# THE MANY FACETS OF WASTE MANAGEMENT: A CASE OF BENGALURU METROPOLITAN AREA

**Sumodhini V.**

*Architect, Visiting Faculty, SJB School of Architecture and Planning, Bengaluru*

*Email:* sumo.blore@gmail.com

Sumodhini V. is an Architect in private practice and Assistant Professor at SJBSAP, with a zeal for writing. Having completed her schooling in India and the US, she is an alumnus of BMSSA and has received training under well-known architects in both Bangalore and Ahmedabad. As a college student she has been speaker and participant in various events. She complements her practice and teaching with a profound interest and training in classical music and dance. She believes that there is much to learn by simple and deep observation of everything and continually adapting our response to it.

***Abstract***

Metropolitan cities around the world today deal with several macro-issues, one of them being waste management. One such city, Bengaluru, for long known as the Garden City, has been clumsily grappling with the giant that is waste management. Bengaluru is one of the fastest growing cities in the world, with the migrant population soon to surpass the non-migrant population. The consequence is a high rate of unplanned and unregulated development, causing large-scale urban sprawl. With urban sprawl comes several issues such as pollution, deforestation, need for mass transportation,water and sewerage system, the waste management system, etc. The importance given to various aspects of the urban metabolism of this city are disproportionate to the actual weightage of these aspects in our day-to-day lives, and consequently, are often overlooked in the architectural and urban design process. The present paper focuses on the ties between one such under-rated aspect, waste management, and architecture, illustrated using the case example of Bengaluru. It briefly explores design solutions successfully applied in other countries, which can be used to cultivate indegenous answers to Bengaluru's needs. It further suggests key strategies to introduce waste management studies into architectural education.

***Key words:*** Garbage; waste management; urban metabolism; urbanisation; Waste-to-Energy

## 1. Introduction

The 21$^{st}$ century is recongnised as the first Urban Century in history, as more than half of the world's population lives in cities as of 2007. This population is projected to go up to two-thirds by 2050, which would generate around 3.4 billion tons of solid waste. United Nations' Sustainable Development Goals (SDGs),

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the Paris Agreement and the New Urban Agenda mention solid waste management as a key issue to be addressed, and had in fact selected it as the theme for the 2018 World Habitat Day. Bengaluru, one of the most rapidly expanding metropolitans in the world, is currently home to over 1.2 crore residents.. The census of 2011 shows that over 47% of this population is made up of immigrants, the trend showing this number grows by 4% per annum. Various factors have contributed to this influx of population to the city, the biggest one being the booming IT sector. This expanding and diversifying population creates a robust urban metabolism. The city is analagous to the human body. As human metabolism refers to flow of food, air and water through the body, urban metabolism refers to the flows of goods, people, waste, biota, energy, food, freshwater, sand and air, through any given urban region. The urban metabolism of most cities, especially in developing countries, tend to be linear in funciton, similar to the human metabolism. That is, there is a linear progression of material or products from freshly produced, to consumed, to finally the waste which is discarded after consumption. Bengaluru is an example of such a city with linear urban metabolism. On the other hand, some developed cities in the world, such as Paris and Rotterdam, are in process of converting their urban metabolism from a linear one to a circular one. This in essence means that they are adopting practices which use waste generated at the end of the product life, as resource for further uses, thereby largely reducing or altogether eliminating the waste sent to landfills or incinerators. They are introducing volarisation techniques on a large scale, whereby maximum uses are extracted out of waste. This realisation has come after several years of research that points out that a linear urban metabolism is not a sustainable one, and if cities are to continue thriving and growing, they must transition to a circular urban metabolism.

