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TOWARDS SUSTAINABLE MANAGEMENT OF PLASTIC WASTE: THE KEY ROLE OF KNOWLEDGE TRANSFER HUB

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ABSTRACT

Knowledge Transfer is a process of sharing abilities, ideas, and information by means of diverse areas of the sector encouraging innovation and improving efficiency with this guide. Besides, it is an applied approach for exchanging knowledge from one part of the business to another. Knowledge Transfer Hub (KTH) is a center for training, knowledge exchange, debate, capacity building, and awareness raising. The KTH acts as an institutional platform for political, public, and private actors, scientific institutions, industry associations, and relevant stakeholders, therefore enabling a sound inter-and transdisciplinary approach in all its endeavors. The aim of this paper is to focus on the main responsibilities of KTH in reference to sustainable plastic waste management with the support of five working groups. In this article, the issue of improper handling of plastic waste is brought to attention as well as potential fixes that could be made to preserve a healthy environment.

***Key words**: plastic waste, knowledge transfer, capacity building, sustainable*

INTRODUCTION

Knowledge transfer is the practice of transferring skills, concepts, and information among various industry sectors in order to promote innovation and increase productivity (Brown, 2021). Additionally, it is a practical strategy for passing on information from one area of the company to another (Maestro, 2020). The Knowledge Transfer Hub is a forum for education, discussion, capacity development, and awareness-building. In order to provide a sound inter- and transdisciplinary approach in all of its undertakings, the KTH serves as an institutional platform for governmental, public, and private actors, scientific institutions, industrial groups, and relevant stakeholders. For the management of plastic trash, translating data into knowledge and practice could be a well-known difficulty (Evode, 2021). Over the past ten years, there has been an increase in information produced by city corporations, municipalities, universities, and a wide range of other sources in the waste management industry. Without an effective system setup, knowledge translation into practice and dissemination in an applicable and understandable format will remain inconsequential to the majority of practitioners. The increased use of plastic products has resulted in a large volume of plastic waste. Plastics are increasingly being employed in regular tasks nowadays (Hammer et al., 2012), e.g., packaging for products produced by a variety of industrial companies, including those that create food, beverages, cosmetics, pharmaceuticals, and other things, in order to deliver them to the customers more successfully and safely.

Pollution from plastic has become one of the world's most serious environmental anxieties as the ability to manage the swiftly thriving supply of throwaway plastic items gets overburdened (Parker, 2021). Plastic pollution is more pronounced in developing Asian and African nations where garbage collection facilities are either inadequate or absent (Breukelman et al., 2019). However, the industrialized world also has issues with adequately collecting used plastics, particularly in nations with poor recycling rates. Raising awareness and incorporating quotidian management into daily lives is a must need for their

applications. Professional stakeholders are also addressees of the KTH, not only the public. The primary objective of this article is to highlight KTH's role in the management of sustainable plastic waste. Problems resulting from improper handling of plastic waste are pointed out, potential solutions that could help put forth for maintaining a healthy environment, and some creative ideas for setting up training sessions, workshops, and campaigns in order to successfully accomplish effective and sustainable plastics waste management.

METHODOLOGY

The preparation of this article was subjected to a literature search that was conducted utilizing several tools, including the Google search engine, webpages, Google Scholar, the Science-Direct database, and the research gate database. Plastic waste, knowledge transfer, waste management, plastics pollution, environmental effects, volume of plastic waste, plastic waste flow, management of plastic waste, etc. in Bangladesh were used as keywords to find pertinent articles using these sites. Microsoft Excel was used in this evaluation to assess the quantitative data from the publications and information sources.

