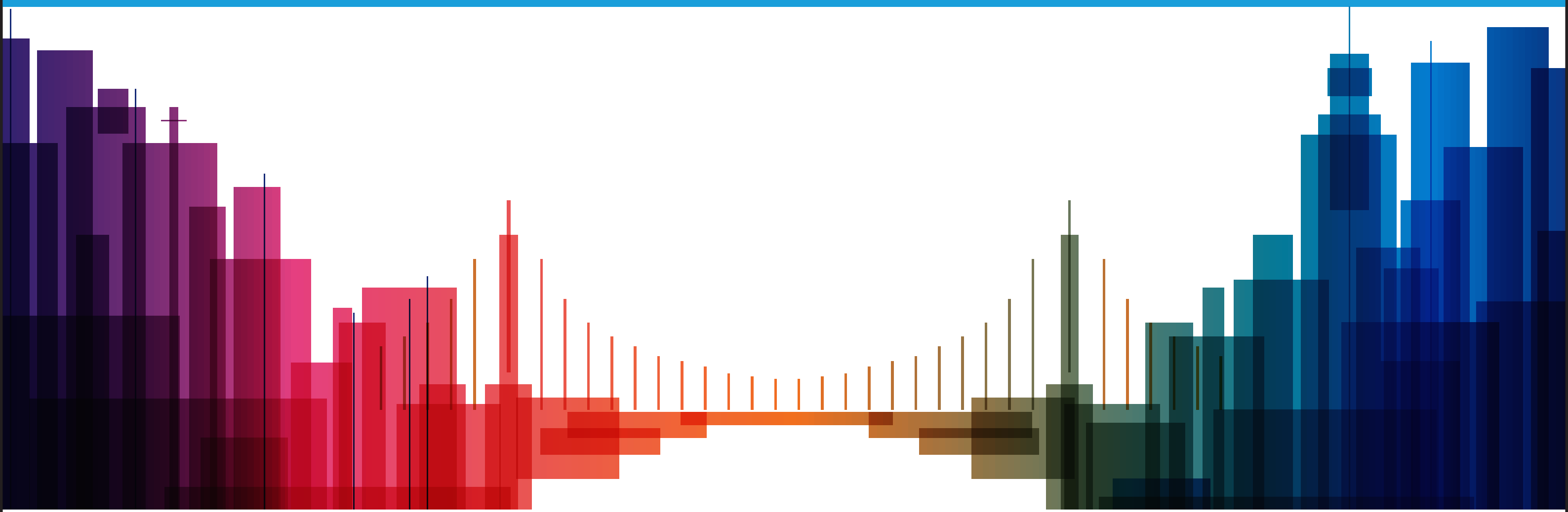
United 4 Smart Sustainable Cities

City solid waste management

Case study of the U4SSC A guide to circular cities

June 2020



Convention on Biological Diversity

United Nations ECLAC

Food and Agriculture Organization of the United Nations

ITU

UNDP Empowered lives. Resilient nations.

United Nations Economic Commission for Africa

UNECE

UNESCO United Nations Educational, Scientific and Cultural Organization

UN environment United Nations Environment Programme

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June 2020

Foreword

This publication was developed within the framework of the United for Smart Sustainable Cities (U4SSC) initiative.

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United 4 Smart Sustainable Cities

Case Study 1 - Spain: SmartWaste - Promoting recycling of municipal waste

Author: Jorge Díaz García-Herrera

Introduction

Background

Cities are responsible for 50 per cent of the global waste generated and are causing between 60 and 80 per cent of greenhouse gas emissions globally. Against this background, concepts such as circular economy are particularly important, even more so when cities consume three quarters of natural resources.[1]

Figure 1: Recycling containers

Source: www.esmartcity.es

Recycling is one of the fundamental pillars of the circular economy; its objective is to use the waste originating in industrial processes as raw material for another process through exchange, reconditioning, repair and re-use in a closed circuit. In this context, what was previously considered 'waste' can become a valuable resource.

