# ENVIS RESOURCE PARTNER ON ENVIRONMENTAL BIOTECHNOLOGY

**SUPPORTED BY:**

**MINISTRY OF ENVIRONMENT, FOREST& CLIMATE CHANGE**

**GOVERNMENT OF INDIA, NEW DELHI**

**ISSN : 0974 2476** **Volume-39** **Number-1, 2021**

# NEWSLETTER

# ON

# SUSTAINABLE MANAGEMENT OF PLASTIC MATERIAL


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## EDITORIAL

All of us use plastics in some form or another. We cannot think of living without it. Yet, we hardly give a thought to its effect on the environment. Tourists flock to hill stations but rarely notice the clogged waterfalls which were a delight only half a century ago. It takes just one heavy shower to cause water logging in our cities. No tourist spot is spared: empty carry bags, thermocol plates and cups, plastic packaging materials are all over the place. Landfills are increasing in size, and the biodegradables cannot be processed to form manure as there is too much of plastic mized with it. This is the situation all over the world. There is already enough plastic floating in our oceans, which together may cover a continent in size. It is killing aquatic animal life, in oceans, river and ponds. We think just burning the plastic waste would free us from this problem. We are not aware of the miasma emanating which is highly carcinogenic.

Two articles in this issue address this vital problem. The article by Rajarshi Mitra ably sums up the trouble created by uncontrolled use of plastics and advocates sustainable use, reuse and controlled use of plastics. We cannot wish away plastics from our lives. But we can learn to use limit its use, and do it wisely.

The article by R. Vasudevan and A. Ramalinga Chandra Sekar is probably of much greater import. The authors suggest using waste plastics in road construction. They have themselves carried out experiments on mixing plastic waste with bitumen, and also use plastic melt to coat stone chips used in road laying. The latter method can incorporate 10 to 15% plastic weight into the bitumen mix. They have even reused the scrap from retarring of roads, causing 50% cost reduction. Use of such techniques may help us get rid of the vast amount of waste plastics lying around.

Prof. Asoke Prasun Chattopadhyay
Dr. Subhankar Kumar Sarkar

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# Use Plastics only through Sustainable Urban Plastic Waste Management

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## Introduction

Plastics is a well discussed topic in case of management and degradation of the environment. As per a study conducted by the University of California, Santa Barbara, since 1950 – when largescale production of plastics was introduced – the rate of yearly production has increased from 2 million metric tons a to 400 million metric tons a year in 2015. This created a global plastic load of 8.3 billion metric ton of plastics till that year (Cohen, 2017). While the major problems of plastics is its long life in the environment and the problem of its disposal with an ever increasing demand of the material, it has earned a bad name as the worst non-ecofriendly material. With increasing awareness regarding the drawbacks of plastics and the problems of its disposal, plastics are being increasingly replaced by more eco-friendly options like biodegradable plastics and paper, particularly in developed and developing countries. However, even with the entry of alternative materials, we are not bothered about reduction of overall consumption of such items. It has been estimated that 40% of the total packaging materials are made of plastics and the need for packaging materials is increasing day by day without any effort of reduction. There is a general social perception that if we substitute plastics with any eco-friendly material such as paper or bioplastics, then the environmental damage may be reduced, and sustainable development may be achieved.

## Sustainable Management of Urban Plastic Waste

As we are advocating use of biodegradable alternatives of plastics, we are grossly missing out a major point of comparing the alternatives through a 'Cradle to Grave' approach of product analysis for its environmental impacts– formally known as life cycle analysis (LCA). Several studies by international bodies like UNEP, USEPA and others have shown that manufacturing of paper leads to nearly double greenhouse gas emission than manufacturing of similar quantity of plastics. Also, paper products consume nearly twenty-five times more water and five times more energy than the plastic products.

Although there is a lot of debate on the exact amount of greenhouse gas emission being triggered by paper manufacturing units, it is proved beyond doubt that plastic materials are greener than the paper in this context, particularly when we consider the use and disposal of single use papers and plastics. In the context of recyclable plastics and recyclable papers also plastic wins the game, as it generates nearly seven times less waste than paper while serving the same purpose. On an average, the climate change index of reusable bags is equal to 27% of the value of the alternative with the highest impact in each study (Gomez and Escobar, 2021). Therefore it is imperative that plastic be considered as more eco-friendly than its popular alternatives. In fact, the biodegradable plastics – when put through similar type of studies – has been found to be worse than paper. However, a reusable cotton bag, if reused to its maximum potential (50 to 150 times) scores better than all the alternatives as per environmental parameters (Mattila et al., 2011).