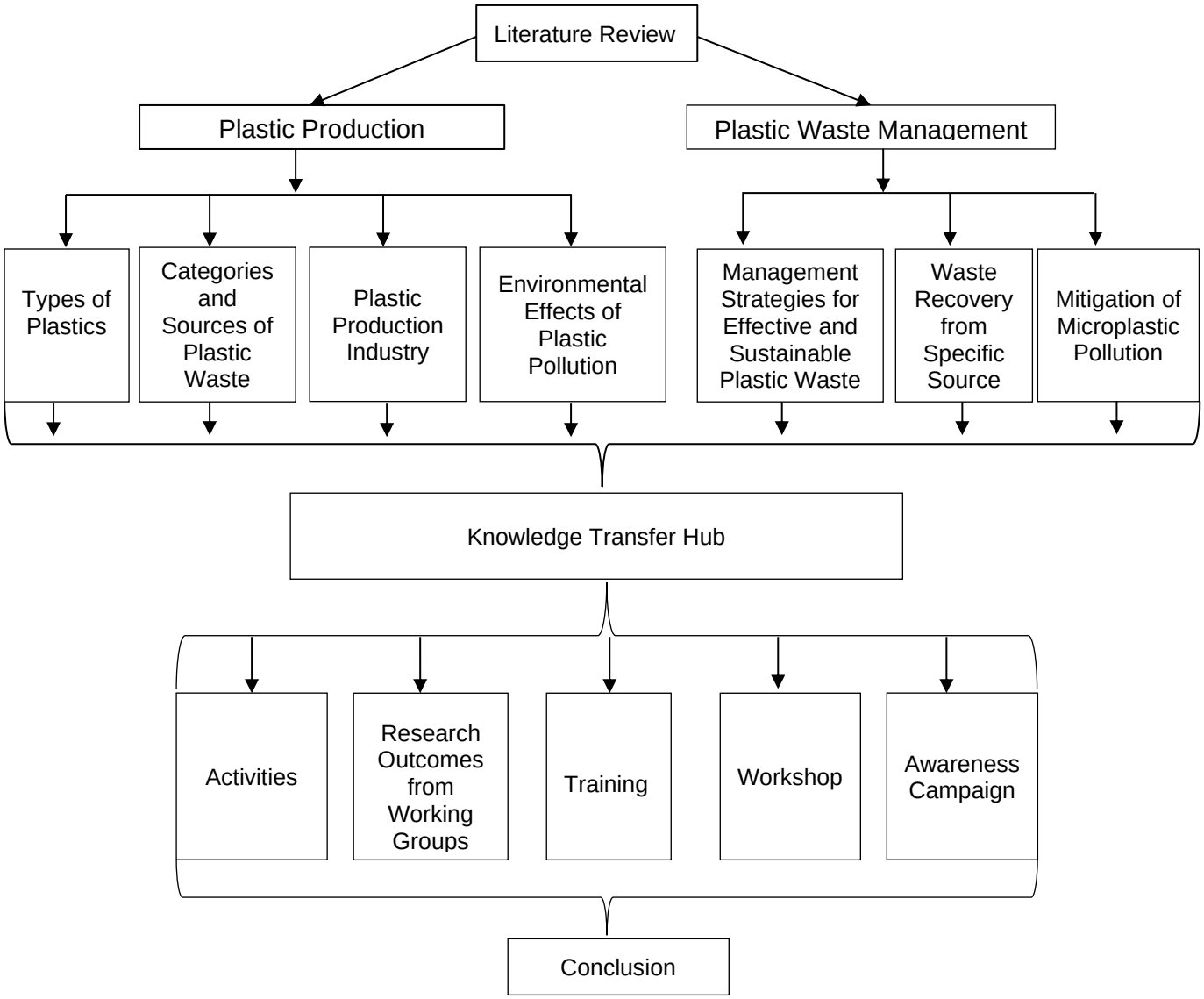

Figure 1 Chronological steps of this study

TYPES OF PLASTICS

Polymers are the primary component of a wide variety of synthetic or semi-synthetic materials known as plastics. Plastics are materials produced from the bio-chemical process technique of poly-condensation or polymerization and polyaddition. For plastic consumers and recyclers, the Society of the Plastics Industry created a detailed taxonomy of plastic goods/items in 1988 (Padgelwar et al., 2019). Plastics products of different categories likely high-density polyethylene (HDPE), polystyrene or Styrofoam (PS), polypropylene (PP), polyvinyl chloride (PVC-U), polyethylene terephthalate (PETE), and others (Evode et al., 2021). Figure 2 shows the percentage of global plastic production by polymer type (Geyer et al., 2017) which are being discussed in the following sections.