According to the latest Eurostat figures, across the EU on average more than 45 per cent of municipal waste (which does not include industrial or hazardous waste) is being recycled. The new Directive (EU) 2018/851 amending Directive 2008/98/EC on waste, maintains a 50 per cent target for 2020, and establishes that the new targets for 2025, 2030 and 2035 will require a one-point annual increase. In that scenario, all EU members will have to recycle at least 55 per cent of municipal waste by 2025, going up to 65 per cent by the year 2035. However, in Spain this figure remains stuck at 29 per cent and the worst part is that the figure has remained practically the same since 2010.[2]

In 2017, Ecoembes, the organization responsible for the recycling of packaging in Spain, created TheCircularLab,[3]the first innovation centre in Europe on circular economy, whose main target is to analyse, design, promote, test and apply in a real environment the best practices in all phases of recycling. Working closely with its technological partner, Minsait[4] (from the Indra Group), TheCircularLab has developed and deployed the SmartWaste initiative, which applies smart city technologies to monitor and control the entire process of recycling urban waste.

Challenge and response

Increasing the rate of urban waste recycling in Spain to meet EU targets requires facing the following challenges:

- The lack of awareness on the part of citizens, due mainly to the lack of information about the importance of recycling and its impact in the environment, and how it must be done at home.
- There is no measurement of the quantity of correct disposal of waste generated at home, so promotion policies like individual or community payment for waste cannot be properly enforced.
- collection is a service mainly undertaken by contractors so local authorities do not have real-time information about how the recycling process is taking place on the streets, and therefore, do not know the needs, type and location of the containers, or the frequency of filling and their efficiency of materials in order to control the compliance of service level agreements.
- Some areas still maintain a low quality of collected material, with a large number of improper elements that make it difficult to re-use, due mainly to the lack of education in recycling of all actors involved in the process.

It is important, therefore, to monitor the recycling process using real-time information, which enhances transparency for the citizens, facilitates the implementation of promotional campaigns, optimises municipal resources dedicated to the collection of urban waste, and increases the efficiency in re-using the material.

In line with this, Minsait has developed the SmartWaste project for collecting and analysing data from all types of sensors located throughout the recycling process, which allows relevant data to be obtained, in order to make predictive models of behaviour that help in decision making. Currently, the SmartWaste project is in the deployment phase as a pilot project in four management units that bring together 275 Spanish municipalities, and serves a total population of more than 600 000 inhabitants.

Promoting circularity

Vision and content

True commitment to the circular economy requires the cooperation of all stakeholders: citizens, as the main participants; local authorities; and the contractors that provide and operate municipal services.[5]

The main objective of the SmartWaste project is to identify the relevant information for each of the previous actors and provide it in a suitable format for decision making, as well as to enable the implementation of initiatives to promote and facilitate the recycling of waste among citizens.

Citizens should, first of all, be well informed. They should know the details of how to recycle correctly, how to separate the different types of waste and where to deposit each of them. Citizens should also be aware of the importance and positive aspects of recycling for the environment. Furthermore, they should know the products that can be obtained from their waste as a result of recycling. On the other hand, they should have the necessary means to participate and to be able to report incidents associated with the waste collection service, such as containers that have been overloaded, broken or burnt, or even collected outside the planned schedule.

Municipal councils and other entities, such as consortia and associations of municipal councils should ensure that waste collection and treatment services are carried out correctly and in compliance with the service levels that have been agreed upon, and, when possible, to increase its efficiency. For this purpose, SmartWaste provides local entities and their contractors with the necessary indicators to carry out the management of the service and guarantee an adequate provision of it.

Through SmartWaste, a municipality can determine the optimal position of waste containers, depending on the distance from the citizens, and combines information by integrating data from other systems, for example, the average age of the population in a specific area. The exit indicators shown by SmartWaste will also allow the determination of those neighbourhoods that are more efficient and those that are not. This information is aimed at improving the quality and recycling rate.

Implementation

The project started a pilot phase in June 2018 with four management units: Consorcio de Aguas y Residuos de la Rioja (CARE), municipality of Logroño, Cabildo de la Palma and Medio ambiente, Agua, Residuos y Energia (MARE) of Cantabria.