From the aforesaid discussion it seems that we perhaps should not say no to plastics, but should also keep it in mind that the LCA studies could not consider the littering with plastics which is the main concern today.

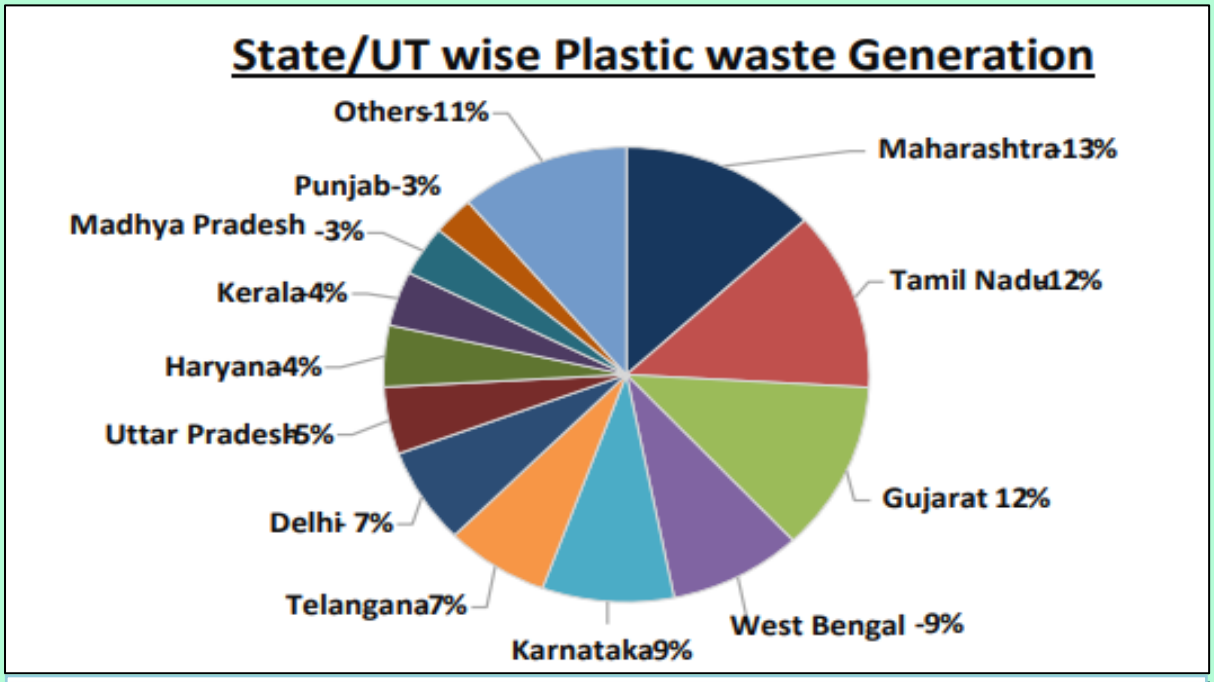


**Fig. 1: State wise plastic waste generation in India**
*Source: Annual report 2019 -20 on Implementation of Plastic Waste Management Rules, 2016. Published by CPCB*

Plastics are making the world unbearable through chocking of drainage systems leading to frequent flooding, killing of marine lives because of suffocation, loss of groundwater recharge areas leading to groundwater depletion and atmospheric pollution with carcinogens coming out of uncontrolled burning of plastic wastes, etc. These are often not considered by those who advocate use of plastics over its alternatives. But these have become primary cause of concern, especially near large urban settlements.