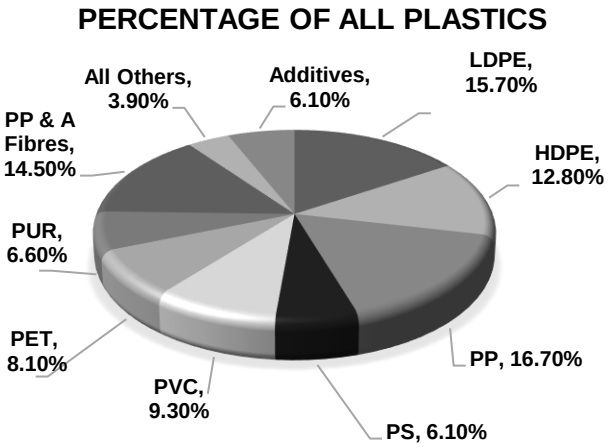

Figure 2 Global plastic production by polymer type (Geyer et al., 2017)

Polyethylene Terephthalate

Polyethylene terephthalate (PET) is the most widespread form of plastic used for example in food packaging that is increasing at the quickest pace due to its distinguishing properties, namely lighter weight, stiffness, toughness, and resilience to grease, oil, and heat (Jamshidian et al., 2010). It can function as a gas and moisture barrier. These polymers sometimes absorb tastes and scents from the drinks and foods stored in them, while being usually thought to be innocuous. These plastics' primary drawbacks are their inability to biodegrade and their susceptibility to oxidation. PET plastic is numerous household items, including soft drinks bottles, clothes, carpet fiber, medicine bottles, rope, etc. Typically, this plastic is recycled into new products. The carpet, pillows, sleeping bags, and other items are made from recycled PET materials.

High-density Polyethylene

HDPE is thought to be particularly safe since it inhibits chemical contamination of food items. This type is being used more frequently due to its being lightweight, incredibly stiff, durable, resistant to weather, as well as abilities of impact-resistant. The HDPE components could be used to create a variety of regular products, including bottles for milk, conditioner, shampoo, detergent, and soap, among others (Parvin et al., 2022). Reusing an HDPE bottle to store food or liquids is dangerous due to potential health risks (Okunola A et al., 2019). Typically, these materials are recycled into garbage cans, flower pots, detergent bottles, and other items. Plastic types not just differ from characteristics but also in terms of recycling. The following section refers to major plastics materials indicated in Figure 3 (ShaktiPlastic, 2022).

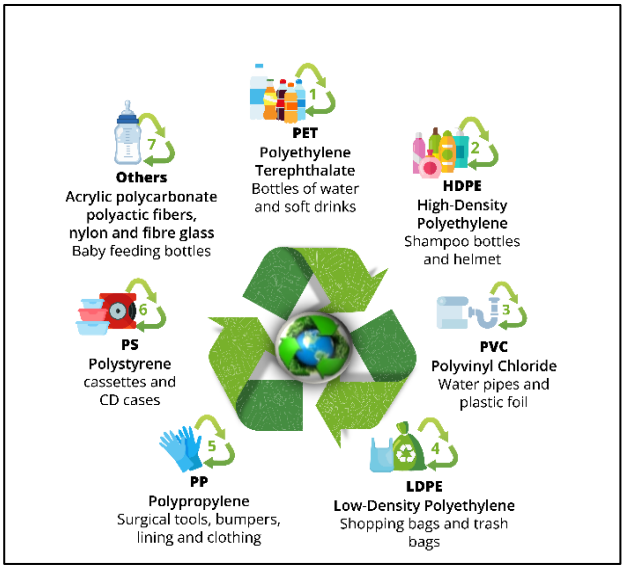

Figure 3 Different types of plastics (**ShaktiPlastic, 2022**)

Polyvinyl Chloride

Different kinds of pipes, tiles and electronic components are made from PVC. Conventional building materials are replaced because of its many useful qualities, including durability, lightweight, affordability, ease of manufacturing, and corrosion resistance (Joseph et al., 2021). It is resistant to chemicals and biological agents because chlorine is one of its main ingredients. Recycling programs typically do not take PVC plastic. PVC is nonresistant against UV and toxics if burned as dioxins, a class of the most toxic synthetic chemicals ever investigated, which are released by PVC plastic can affect the immune and reproductive systems and cause cancer (Children's Environmental Health

Network, 2016).