Table 1: Management units of the pilot project SmartWaste

	Municipalities	Inhabitants	Area (km²)	Vehicles	Light packaging waste (Tn)	Paper waste (Tn)
CARE	173	164 918	4 964.09	7	2 523.2	3 892
Logroño	1	150 876	80.91	10	2 308.4	3 560.6
La Palma	14	86 528	708.3	15	822	1 604.3
MARE	84	245 926	5 321	41	2 403.4	3 997.5
Total	275	648 248	11 074.3	73	8 057	13 054.4

Source: Minsait

SmartWaste is operated by monitoring technologies such as:[6]

Fill-level sensors, installed in the waste containers, these facilitate the optimisation of waste collection routes in real time, so avoiding situations in which containers are empty. The result is greater service efficiency, cost reductions and lower emissions from vehicles.

Container weighing systems are also being installed in garbage trucks to calculate the contribution of a specific area. This information is combined with the fill level measured by the sensor in the container, and thus the density of the waste can be calculated. By combining with historical data and calculating possible deviations, it would be possible to know if the contents of a container are of the appropriate quality (whether the container contains inappropriate material that does not correspond with the waste type in question).

RFID tags[7] installed on containers that enable collection service traceability, providing information related to the time of collection, movement or cleaning of a container. In this way, local councils and/or service operators can compare the service provided with the planned service, detecting possible deviations.

The vehicles are also equipped with devices that facilitate the collection, sending information about the driving and determining patterns to make it more efficient. They are also fitted with cameras, which can record the status of a container before and after collection in order to monitor the process.

A centralised IoT open platform provided by Indra and tested in multiple Smart City projects, analyses the collected data in real time from sensors in containers and vehicles for waste collection. Being cloud-based, these centralised services do not require the installation of an infrastructure in the management units and the connectivity to the platform is carried out through APIs and/or web services, facilitating the entry of data from any type of device, and integration with other information systems.

The IoT platform also relies on a Geographic Information System (GIS) and Big Data techniques to analyse the causes of the performance and impact of recycling and waste management in cities and territories.