In a linear urban metabolism, such as Bengaluru, the vast population consumes vast amounts of resources such as land, fresh water, air, food, electricity, clothes, appliances, vehicles, etc. Moreover, in a metropolitan city like Bengaluru, the amount of consumption is compounded due to the prevailing culture of capitalist consumerism, one of the lesser desirable imports from the Western world. Consequently, the consumption of these resources results in vast quantities of solid waste. Currently, Bengaluru generates upwards of 3,500 ton of municipal solid waste, or MSW, per day, most of it unseggregated and fated to be unscientifically dumped at landfills. The BBMP, the main governing body for solid waste management in the city, has two designated landfill sites, although there are tens of unapproved landfill sites being used by the private contractors for dumping unsegregated solid waste. While the BBMP is committed to safely and regularly collecting MSW from 100% of residents and commercial buildings, it only carries out 30% of the collection, outsourcing the remaining 70% to private contractors. The BBMP has in place a system that genuinely attempts to collect and dispose of waste as efficiently as possible. The process takes place in two phases. The primary collection of MSW is done door-to-door by Pourakarmikas on a daily basis using auto-tippers or push-carts. These then converge to a secondary location where the waste is loaded into a compactor or a tipper-truck and sent away to one of the

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landfill sites. In addition, dry waste collection centres or DWCCs have been set up in nearly all wards for the segregation of dry waste such as paper, cardboard, plastic, glass, etc. This segregated waste is then sent to recycling plants for processing. The BBMP has set up this waste collection method in all 198 wards of the city.

The system, however, is not perfect. The basic shortfall is two-fold. The first is that while the BBMP is very clear about managing door-to-door collection, it ambiguous about waste that gets accumulated in street corners, emply lots and other public areas. In addition, when it comes to the disposal of industrial waste, the Hazardous Wastes (Management and Handling) Rules, 1989 (as amended in 2003) lays out the guidelines for proper handling, treatment and disposal of industrial waste, but the execution is left to the discretion of the industries. The second is the apathy of the residents and lack of sensibility towards segregation of solid waste. For a solution, we need only look at our basic behavioral tendencies. A better system would be to incorporate the waste hierarchy into our daily lives. The residents need to conscientiously follow the waste hierarchy as a basic principle of waste management. In fact, this principle is suitable for adoption on all levels of society, individual, urban, state, national and even global level. As described by the International Solid Waste Association (ISWA 2009):

*'...the waste hierarchy is a valuable conceptual and political prioritisation tool which can assist in developing waste management strategies aimed at limiting resource consumption and protecting the environment'.*


**Figure 1:** The Waste Hierarchy;
**Source:** UNEP report 'Waste and Climate Change: Global trends and strategy framework' 2010

**2. Waste and its dimensions**

The BBMP caters to approximately 25 lac households and 3.5 lac commercial properties, spread over 8 zones and 198 wards, as per its own city statistics based on the 2011 census. The estimated per capita waste produced is 0.4–0.6 kg/ capita/day. At present only 10% of the waste is recycled. Biodegradable waste makes up 55–60% of the overall MSW. Recyclable material such as paper, cardboard, glass, metal, plastic, electronic make up 16–25%. The remaining 15% are inert materials that go to landfill.

Bengaluru, being an IT hub, generates large quantities of e-waste. Recyclers identified by the KSPCB (Karnataka State Pollution Control Board) are managing the e-waste at large IT companies. Today e-waste is one of the rapidly growing environmental problems. With extensive use of computers and other electronic equipments coupled with increasing discarding habits, rapid technological change, there is a significant increase in e-waste generation at the household level and public sectors. E-waste is a goldmine of resources, quite literally speaking. For example, 1 tonne of telephones

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yields 140 kg of copper, 3.14 kg of silver, 300 gm of gold, 130 gm of palladium and 3 gm of platinum. It is in the city's own good interests to extract these resources rather than discard them.

The composition of waste, as per BBMP data is as follows:

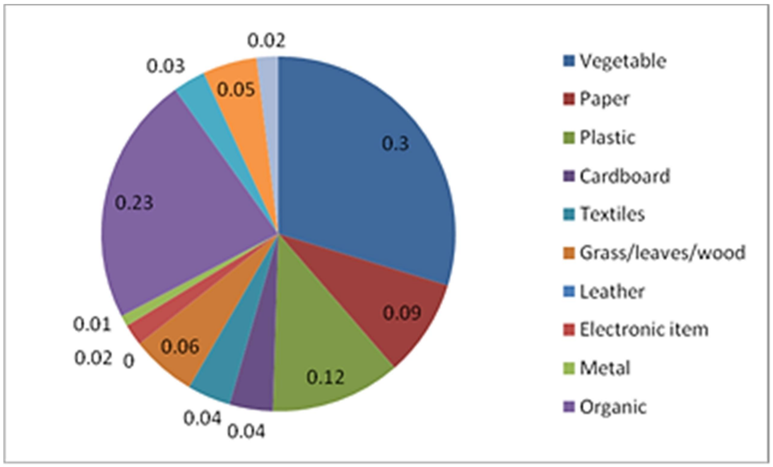


**Figure 2:** Approximate composition of MSW, Bengaluru, **Source**: http://bbmp.gov.in

**2.1. Physical-Social-Economical dimensions of waste**

In today's globalised world, everybody wants to live in an attractive city. One of the characteristics of globally attractive cities such as London, Paris and Florence is their visual cleanliness and lack of littering. The visual cleanliness speaks of efficient governing systems. Successful waste management has a direct effect on the percieved image of a city, and it positively enhances the sense of pride that a resident feels in living in that particular city. Not only this, a city whose image is positively percieved around the world is more likely to attract higher land value, talented individuals, industries and businesses, and educational instituitions, all of which are codependant drivers of development in that city. Conversely, mismanagement of solid waste can have negative impacts on the image of the city. Municipal solid waste, if left uncollected and untreated, is a health hazard, likely to breed insects, and worms, release toxins, GHG and unpleasant odour, and even contaminate the land, water and air around. These impacts are also refered to as disamenities due to MSW and they affect the health of people living in that locality. The failure to address MSW also causes the governing bodies to appear incapable, thus bringing down the desirability to invest in the city.

Municipal solid waste in any city, but especially in cities in developing countries, have high content of human/animal fecal matter, toxins, allergenic and infectious substances. Insects and rodents breed on solid wastes and can spread diseases like cholera, malaria, chicken guinea and dengue fever. Workers who handle solid wastes seldom work with safety equipment such as gloves and masks, putting their health at risk on a daily basis. Although waste management has

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provided employment opportunity for over 20,000 workers, including Pourakarmikas, rag pickers and scrap dealers, majority of whom are mostly from the BPL community, they often carry social stigma due to the conditions that they work in, and due to their vulnerability to skin ailments and other infections. This situation can be improved if the waste generators as well as managers conscientiously follow the procedures for hygienic waste disposal, to create better working environment for the waste workers.

**2.2 Environmental Impact of waste**

The method of waste management has a direct impact on the environment. Research published by the United Nations Environmental Program (UNEP) has shown that landfills around the globe contribute to greenhouse gas (GHG) emissions, estimated at approximately 3-5% of total anthropogenic emissions in 2005. Mixed waste dumped in landfills generate methane (approx. 50%) and carbon dioxide (50%) due to action of microbes in an anaerobic environment. Methane and carbon dioxide are greenhouse gases, whose presence in the atmosphere contribute to global warming and climate change. Methane is a particularly potent GHG, and is currently considered to have a global warming potential (GWP) 25 times that of carbon dioxide. Landfills, however, are not the only sources of GHG emissions. The process of transporting waste, treating it and recycling are all activities which contribute to the greenhouse effect. UNEP has shown that prevention and recovery of wastes (i.e. as secondary materials or source of energy) avoids GHG emissions in all other sectors of the economy, such as energy, forestry, agriculture, mining, transport, and manufacturing. In addition, landfill leachate is one of the main sources of groundwater and surface water contamination when it is not scientifically collected, treated and safely disposed as it may percolate through soil reaching water aquifers.

Non-biodegradable waste such as plastics, glass, batteries, etc. take anywhere between few decades to a millenium, depending on the type of compound. Hence, it is preferable that the use of such non-biodegradable material be reduced, or avoided althogether. Overall, an effective approach to waste management is one which is guided by the waste hierarchy on all levels, ranging from individual to global.

**3. Waste and its positive attributes**

Waste management plays an important role in raising or lowering the quality of our lives. Successful waste management not only has the power to add to the aesthetics of a city, but it also helps to improve the health of the city and its people. Cleaner neighbourhoods, water and air all contribute towards a higher quality of life. A city with a circular metabolism does lesser irreversible damage to the environment, and hence, is more sustainable in the long run. Waste, when segregated and processed properly, can be a source of material through recycling, a source of manure when composted, and a source of energy when used in waste-to-energy or WtE plants. While first preference undeniably needs to be given to reducing and reusing waste at the source level, waste that is unavoidable needs to be segregated and diverted into these various pathways if we are to extract maximum resourcefulness from waste.