Low-density Polyethylene

LDPE is recognized as not only good but also safe plastic material due to its resistance to chemicals, impacts, and moisture. Due to its strength and flexibility, LDPE is used to produce more everyday objects, including food wraps, sandwich packs, beverage containers, and plastic bags for supermarket shopping (Emblem, 2012). It should be utilized again or put to another use after its initial function because it is seldom recycled (Hossain et al., 2020).

Polypropylene

PP's greater strength and durability are due to its resistance to soap, water, detergent, bases, and acids (Pradhan et al., 2020). Because of its higher temperature endurance ability, various types of products have been prepared from it. It can be produced transparent, opaque, or in a range of colors at the time of manufacturing. It is used to create items such as lunch boxes, medicine packing, yogurt pots, butter containers, ketchup bottles, plastic bottle caps and sauce bottles. PP can be recycled into manhole stairs, lumber, and vehicle battery casings, among other things.

Polystyrene

PS, a thermoplastic polymer, is frequently used to create rigid foam and solid plastic materials. This plastic is regarded as dangerous because when heated, it releases compounds that could be harmful (Farrelly and Shaw, 2017). It is used to create a variety of everyday things, including packing foam, plastic cutlery and boxes, egg cartons, tea and coffee cups, and teapots. It is frequently recycled, although it can be challenging to put into effect since it can take a long time (hundreds of years) for degradation if recycling is not done properly.

Categories and Sources of Plastic Waste

Plastic waste is generated from various categories of sources including bottles, caps, lids, food containers, bags, packaging wrappers, straws, utensils, cling wraps, etc. It can be inferred that one of the major sources of plastic waste is PET bottles (Vora et al., 2021). Research had been conducted in Japan from 2000 to 2015 for evaluating the huge number of used plastics for various purposes which were categorized in Figure 4 by the generation of plastic waste sources (Colvalcar, et. al., 2022).

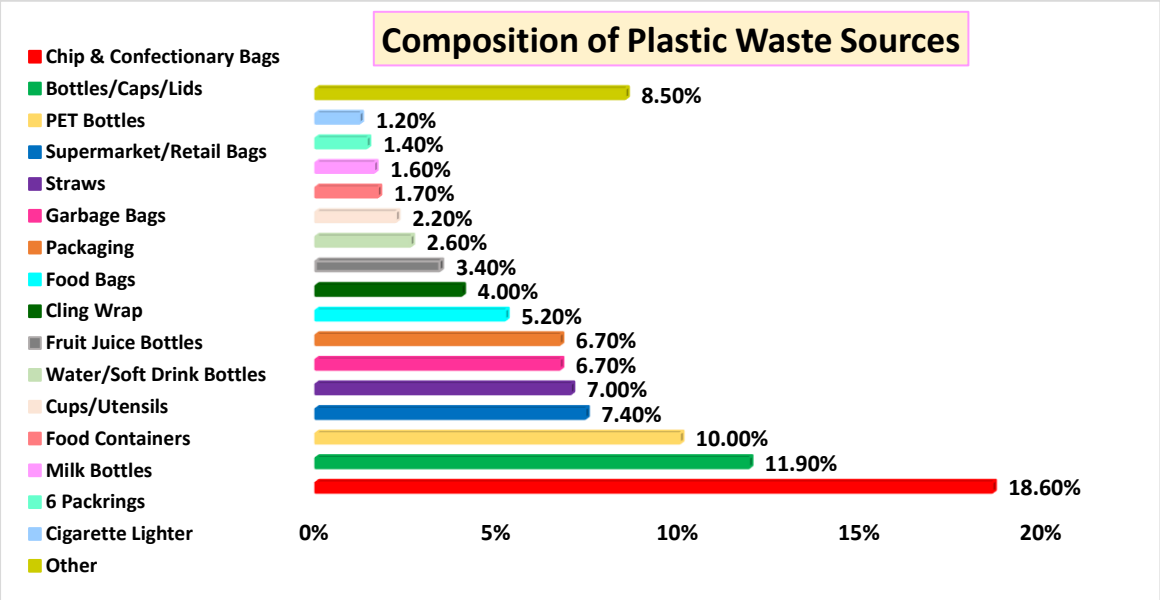

Figure 4 Categorization and composition of plastics for various sources (**Colvalcar, et. al., 2022**)