We cannot disagree with the fact that today it is nearly impossible to carry out our activities without plastics as it has invaded every aspect of our daily life. Hence we must go for the sustainable use of plastics following some set of standards and strategies agreed upon internationally. In India, there exist the Plastic Waste Management (PWM) Rules (2016), with its latest amendment of 2021. The regulations in India and other countries throughout the globe on the use of plastics, especially the use of carry bags, all stress on adopting single use plastics. However, the partial implementation of the ban has been found to trigger an altered pattern of consumption of plastics in some studies. Taylor (2019) reported that 40 million tons of single use plastic elimination had been offset by an increase in 12 million tons of trash bag purchase in a particular region of USA. Instead of switching over to single use plastic bags, reuse of existing plastic items is preferable as it effectively reduces both consumption and production of the material. A tendency of reusing plastic bags encourages users and manufacturers to go for heavier plastic bags instead of the lighter ones with high potential of littering. The reusable durable polypropylene (PP) bags and slimmer polyethylene (PE) bags need to be reused for 10 – 20 and 5 – 10 times respectively to qualify for a climate friendly plastics product (UNEP, 2021). Therefore, any regulation towards the manufacturing and use of single use light plastics may act effectively in overall plastic management and reduction of environmental impacts.

An estimated 9% plastic wastes generated during 1950 to 2015 has been recycled, among which only 10% has been recycled more than once and 12% of the waste has been incinerated. The rest amount are still available in landfills or in the environment, our oceans and water bodies (CSE, 2020). As per the date provided by central

pollution control board, in 2019-20 India produced 3.47 million tons of plastic waste, among which 69% was contributed by 7 states viz. Maharastra, Tamilnadu, Gujrat, West Bengal, Karnataka, Telengana and Delhi (CPCB, 2020). However, in per capita plastic waste generation Goa tops the list followed by Delhi and Kerala (CPCB, 2020).

**Fig. 2:** Unorganiszed recycling of plastics at Kolkata (Dhapa area)

There are different categories of plastic waste defined by the CPCB, which should be processed and recycled by recycling units. Single-use and multi-layered plastics can be considered the most difficult to process or recycle. While there have been numerous policy interventions to institutionalize PWM, managing solid waste, mainly plastic waste, has been a challenge for Union Law Boards (ULBs) across the country. The 'circular economy' is a concept that advocates the ways of doing more for less while satisfying the societal needs. As per the Circulatory Gap Report, 2021, the proper implementation of circular economy can reduce GHG emission by 39% and use of virgin resources by 28% and in doing so, the use of recycled plastics instead of single-use plastics or its alternatives in various sectors has an important role to play.

India is a country with much recycling practices for plastics wastes compared to the global average. While a significant part of the recycling remains in the unorganized sector, it provides important economic input to the society, particularly in highly crowded cities like Mumbai, Kolkata etc. The Plastic Waste Management (PWM) Rules of 2016 have framed several regulations and bans the use of single-use plastics and made it mandatory to mark the recycling status of the plastics used in multilayer packaging materials. Plastics like polystyrene (PS), polypropylene (PP) and low density polyethylene (LDPE) are not wholly or partially recyclable mostly because of their low weight and consequent economic nonviability. On the other hand, plastics like PolyethyneneTerepthal (PET), High-Density Polyethylene (HDPE) and Polyvinyl Chloride (PVC) can be reused or recycled several times leading to lowering of environmental impacts.

**Table: Types of plastic**

| Type of Plastic | Code | Recyclable or not |
|---|---|---|
| **PolyethyneneTerepthalate (PET)** | 1 | Yes |
| **High-Density Polyethylene (HDPE)** | 2 | Yes |
| **Polyvinyl Chloride (PVC)** | 3 | Yes |
| **ow-Density Polyethylene (LDPE)** | 4 | Yes |
| **Polypropylene (PP)** | 5 | Yes |
| **Polystyrene (PS)** | 6 | No / Few |
| **Others** | 7 | No |

## BOX 1: Strategies

1. Promotion of HDPE, PET etc. as packaging materials over PP, PS etc.
2. Ban implementation on single use plastics as per the provision of PWM Rules, 2016.
3. Segregation at source for commercial and domestic plastic disposal.
4. Implementation of EPR and/or PRO for producers under its jurisdiction.
5. Organizing the un-organized recycling systems.
6. Regular awareness and strict monitoring.