### 3.1. Waste as a resource

Segregated waste yields several types of material, organic, recyclable and other inert material. The waste generated in Bengaluru consists largely of organic and recyclable material. Of these, organic waste makes up more than half of the total waste generated in the city. To address this type of waste, the BBMP has contracted a vendor to set up an organic waste converter plant in Jayanagar. The plant processes 1,000 kg of organic waste from the ward everyday, producing 300 kg of manure every 10 days. The contractor is able to sell 15 ton of good quality manure every month. The success of this project has prompted the BBMP to search our other suitable locations in the city, such as fruits and vegetable markets, for such plants.

Hygienically separated waste can be used a second source of material like glass, metal, cardboard and paper by recycling or upcycling. Another, rather innovative method to upcycle such inorganic waste is by reusing it to conduct activities where members of the community can gather and create art. One such not-for-profit organisation in Australia, called Reverse Garbage, promotes environmental sustainability and resource reuse. They conduct art workshops and provide environmental education. Their raw material is made up of high quality industrial discards and pre-approved, hygienic discards from households.


**Figure 3:** Reverse Garbage facility in New South Wales, Australia

**Source:**https://www.howwemontessori.com/how-we-montessori/2020/03/outdoor-loose-parts-play-visit-to-reverse-garbage-sydney.html

Another industry in which waste can be used as a major resource is the energy industry. The example of Sweden, with its WtE success, has shown us that putting in place extensive and efficient waste management systems means that municipal waste in landfills can be almost non-existent. About 99.3 % of all household waste in Sweden is recycled or recovered as energy, making it the leader in efficient waste management. Sweden's waste is recycled as district heating, electricity, biogas, fertilizer and materials. Sweden is the only country in the world to import garbage, attesting to the usefulness of waste, when dealt with using optimal technology.

### 3.2. Various challenges and opportunities

In a city like Bengaluru, the volume of waste generated offers a constant, reliable and major source of material and energy. Waste is a resource that no country can run out of. With the current growth rate, the quantity of waste can only increase. It is essential that systems be put in place for timely collection and

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scientific treatment of such waste, which can further lead to recycling or WtE plants, whichever is more appropriate. In a country which relies mostly on thermal and hydrothermal power plants for all its energy requirements, WtE plants could be set up to provide supplemental energy. Similarly, identifying suitable locations to set up organic waste converters which can cheaply produce vast amounts of good quality manure is the right direction to take for a country like India, which is still largely dependant on its agricultural sector. Currently the most pressing requirement is for cities to organise themselves into systematic machineries that efficiently address the issue of waste management, and to search out or innovate new technology that would help them to tackle this issue.

## 4. Waste and Architecture

The workings of urban metabolism of a city is sheltered within the small and large architecture and urban planning of the city. If urban metabolism can be likened to the metabolism in the human body, then the architecture and planning of that city is the human body itself. Just as the city's communities need to be planned for efficient inflow of goods, vehicles and people, they need to be planned for efficient outflow of wastes without hindering the functions of the communities. For the city to perform optimally, the network of waste collection and processing needs to be set up in a way that addresses waste from all sources and in all forms. Hence, architecture and planning are inseparable from waste management. The study of waste management in architectural education and practice worldwide must be made indispensible, if buildings, and in turn cities are to be designed for sustainable and efficient waste management. This can be done through study of literature, case studies of successful waste management techniques and through experimentation. This knowledge, along with the study of city's waste generation patterns, can then be used to create innovative, but indegenous solutions. The current situation calls for architectural intervention based on research and innovation in waste management systems and techniques, crucial not only for evolving holistic design for the future, but ultimately for achieving a circular metabolism for any city.