Plastic Production Industry

In Bangladesh, one of the major industrial sectors that significantly contributes to the national economy is plastic. With over 5,030 plastic manufacturing businesses (Hasan, 2021) and these businesses are meeting 80% of local consumer demands with yearly domestic sales of nearly TK28,000 crore and roughly 15 lakh jobs created (Noyon and Ahmed 2021). Those industries create a wide range of goods for both the home and international markets. Numerous goods in different economic areas, including textile, healthcare, construction, electronics, energy production, automobiles, etc., contain plastic as a fundamental component. Bangladesh produces a variety of commodities, including PVC pipes, clothing, bags, accessories, toys, sanitary items, and packaging for the Fast-Moving Consumer Goods (FMCG), pharmaceutical, and food processing industries. Accordingly, the manufacturing of plastics accounts for 1.5% of all exports and 1% of our overall GDP (Rahman, 2021 and Begum, 2021). Bangladesh is the world's 89th-largest exporter of plastics and will become the fiftieth-biggest plastics exporter (Begum, 2021). There are many sectors available in Bangladesh for plastic consumption like the packaging industry, agricultural sector, construction, and infrastructure sector, automobile manufacturing Sector, plastics from the biomedical sector, electrical and electronic equipment manufacturing industry, solar PV and LED manufacturing sector, and others.

Environmental Effects of Plastic Pollution

Plastic pollution is the accumulation of synthetic plastic products in the ecosystem towards the point where they endanger not only human communities but also wildlife and their ecosystems (Moore, 2022). Global plastic pollution is a concern. On average, 7 billion of the 9.2 billion tons of plastic produced in between 1950 and 2017 become waste and discarded or disposed of in landfills (Plastic Pollution, n.d.). Plastic pollution has the potential to alter natural habitats and processes, reducing ecosystems' ability to adapt to climate change. and negatively influencing the social well-being, livelihoods, and food production of hundreds of thousands of people. Chlorinated plastics have the potential to leak dangerous chemicals into the soil around them, which can then seep into nearby water sources like groundwater (United Nations Environment Programme, n.d.). Nurdles are plastic pellets that can be used to make plastic goods. The waters receive a huge spill of nurdles. Plastics in the ocean normally break down within a year, but not completely, and some plastics may release harmful compounds into the water during this process, including polystyrene and bisphenol A. According to the study, by 2050, there will be more plastic in the ocean than fish (Knoblauch, 2022). Figure 5 depicts a situation in which environmental pollution results in poor plastics management. Throughout the whole lifecycle of plastic, humans are furthermore exposed to a variety of harmful substances and microplastics by direct skin contact, ingestion, and inhalation. These microplastics are detrimental to the environment, wildlife, and people. Microplastics, which are accessible to many creatures and can be stored and eaten for food, are a concern to animals and the environment, mostly because of their small size (5 mm). According to World Wide Fund for Nature (WWF), the average person may be consuming 5 grams of plastic on a weekly basis (Network, 2022). Due to prior manufacturing use and degradation processes, each microplastic also has a unique makeup. Microplastics can attract extremely dangerous trace compounds including medicines, heavy metals, PFOS, or plasticizer remnants. This raises the possibility of physical and chemical harm from microplastics to living things and ecosystems (Law et al., 2014).

