management–A case study in Nepal. *In Springer eBooks (pp. 185–196).* https://doi.org/10.1007/978-981-15-1543-9_17

Koutsogiannis, M. (2023, September 30). *Pickled watermelon rind.* FoodByMaria. https://www.foodbymaria.com/pickled-watermelon-rind/

Mayor Marcy Teodoro Presentation: Marikana City Ecological Solid Waste Management https://liveablecities.ph/sites/default/files/Mayor%20Marcy%20Teodoro%20-%20Presentation.pdf

Lohani, A., Bista, B., Mahato, A. B., Khanal, A. J., Dulal, B., Tripathee, B. R., Karki, K., Gurung, S. B., Kafle, S., & Karki, B. K. (2025). Seasonal variation in solid waste composition and characteristics in a newly formed Semi-Urban municipality of Nepal. *Cleaner Waste Systems,* 100228. https://doi.org/10.1016/j.clwas.2025.100228

Lohani, S. P., Keitsch, M., Shakya, S., & Fulford, D. (2021). Waste to energy in Kathmandu Nepal–A way toward achieving sustainable development goals. *Sustainable Development,* 29(5), 906–914. https://doi.org/10.1002/sd.2183

Luitel, L., K. P., & Khanal, K., S. N. (2010). STUDY OF SCRAP WASTE IN KATHMANDU VALLEY. *KATHMANDU UNIVERSITY JOURNAL OF SCIENCE,* 6(March, 2010), 116–122.

OYR Frugal & Sustainable Organic Gardening. (2014, October 12). 2 Min. Tip: *How We Use Eggshells in Our Garden (Eggshell Calcium)* [Video]. YouTube. https://www.youtube.com/watch?v=8l7Sclh107o

Pathak, D. R., & Mainali, B. (2018). Status and Opportunities for Materials Recovery from Municipal Solid Waste in Kathmandu Valley, Nepal. *In Environmental science and engineering (pp. 436–443).* https://doi.org/10.1007/978-981-13-2221-1_46

Polo, J. D. A., Toboso-Chavero, S., Adhikari, B., & Villalba, G. (2024). Closing the nutrient cycle in urban areas: The use of municipal solid waste in peri-urban and urban agriculture. *Waste Management,* 183, 220–231. https://doi.org/10.1016/j.wasman.2024.05.009

P. Moktan, A Chandra Lal (2023); Department of Architecture, IOE, Tribhuwan University, Nepal: Public private partnership in sustainable solid waste management: A case of Madhyapur Thimi https://conference.ioe.edu.np/publications/ioegc14/IOEGC-14-039-C1-6-582.pdf

Rayamajhee, B., Pokhrel, A., Syangtan, G., Khadka, S., Lama, B., Rawal, L. B., Mehata, S., Mishra, S. K., Pokhrel, R., & Yadav, U. N. (2021). How well the government of Nepal is responding to COVID-19? An experience from a Resource-Limited country to confront unprecedented pandemic. *Frontiers in Public Health,* 9. https://doi.org/10.3389/fpubh.2021.597808

Sahas, & Desk, L. (2024, March 4). *Buttermilk to honey, natural sprays to protect plants from damage*. News18. https://www.news18.com/lifestyle/buttermilk-to-honey-natural-sprays-to-protect-plants-from-damage-8803417.html

Shakya, P. R., Shrestha, P., Tamrakar, C. S., & Bhattarai, P. K. (2008). Studies on potential emission of hazardous gases due to uncontrolled open-air burning of waste vehicle tyres and their possible impacts on the environment. *Atmospheric Environment,* 42(26), 6555–6559. https://doi.org/10.1016/j.atmosenv.2008.04.013