In this context, the societal response has been critical in urban PWM and a human centric science based strategies may be adopted. The Ministry of Environment, Forest and Climate Change, Government of India (MoEFCC, GoI) has mandated through PWM Rules 2016 for development of a three-pronged approach e.g. (i) **Extended Producer Responsibility (EPR),** (ii) **Producer Responsibility Organization (PRO) and** (iii) **Buy Back system for the plastic products** (NitiAyog – UNDP, 2021). The **EPR** system puts the responsibility on the producer to take back and recycle the plastic material, while **PRO** system promotes a new business arena for some third party organization, who will bear the responsibility of producers for disposal and recycling. The **Buyback** system is an emerging model for managing plastic waste where the original seller of the goods buys them back post-consumer use (NitiAyog – UNDP, 2021).

## Conclusion

It seems that, instead of saying 'No' to plastics, if the Urban Local Bodies (ULBs) develop and strictly adhere to the strategies for promotion of plastics with higher reuse and recycling potential and specific plan for proper disposal of the plastics through organized effort, then environmental threats can be better managed while satisfying the societal needs (Box 1).

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# Utilization of Waste Plastics in the Construction of Flexible Pavement- Not to ban but to plan

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## Introduction

This is the plastic age. Plastics are polymers which have found their use in many fields like packaging, electrical and electronics industry, fertilizers, agriculture, toys and engineering materials, domestic appliances, building materials and so on. Ten metric tons is the expected consumption for 2017, which is expected to rise to 20 Metric tons in 2020. Today plastics have become friend of the common man. It is part of all the essential things in human life such as furnitures, plates, etc. The most important application or use of the polymeric materials is their use in packaging industry as carry bags, tea cups, sheets and films, multi layered films and thermocol. This occupies 35% to 40% of the total plastics consumed every year. The polymers used for the manufacturing of packing materials are polyethylene (PE), polypropylene (PP) and polystyrene (PS). Polyvinyl chloride (PVC) is used in the manufacturing of wires, electrical tube, flex etc. These packing materials once used are thrown away into the environment as solid waste materials. These materials accumulate in places like water canals, rivers and also mix with the municipal solid waste (MSW) (nearly 9%). This results in water logging, creating stagnation of sewage water and poor hygienic conditions. Moreover plastics are not biodegradable *P*er se the accumulation of waste plastics at various corners is an eyesore. The presence of waste plastics in the MSW also contaminates the organic waste available in the MSW, which may be used as manure after conversion. Thus plastic waste has become a major cause of environmental pollution.

Governments worldwide do not seem to have a clue to deal with this issue. Rather, they are planning to ban the use of plastics. Plastic manufacturing is a major industrial development of our country, in which more than 10 crore peoples are engaged. Moreover the plastic industry enjoys subsidy provided by the government. Hence, simply banning the use plastics may result in a major economic disorder in the country. To avoid such a possibility, the government has taken various steps to reduce the use of plastics like increasing the thickness of carry bags, creating awareness to reduce the use of plastic materials, recycling of recyclable waste plastics and reuse of waste plastics. So the banning of plastics will not be solution for plastic pollution. Finding solution to plastic pollution is the need of the hour. This scenario motivated us to work on the use of waste plastics and to dispose it in an ecofriendly way.

Today, technological developments both in electrical and electronic products have resulted in the production of e-waste having a lot of toxic compounds. Their disposal must also be addressed. Work is going in this direction. The problems we face are needed to be attended through appropriate technology so that the benefits can reach the common man.

## Critical challenges

The process is very simple and in situ, no sophisticated technology is involved. The plastic-incorporated tar roads are performing very well even after 10 years without any permanent deformation like rutting, raveling, edge cracking and potholes. It helps to use waste plastics and the process is eco friendly and hence the disposal of waste plastics is not a problem.

Yet we face challenges in the following area:

1. Though plastic waste is available in large quantity, it is not properly collected and made available for the use of this technique.
2. Self help group consisting of village women are being employed for the collection of waste plastics. They have been given financial aid and support by the government. Since the road laying contractors are not in favor of this technology, the self help groups are not able to get expected business.
3. Awareness among the technology groups is less and they show less interest in the process.
4. Awareness camps can help the younger generation. But it is not properly extended or promoted in spite of government schemes like Swachh Bharat.
5. This technology is made in India. Yet it has not taken off as expected.
6. The role of the politician is important, who can promote this technology.
7. Presently, the addition of waste plastics in process of road laying is done manually. If the process is automated, the process will become still more successful.
8. Most of the contractors are not in favor of this technology as the plastic roads are durable in nature and cannot be relayed soon.