Figure 5 Scenarios of environmental pollution by plastic waste (**Knoblauch, 2022 & Amadeo, 2022**)

DISCUSSION

PLASTIC WASTE MANAGEMENT

Management Strategies for Effective and Sustainable Plastic Waste

One of the key obstacles in solid waste management is the absence of a proper system. The effects are far more pervasive since improper disposal puts a strain on the landfills as well as presents health risks to garbage collectors, those are primarily female. Concerns about the environment and worker

safety should be shared throughout the small-scale downstream fragmented industry. In Bangladesh, basically enforcement, infrastructure, and the availability of cost-effective substitutes in addition to robust and stringent waste management systems are the primary execution problems in order to significantly improve the current situation (Mourshed et al., 2017). Rural areas are highlighted in the plastic waste management guidelines to a management perspective, but rendering technology and capacity building have not been sufficiently specified. Long-term economic stagnation might result from a plastics ban. Bans and regulations must take infrastructure accessibility and management plan into account. It is crucially vital to design management plans for waste and retain recycled materials' market value. The life cycle assessment (LCA), coupled with consumption information and legislation, would provide the foundation for the design and adjustment of the baseline model for plastic waste management and recycling.

Waste Recovery from Specific Source

According to (Hahladakis and Iacovidou, 2018), in the packaging industry, the primary polymer types used are PVC, PE, PP, and PET whereas the preliminary polymer types used in the agricultural industry are PP, PVC, PE, HDPE, LDPE, and LLDPE. The three important polymers utilized in building and infrastructure are PP, LDPE, and HDPE. Policymakers should prioritize source-specific waste reduction, and both commercial and domestic sources should be located and removed (Hahladakis and Iacovidou, 2018). Planning in the short and long terms is necessary depending on the product's lifespan. The recovery of resources from food packaging, taking into account and PE, PVC, PET, and PP, should be given top attention. One of the biggest issues facing in plastic waste management systems is recycling and waste removal from multilayer food packaging. Regarding food packing, reprocessing methods, sorting, and separation should be taken into account. The quality of recovered plastics must be improved, which calls for improved sorting and reprocessing technologies.

Mitigation of Microplastic Pollution

A rising danger to terrestrial and aquatic ecosystems is microplastic (MP) pollution. It is plentiful, and enduring in the environment. Research on alternatives and prospective remediation strategies has received a great deal of attention due to economical, environmental, and social concerns regarding the impact of MP contamination on ecosystems. Studies on MP contamination in terrestrial ecosystems are scarce compared to studies on aquatic habitats, which have received extensive study and analysis. Recent developments in MP pollution cleanup technology as well as their ramifications for the economy and society have been adequately studied and it has been found that cleanup is not possible (Arienzo, 2022). MPs are common in all areas where people interact with the environment (soil, water, and atmosphere), are harmful to ecosystem biota, and eventually contaminate food chains and have a negative impact on human health. Leaking plastics, products containing plastic (such as fertilizers, pesticides, biosolids, and wastewater), agricultural usage of plastic mulch, cosmetics, and polyamide-made textiles are the predominant contributors to MP pollution (Sajjad et al., 2022). It is crucial to create substitutes for traditional materials like plastics that may lessen or eliminate the difficulties related to MPs for completely eliminate this issue. Additionally, waste management systems must be improved to stop plastic waste from leaking into ecosystems, and cleanup campaigns must be implemented. Given that it breaks down more quickly and is more susceptible to microorganisms than ordinary plastic, biodegradable plastic is acknowledged as a viable substitute. The removal of MPs through microorganisms reveals a possibility for addressing the issue of MPs harming ecosystems by combining biodegradable polymers with bioremediation (Padervand et al., 2020). Therefore, bio-degradable plastics manufactured from non-edible biomass, such as algae, may provide a way to stop MP pollution and encourage the sustainability of ecosystems. It is critical to do an in-depth study for evaluating the environmental, economic, and societal implications of bio-degradable plastics as well as the bioremediation of MPs in ecosystems in order to prevent any potential harm to ecosystems and health (Roy et al., 2022).