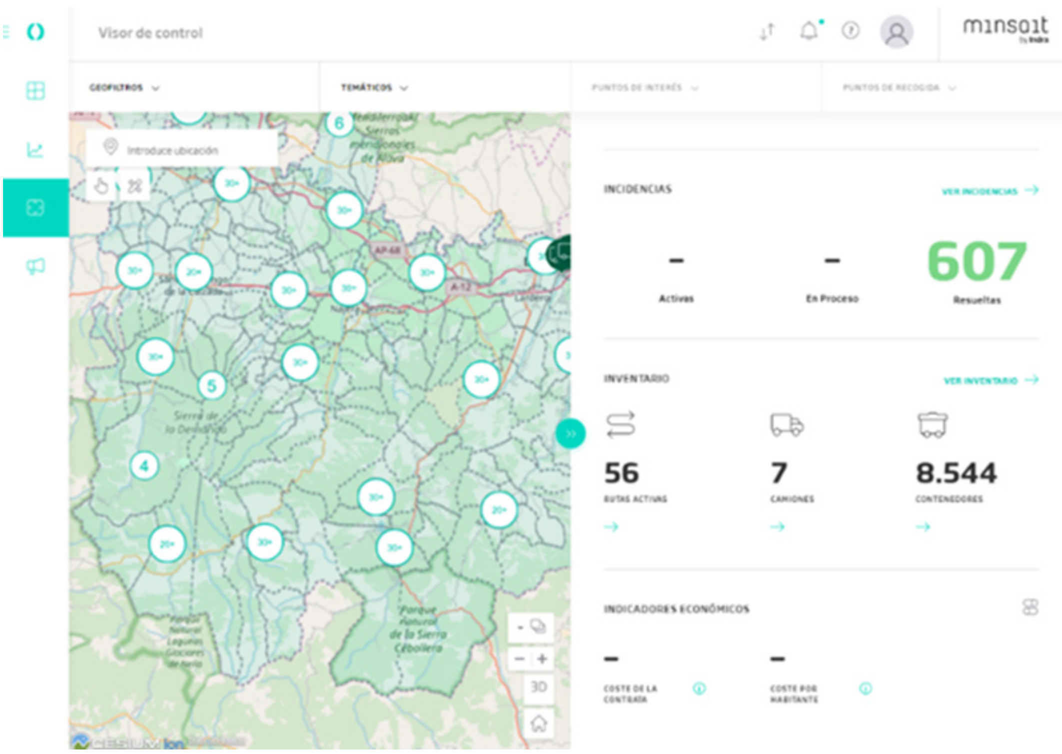
Results

The project pilot deployed in the management units offers data that will serve to improve the collecting process and to take measures that encourage recycling in citizens and municipalities. These data come from the IoT network, but they can also be linked to other information systems like the census, so the platform allows setting correlations between the recycling process and other variables like density of population, building occupation, family members, age, level of education, and so on. The information obtained by SmartWaste can be used for the internal management of the processes, but also made public to the citizens, in order to support raising awareness about waste recycling.

These indicators are grouped to form rates that are displayed in different visions of a Balanced Scorecard, depending on the stakeholder to whom the information is directed:

1) Vision of the recycling infrastructure: The SmartWaste platform allows service providers to know the exact location of the containers, their filling status and the needs of the area in which they are located (Figure 20). The data obtained can be grouped according to the needs and reach a high level of granularity, allowing statistical analysis and simulations. The next step would be to use the result of the analysis to optimize the number and location of containers and the types required. Later, it could also be used for the implementation of payment policies for waste

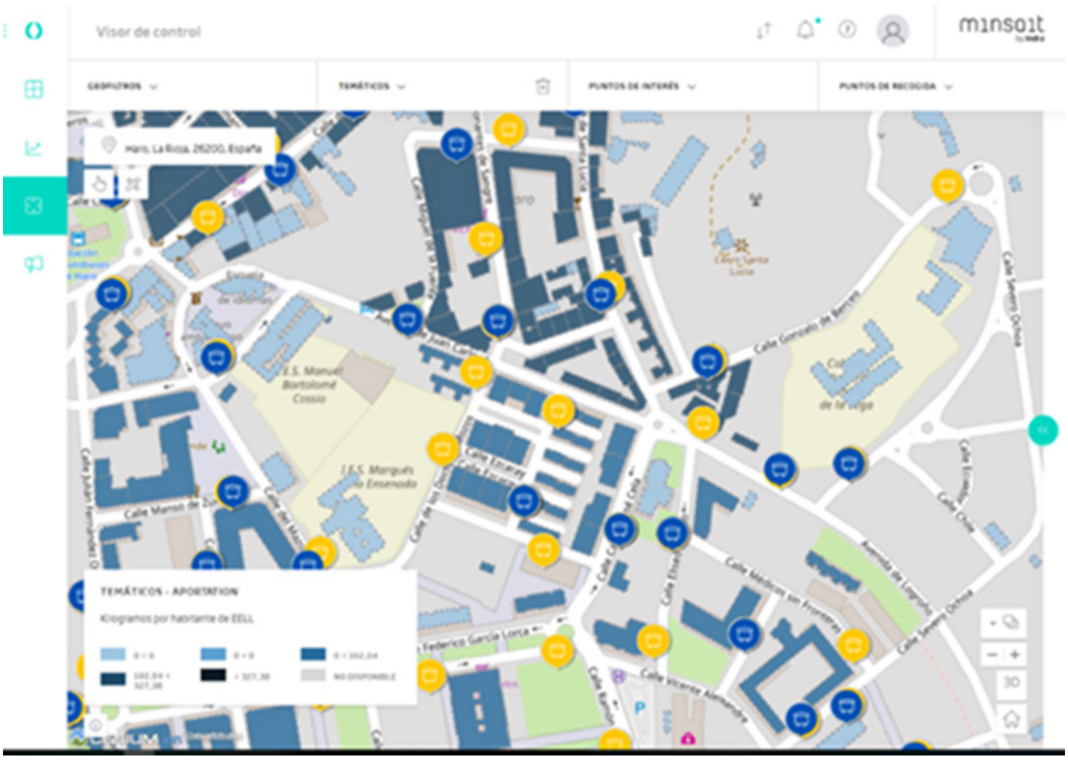
Figure 2: Section of one city with the location of containers



2) Vision of control and optimization of collecting service: The information provided by the platform allows the planning of routes and the frequency of collection in an optimal way, according to the status of the containers, as well as compliance with the collection agreements; the analysis of the

incidents detected during the service; the real-time monitoring of vehicles and traffic; and the monitoring of driving patterns.