### 4.1. Waste from Architecture

The debris from construction activities is known as construction and demolition waste, or C&D waste. The quantity of C&D waste generated in Bengaluru is around 2,500-3,000 ton per day. Although there is a C&D waste processing plant, privately run by Rock Crystal in north Bengaluru's Chikkajala area, with a processing capacity of 1,000 ton per day, it currently only processes 80 ton per day. The remaining construction debris is dumped into quarries, empty lots, and lakebeds. The setting up of a second C&D waste processing plant, with 750 ton per day capacity, in Kannur is in the works. However, the inaccessibility of the processing plant and lack of demarcated aggregation points for collecting and transporting construction debris, along with the fee that is charged for utilizing the services means waste generators have no incentive to transport their debris to the processing plant. This problem could be solved by demarcating 6-8 aggregation points for C&D waste collection, as suggested by experts, and by reimbursement provided by the municipality for transportation expense, as it is done in the cities of Delhi and Indore. In addition, in expansion or renovation projects,

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architects can consider the possibility of constructing around or over existing buildings, if they have retained their strength and stability. This would help to reduce the overall quantity of C&D waste generated in the city.

**4.2. Architecture from Waste**

There are endless opportunities for architects to explore and innovate with waste material as resources for building. Already several experiments have been carried out around the world using discarded material, directly and without any form of processing, as building material. Few examples are illustrated below.

**Figure 4:** Waste House, Brighton, UK (made of 85% waste material)
Architect: Duncan Baker-Brown
(collaboration with undergraduate Brighton students.)
**Source:**https://www.dezeen.com/2014/06/19/waste-house-by-bbm-architects-is-uks-first-permanent-building-made-from-rubbish/

**Figure 5:**Salvaged tyres used to build retaining walls
**Source:**https://in.pinterest.com/pin/8796161759675465/

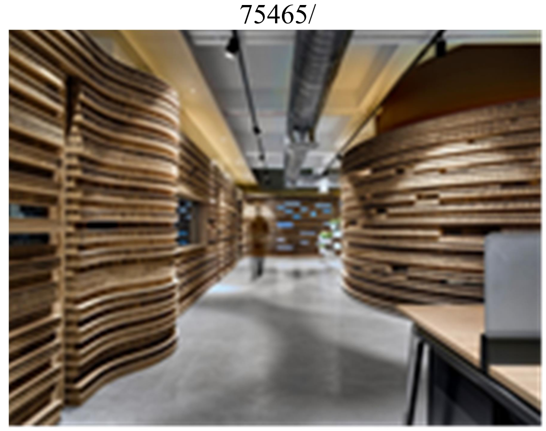

**Figure 6:** The Cardboard Office / Studio VDGA, Pimpri-Chinchwada, India
**Source**:https://www.archdaily.com/931438/the-cardboard-office-studio-vdga/5e14bada3312fdf5c9000252-the-cardboard-office-studio-vdga-photo

**4.3 Waste in Architecture**

The consideration given to handling, storing and segregating waste in all types of building, including office, residential, industrial, institutional, etc, needs to be stressed by the designer/architect in order to shift the mindset of the users of the building. Architects and planners need to provide for waste management at all scales of building and planning if the tendency of the user is to change from repulsion to accepting the truth about waste. Making waste management an integral part of building program helps to set a routine for waste disposal. Building design and urban planning need to provide proper segregated storage and circulation path for waste, making it clear to the users and residents that waste is an unavoidable part of day-to-day life and that it needs to be addressed in a practical and sustainable manner.

### 4.4. Architecture for Waste

The design trend for the foreseeable future is likely to follow innovative solutions for waste management, be it products, buildings or urbanscape. Not only that, architects are being commissioned to design such facilities as waste sorting and treatment centres, which were previously considered as purely functional, but dull buildings. Such centres are adopting innovative methods of highlighting waste as resource and opening up to public to help spread awareness about the usefulness of waste. Few examples are illustrated below.

**Figure 8:** Rooftop view of Maag Recycling, Winterthur, Switzerland
Architects: OOS
**Source:**
https://archidose.blogspot.com/2005/11/maag-recycling.html

**Figure 9:** The WtE Design Lab, Northeast Coastal Park, Barcelona, Spain

Architects: Abalos & Herreros

**Source:**https://research.gsd.harvard.edu/wte/item/interview-inaki-abalos/

**Figure 10:** North Granada Ecoparque - Clean Point (waste collection centre)
Architect: Gonzalo Arias Recalde
**Source:**
http://ariasrecalde.com/ficha.aspx?proy=34


**Figure 11:** One of the several mobile waste collection vehicles in Granada
**Source:**https://www.interempresas.net/Reciclaje/Articulos/104113-Ecoparque-movil-conocer-invita-a-hacer.html

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**Figure 12:** Kara/Noveren Thermal Power Plant, Roskilde, Denmark
Architect: Erick Van Egeraat.
**Source:**http://www.martinbiopower.com/projects/case-studies/roskilde-plant-denmark/

A deeper involvement of architects and urban designers in designing a city's waste management system may be facilitated by introducing the subject of waste management in the educational and training process, i.e., strengthening the foundation laid at an early stage of education in these desciplines by making it a vital part of the curriculum.