Knowledge Transfer Hub and Its Role in Plastic Waste Management

Knowledge Transfer Hub and Its Activities

Knowledge Transfer Hub (The HUB) is a building for disseminating knowledge, arranging training, workshop etc. In order to facilitate a sound inter- and transdisciplinary approach in all of its undertakings, the HUB serves as an institutional platform for governmental, public, and private actors, scientific institutions, industrial groups, and relevant stakeholders. The Hub will facilitate the transfer of knowledge between enterprises, make it simple and quick for teams to access it, and do away with

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communication's need for both time and space. Additionally, it encourages employees to understand the value of sharing knowledge when providing customers with services that are specifically tailored to their needs. Respecting each person's dignity requires creating an environment that fosters professional growth and acknowledges each individual as an important part of a team that is focused on providing excellent customer service. An effective knowledge transfer strategy comprises Technology, Culture, Measurement, and Infrastructure. According to figure 6, the SCIP plastics project has five working groups doing research on five specific terminologies regarding plastic waste/pollution management through analysis in waste lab. Those observations/findings will have been transmitted through

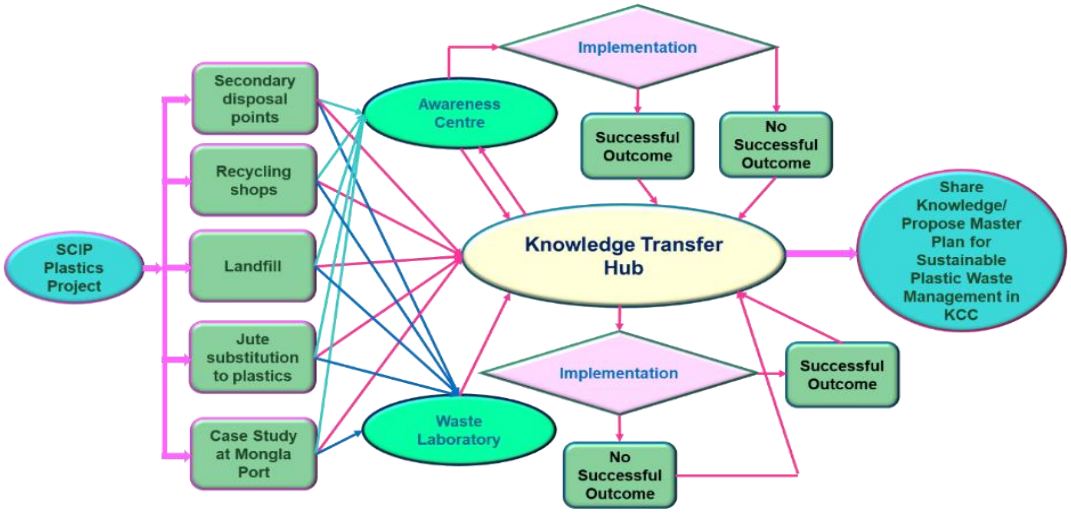

Figure 6 Role of knowledge transfer hub

Knowledge Transfer Hub and awareness center. After transferring the knowledge, field evaluation would be carried out to observe the actual scenario and effectiveness of the shared information. Both successful and unsuccessful outcome will come back to the Hub for further research and development. After that, all successful events or data should be used for masterplan preparation and rules/regulations implementation.

Figure 7 Knowledge transfer hub

The Hub is physically located on the KUET campus at the Department of Civil Engineering. It comprises these entities: the Board of Directors (BoD), Waste Lab, Awareness Centre, Working Groups, and Ombudsman.

The Hub's management and oversight are vested in the Board of Directors. Its primary responsibilities include monitoring and directing Hub activities in accordance with the vision and purpose statements and ensuring that the code of conduct is implemented as required. The BoD monitors communication and collaboration between the Waste Lab, Awareness Center, and Working Group activities and outputs.

Figure 8 Board of directors' meeting

The Waste Lab is situated at the Department of Civil Engineering, Khulna University of Engineering & Technology (KUET), Khulna-9203, Bangladesh. Staff from KUET are in charge of and run the waste lab. It serves as a training center for young researchers, supports the research initiatives carried out by the Hub's Working Groups, and completes contract work for the government, companies, and industry. It submits the reports and updates to the BoD.

Figure 9 Waste lab

The location of Awareness Centre is in Khulna City Corporation (KCC) premises, Khulna. It is directed and run by KCC employees, with assistance from KUET staff, and it submits reports to the BoD. It serves as a bridge between local inhabitants, the local municipality, and research. The awareness center plays the role of disseminating the outcome of the five working groups with the mass people.