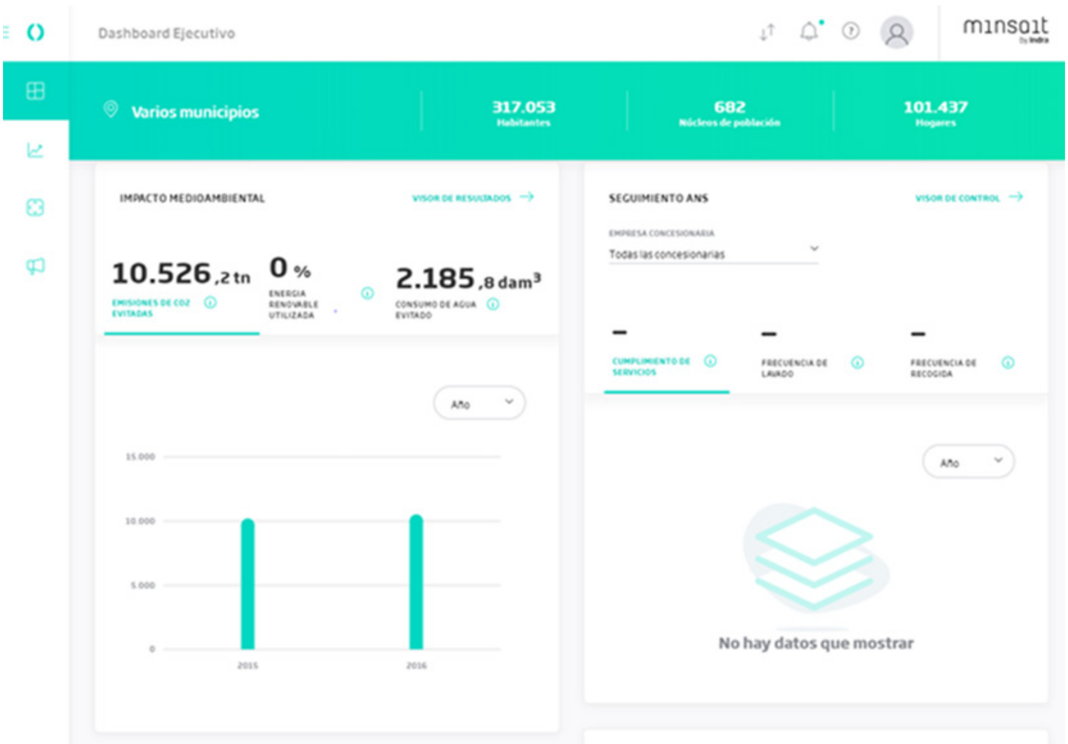
Figure 3: Control of the collecting services



This information is of special interest for the contractors that operate the service in order to enable them to optimise the use of their resources.

3) Vision for monitoring the performance of the process: The level of detail in the data allows us to know the environmental impact in terms of energy (CO2 emissions) and water savings (Figure 21), and also the percentage of recycled material that will be useful for re-use at the container level (Figure 5), which will serve to implement promotion campaigns in specific areas that increase the performance of the process.

Figure 4: Environmental impact: CO2 emissions and water consumption avoided



The specific indicators provided by the platform are:

- Percentage of selective collection on total waste collection
- Percentage of selective collection on organic waste collection
- Percentage of selective collection on light packaging waste collection
- Percentage of selective collection on paper and paperboard waste collection
- Percentage of selective collection on solid urban waste collection
- Average improper waste
- Selective collection by citizen and year
- Light packages collected by citizen and year
- Paper and paperboard collected by citizen and year
- Solid urban waste collected by citizen and year
- Organic waste collected by citizen and year

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List of discussions partners/interviews

- Miguel Angel González San Román, Digital Solutions Director at Minsait.
- Mr. Marcos Leyes Bastida, Digital Specialist at Minsait.
- Mr. Fernando Sanz Merino, Innovation Specialist for Smart cities at Ecoembes.