**5. Way forward**

The need of the hour is for architects, designers and planners to look at waste management as being in a key position to affect the aesthetics and health of our homes, streets, neighbourhoods, cities and ultimately our countries. The design approach would be made more holistic by incorporating the needs of waste management into the design from the earliest stage. It needs to be looked at as a service requirement, on par with other services like electricals, water supply and drainage. As generators of waste, we need to be aware of how waste management, or the lack of it, may affect the quality of our lives. The basic values of waste management, such as the waste hierarchy, need to be taught and inculcated in young minds. Higher education in the fields of architecture, engineering, urban planning and other allied fields, need to teach waste management as a dedicated subjects, through contextual study of waste management technologies and system of circular metabolism in cities around the world, through the means of literature study, site visits and problem solving exercises. It needs to be made an indispensible subject in higher studies and training, with special encouragement given to research in this field, especially for architects, designers, engineers and planners. Accordingly, given below is a suggestive program for step-by-step introduction of waste management studies in Architectural Education.

**Table 01:** Suggestive program for introduction of SWM studies in Architectural Education
**Source:** Author

| Semester | Study topic | Methodology/approach | Learning and outcome | Assessment |
|---|---|---|---|---|
| 01 | Introduction to solid waste management and principles of waste hierarchy | Textbook study<br>Comparative case studies of one indian and one western city | Understanding of depth and range of solid waste management in daily living and design | Submission of Case study report and Viva voce |
| 03 | Components of | Textbook study | Appreciation for | Submission of |

| | | | | |
|---|---|---|---|---|
| | Solid Waste and Urban metabolism | Visits to local sorting centres and landfills | resource that can be extracted from solid waste | site visit report and Viva voce |
| 05 | Study of recyclable and non-recyclable waste | Textbook study<br>Visits to recycling plants<br>Isolated design exercises<br>Case studies | How to design for solid waste management and integrate waste hierarchy principles into design | Submission of short portfolio containing site visit reports, case studies and design exercises and Viva voce |
| 07 | Design Solid waste management system for design project | Incorporation of solid waste management facilities into main design project | Understanding of solid waste management as a must-have for all design projects | Assessed as part of main design project |

Additionally, below are some activities that may be taken up at a community or city level.

**Table 02:** Suggested activities at community or city level for addressal of MSW.

**Source:** Author

| Method | Activity |
|---|---|
| Summer/Winter workshops | 1. Composting techniques for various scales<br>2. Building structures to scale using upcycled dry waste<br>3. Art, sculpture and installations out of upcycled waste<br>4. Making public facilities such as benches and rain shelters using upcycled waste |
| Proposals to governing authorities | 1. Study and suggest efficient collection schedule for various types of wastes based on ward-wise Municipal Solid Waste profile<br>2. Design mobile collection vehicles for recyclable wastes<br>3. Design local collection points to receive segregated waste and facilitate waste compactor/ auto-tipper movement<br>4. Introduction of basic principles of solid waste management and waste hierarchy in government and private schools and colleges. |
| Social responsibilit activities | 1. Carrying out awareness drives and demonstrating the usefulness of waste and the need for conscientious segregation at source<br>2. Putting up street plays and posters to inform about waste hierarchy |

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The above program, though only suggestive, dilineates the various ways that the study and understanding of waste management could be made part of architectural education, and hopes to open up possibilities that these could be adopted by educational institutions. A holistic education and training process will ensure a holistic way of looking at the design process at the building, community, city level and further on. This, in combination with research and science based regulations, will systematically help our cities to transform into cyclic metabolisms for sustainable, self-sufficient and eco-friendly growth.

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