Figure 10 Awareness center

Working Groups conduct the research projects for the Hub. The number and particular research areas of the Working Groups are decided by the Hub's Board of Directors. Teams for the Working Group may include participants from various national and international universities and stakeholder organizations. There are currently five working groups that deal with waste collection, recycling plastic, landfilling, waste management at ports, and jute as a substitute for plastic. Those working groups' research findings may act as primary data/information for Knowledge Transfer Hub.

Figure 11 Meeting with working groups

The BoD appoints and approves the Ombudsman. S/he is designated as the liaison for all Hub employees and stakeholders. S/he will function as a mediator and an advocate for the rights of the Hub's participants, including its employees and stakeholders. S/he analyzes complaints, presents the relevant findings to the BoD, and assists parties in coming to a mutually beneficial resolution in the event of violations of the code of conduct or the Performance Standards.

Role of Knowledge Transfer Hub in Plastic Waste Management

Five working groups e.g. assessment of secondary disposal points, recycling shops, landfill, plastics substitution potential by jute and case study at Mongla Port are doing their research where plastics pollution is the main concern. Research outcomes from five working groups would be shared with the HUB. The HUB will analyze and demonstrate the findings. After analyzing the research observations, the HUB will arrange necessary training, workshops, or awareness campaign to disseminate the gathered knowledge with the respective stakeholders and mass people. The HUB will also go for practical application of the research outcome to justify the findings. With the field-level implementation, the HUB will be able to understand what would be possible in real-life practice and what not. The best practice from the implementation section would be treated as the final outcome for mass sharing and preparing a master plan for sustainable plastic waste management.

Training is regarded as an essential element for human capacity development. It comprises developing a certain ability to the required level via training and practice. A person may be placed in a situation where they can accomplish their work precisely, successfully, and conscientiously with the help of training, which is a very useful tool. Training is the process of enhancing a worker's abilities and knowledge to carry out a certain task. The HUB would be acted as a center for arranging training to aware people, stakeholders, and others behavioral changes towards plastic waste.

A workshop is a conversational or practical session where a bunch of individuals exchanges knowledge or experience on a certain topic. Workshop arrangement is another major activity of the HUB. The key participants of the workshop would be stakeholders from relevant organizations, institutions, civil society, and others. In the workshop, the participants' feedback would be taken for future use and modification.

An awareness campaign is any planned, time-limited effort only intended to raise public awareness. The primary objective of an awareness campaign is to increase visibility. The HUB would play an active role in arranging awareness campaigns in different locations showcasing the impact of plastic pollution and motivating people to reduce plastic use. Besides, the Awareness Centre (AWC) located on KCC premises would support and join hands together for the successful accomplishment of the campaign. AWC and KTH are working together.

CONCLUSIONS

Nearly every human activity makes considerable use of plastic. A significant problem that is drawing all environmental concerns is the sustainable handling of plastic garbage. The most crucial challenge in protecting the environment is the appropriate and efficient handling of the enormous amount of plastic waste produced worldwide. Plastic is one of the main industrial sectors in Bangladesh that considerably boosts the country's economy. With more than 5,030 plastic manufacturing companies, which generate annual domestic sales of over TK28,000 crore and generate almost 15 lakh employment, they are able to satisfy 80% of local consumer demand. Plastic pollution on a global scale is a problem. Of the 9.2 billion tons of plastic generated between 1950 and 2017, 7 billion tons are often wasted, abandoned, or

dumped in landfills. Natural habitats and processes might be affected by plastic pollution, which would make it harder for ecosystems to adapt to climate change, affecting hundreds of thousands of people's social well-being, means of subsistence, and food production negatively. Sustainable plastic waste management is a great challenge for the whole universe. This paper presents the vital role of the Knowledge Transfer Hub (The Hub) in the sustainable management of plastic waste. According to the discussion viewpoint, it is clear that the responsibilities of the Knowledge Transfer Hub are tremendous for the successful implementation of plastic waste management.

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