Case Study 2 - India: Use of plastic waste in road construction

Author:

Vimal Wakhlu

Introduction

Background

The modern urban lifestyle dictates the generation of plastic waste, which needs to be disposed of or recycled. With developing countries undertaking considerable road construction activities, some have found a way to repurpose plastic waste for road construction.

As the world's second most populous country, with a population of 1.3 billion, and a significant plastic waste problem, India is a noteworthy case study. In India, almost 70 per cent of the population live in villages. Even though rural inhabitants do not generate quite as much plastic waste as their urban counterparts, this amount is still substantial given their sheer number. Meanwhile, across India, about 174 km of roads are built every day, whilst the amount of plastic waste generated exceeds 5.6 million tonnes per year. Merging these two could potentially represent a solution for re-using plastic waste in India.

Challenge and response

Over the last few decades, plastic materials have become an integral part of the modern lifestyle. Plastic bags, packing material, bottles, cups, and various other items have slowly replaced their counterparts that are made of other materials, largely thanks to the advantages of plastic. Plastic is durable, easy to produce, light, odourless, and chemically resistant. However, plastic materials have an important drawback: they decompose at an extremely slow pace which poses serious threat to the environment.

The challenge that most of the cities in India, and in other developing countries, are facing is the enormous amount of plastic waste that is generated due to modern ways of living, and this is becoming increasingly difficult to handle. Most people living in cities start their day generating waste such as milk wrappers.

While improper plastic waste disposal poses a serious risk to the ecological system, it also impacts human health directly. Hence, the opportunity of converting plastic waste into a resource for road construction activity is very much needed in countries like India.

The solution involves using plastic waste in road construction via a special technology, which makes the road stronger, less susceptible to the vagaries of nature and with less maintenance costs. At the same time, we are getting rid of plastic waste generated inside the cities. Thus, it represents a smart solution, which pertains to the Circular Cities deliverable of U4SSC.

Promoting circularity

Vision and content

Plastic garbage is a common sight around the country and has started to cause numerous problems. For instance, plastic waste clogs drains, causing floods. It also represents a choking hazard for animals that eat plastic bags and similar items. Moreover, plastics found in fields block germination and prevent rainwater absorption. Plastic waste also causes significant water pollution.

Recycling plastic can be done only 3–4 times and melting the plastic for recycling releases highly toxic fumes. In India, plastic waste is recycled inefficiently. About 60 per cent of the plastic waste collected and segregated gets recycled back into materials for further processing into consumer products, while the remaining 40 per cent is left unutilized. This remaining plastic waste needs to be handled effectively in order to protect the environment.

The plastic waste can be used in road construction. Field tests have proved that after proper processing, plastic waste can be used as an additive to toughen roads while also helping to save the environment. Plastic increases the melting point of the bitumen. A city using this technique for road construction and maintenance is bound to benefit socially, economically and environmentally. Consequently, it should be a part of any long-term city smart vision and strategy.

Implementation

Using recycled plastic to build roads has already been done in different parts of India, starting from Tamil Nadu. The idea is gaining traction worldwide and is being tried out in countries like Uganda.

In India, which has a heavy rainfall during the monsoon season, the usual bitumen used in laying roads is lost when rainwater penetrates underneath the layer and strips it from the binding layers below. When plastic is used to coat the bitumen, it prevents water from seeping in. The road layer, therefore, remains strong even after lashing rain.