Siddharthan, T., Pollard, S. L., Quaderi, S. A., Mirelman, A. J., Cárdenas, M. K., Kirenga, B., Rykiel, N. A., Miranda, J. J., Shrestha, L., Chandyo, R. K., Cattamanchi, A., Michie, S., Barber, J., Checkley, W., & Hurst, J. R. (2018). Effectiveness-implementation of COPD case finding and self-management action plans in low- and middle-income countries: global excellence in COPD outcomes (GECo) study protocol. *Trials*, 19(1). https://doi.org/10.1186/s13063-018-2909-8

SOLID WASTE MANAGEMENT OF KATHMANDU METROPOLITAN C NRead. (n.d.). https://nepalindata.com/resource/pdf/SOLID-WASTE-MANAGEMENT-OF-KATHMANDU-METROPOLITAN-CITY-ENVIRONMENT-AUDIT-REPORT--2015-ABSTRACT/

Sthapit NR, Jnawali, BM, Kaphle KP (March 2000) Unpublished report on the exposure visit to Excel Industries Ltd. Mumbai, India in relation to solid waste management by Department of Mines and Geology, Government of Nepal Sustainableholly. (2022, October 12). *Dried banana peel fertilizer.* Sustainable Holly. https://sustainableholly.com/dried-banana-peel-fertilizer/

Swachha Bharat Mission-Urban 2.0: *Ministry of Housing and Urban Affairs, Government of India* https://sbmurban.org/

SOP for zero-waste events (official functions/weddings/social or religious functions) https://sbmurban.org/storage/app/media/SOP-for-zero-waste-events.pdf).

Teal House Farm. (2024, January 24). *5 Ways To Use Lemon Peels #nowaste #budget #frugal #moneysaving* [Video]. YouTube. https://www.youtube.com/watch?v=J_BoXCiRwnU

Team, C. O., & Team, C. O. (2022, November 16). COPD – overview, causes, *symptoms and treatment in Nepal.* Clinic One Kathmandu Nepal. https://clinicone.com.np/copd-cases-in-nepal/

Thapa, R. B., Murayama, Y., & Ale, S. (2008). Kathmandu. *Cities*, 25(1), 45–57. https://doi.org/10.1016/j.cities.2007.10.001

Thapaliya, A., Dangi, M. B., Boland, J. J., Rijal, K., & Adhikari, S. (2024). Solid waste characterization in the slum areas of Bagmati River - A case of Kathmandu, Nepal.

Environmental Development, 101079. https://doi.org/10.1016/j.envdev.2024.101079

TIMESOFINDIA.COM. (2024, January 5). *5 ways to use orange peels in your beauty routine.* The Times of India. https://timesofindia.indiatimes.com/life-style/beauty/5-ways-to-use-orange-peels-in-your-beauty-routine/articleshow/106547553.cms

User, S. (n.d.). *How to Make Fertilizer from Kitchen Waste*. https://www.gardenislife.com/articles/plant-care/how-to-make-fertilizer-from-kitchen-waste

United Nations: International Day of zero waste 30 March https://www.un.org/en/observances/zero-waste-day

Peng Jiang, Lea Zhang, Siming You, Yee Van Fan, Ramond R. Tan, Jiri Jaramir Klemes, Fengqi You, Blockchain technology application in waste management: Overview, Challenges and Opportunities (October 1, 2023) *Journal of Cleaner Production* https://www.sciencedirect.com/science/article/abs/pii/S0959652623026240

Role of robotics in waste sorting and recycling (January 30, 2024) https://green.org/2024/01/30/the-role-of-robotics-in-waste-sorting-and-recycling/

Why are we show casing our AI-powered waste sorting robots at IFAT 2022 https://recycleye.com/ai-powered-waste-sorting-robots-ifat-2022/

Strengthening Local Capacities in Integrated Sustainable Waste Management (ISWM) in small and medium municipalities of Nepal (2008) Practical Action Nepal in support of European Union under EC Asia Euro Pro II Program

3R Guidebook for Offices (24 January 2017) National Environment Agency (NEA) Singapore framework https://www.nea.gov.sg/docs/default-source/resource/participate/3r-guidebook-for-offices.pdf