Key features and design

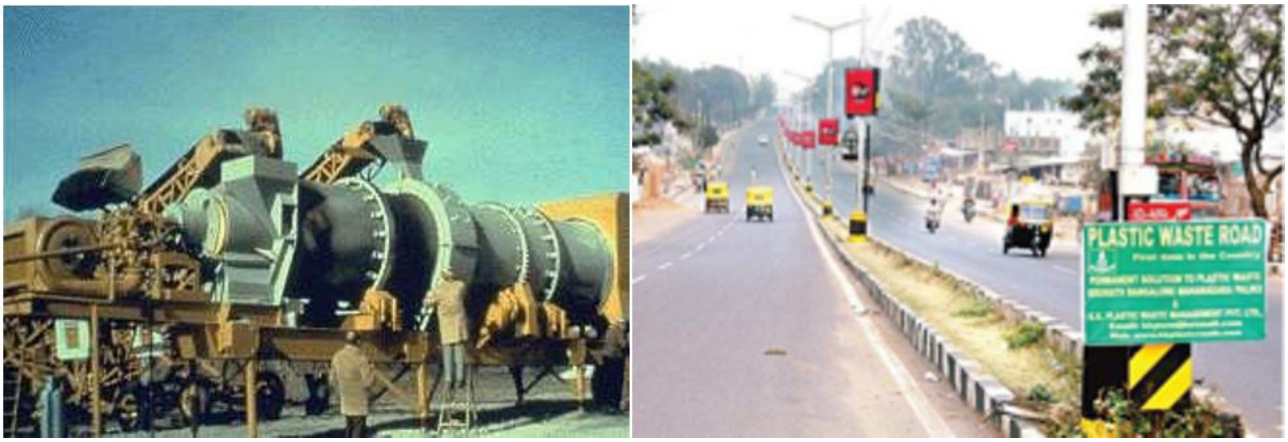
The technology for this was developed by the 'Plastic Man' of India, Dr Rajagopalan Vasudevan, Professor of Chemistry at Thiagarajara College of Engineering, Madurai, India. It promises to make a significant difference to the quality of roads in India.

The **process** begins with the sorting of plastic waste, the shredding of the waste into tiny pieces, roughly 2–4 mm in length, and by adding the shredded polymer waste to stone aggregate. The stone aggregate, which is comprised of granite and ceramic pieces, is heated to 160–170° C. The coated stone aggregate is then added to bitumen at a temperature between 155° and 163° C, and the mass is mixed thoroughly. This mixture is then loaded onto road layers that put the final coat on the road. It is finally levelled with a roller.

Figure 5: Aggregate

Figure 6: Plastic waste

Figure 7: Mixing of shredded waste plastic, aggregate and bitumen in a central mixing plant



Policy enablers

The state governments in India support this concept. A Government of India order in November 2015 made it mandatory for all road developers in the country to use waste plastic, along with bituminous mixes, for road construction. This was primarily aimed at helping to overcome the growing problem of plastic waste disposal in India.

Stakeholders involved

The project was elaborated using the technology developed at the Thiagarajara College of Engineering, Madurai, Tamil Nadu, and then implemented on a commercial scale on small highways by the highway authorities. The same concept is being extended to major highways and also to the city roads, particularly in those areas with excessive rainfall.

Results

This project has succeeded in leading the cities to solve two major challenges in a city in India:

- Prevention of potholes during rainy seasons.
- Disposal of non-biodegradable plastic waste.

In addition to contributing towards good road construction, namely roads that have a longer life and require less maintenance, this project helps in the process of handling urban plastic waste. This constitutes a sustainable and smart solution.

There are other indirect tangible benefits. Potholes in a city cause a slowing down of the traffic, which, in turn, increases air pollution and also results in the wasting of precious fuel, which needs to be imported. Apart from this, potholes on the city roads make them prone to accidents, particularly during the rainy season. Mitigating this challenge is an important step towards improving the quality of life in a city. It has had the following impacts:

Social impact: There are many people involved in collecting waste, including plastic waste. Since there is an opportunity for them to sell this waste to organizations involved in road construction, this constitutes a potential source of income, as road construction activity in a developing country is a continuous process. Smooth flow of traffic due to prevention of potholes during rainy season also ensures better quality of life.

Economic impact: The use of plastic materials in road construction ensures the road's greater longevity. Polymerised bitumen makes the road more flexible and can take heavy traffic without showing signs of wear. Thus, less maintenance is required in the process, which is also economically beneficial in the short term, as well as over the long run. There are also significant savings in the use of fuel resulting from the improved quality of roads.

Environmental impact: Plastic waste is a big challenge, particularly for the environment. Many types of plastic are not recyclable. But when used along with the bitumen prevents the environmental degradation due to plastic waste.

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7 The RFID tag is an ID system which consists of a chip, some memory and an antenna. It uses small radio frequency identification devices for identification and tracking purposes. More information is available at https://internetofthingsagenda.techtarget.com/definition/RFID-tagging

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