## Scaling up of the process

Utilization of waste plastics for flexible pavement is the project, for which a new technology has been developed indigenously. This technology is simple and can be adopted easily with little cost and zero outlay. Major road laying is done by the government, at the local panchayat, municipality or metropolitan levels. The National Highways Authority of India (NHAI)

is doing major road works in India. The technology can be adopted by the consumers. India has not less than 41 lakhs Kms of road network of which 66,000 Kms are national highways and 24,00,000 Kms are rural roads, state highways etc. More than 50,000 Kms of roads have been already laid by using this technology. Nearly 11 states have started implementing the technology. Details of plastic incorporated roads laid are available in the NRRDA web page. In addition, other countries have also shown interest in the project and steps are being taken to transfer the technology them.

In the construction of plastic incorporated tar road, the technology can be used in both Mini Hot-Mix plant and in Central Mixing plant and hence there is no problem of scaling up of this technique to larger extent. As for financial benefits, by using this process an extent of 10% of the total project cost at least will be reduced. This is due to the reduction in the use bitumen and reduction in maintenance expenditure of the road. The life of the road is not less than 10 years.

Many foreign countries like Indonesia, Malaysia, Brunei, South Africa are requesting for this technology to be adopted in their respective countries.

## How the problem is addressed by the project

Reuse of waste plastic in road construction is a suitable solution for the disposal of waste in an ecofriendly manner, thus avoiding the pollution created by plastics in the environment. Presently, the waste plastics are either in landfills or are incinerated. Both the processes are non-technical and affect the environment adversely. In this context, since the project of plastic incorporated road laying avoids land filling and incineration of waste plastics, it is considered as an effective process for the disposal of waste plastics.

Scientifically plastics are the byproduct obtained from petroleum refineries and hence they are only hydrocarbons. Bitumen is also byproduct obtained from petroleum distillation. Hence there should be compatibility between plastics and bitumen and also with other products from

petroleum distillation. This behavior was tested and has been proved technically.

Attempts were made to modify bitumen by dissolving plastics in bitumen. This was partly successful but we could dissolve only lower percentages of plastic (1% to 3%) in bitumen. Moreover the scaling is also very difficult and the process involves high cost. Hence there is a need for an alternative method. A newer method has been developed by coating waste plastics over hot stone aggregate and uses the same for road construction. Here the consumption of waste plastics is high (10% to 15%). This method is patented in 2002 by Dr. R. Vasudevan. This technology was also coded by the Indian Road Congress in 2013 (IRC-SP-98-2013). Using this technology more than 50,000 Kms of road has been laid in India.

For a 1 Km length road of width 3.75 m, we need one ton of plastic. India has 41 lakhs Kms of roads. If all the roads are converted/made with plastic incorporated tar, we need more than 100 lakh tons of waste plastics and practically India does not have this much waste plastics. We have only 16 lakhs tons of waste plastics.

Performances of the roads laid were also studied under the guidance of Central Pollution Control Board, New Delhi. The results obtained were highly encouraging. Moreover the use of waste plastics in this technology is high and we can use 10% to 15% of waste plastics to the weight of bitumen.

Further works helped to develop other products like Plastone blocks, which are substitutes for paver blocks. This product consumes a large amount of waste plastics. Plastone blocks can be used as road side paver block. The Plastone blocks manufacturing process also helps in the reduction in the use of cement, sand and water, since the process use waste plastics as a binder. Hence by using these technologies almost all the plastic waste available in the country can be reused and the disposal of waste plastics will no longer be a problem.

Moreover the waste plastics which were thrown to the streets will get a **value addition**. The use of waste plastics in the present project directly creates a demand for waste plastics in the market. Already in many states the self help group and some other NGOs are involved in the process of collection of waste plastics. They collect and shred the waste plastics and sell it to the concerned authorities for Rs. 20/- to 25/- per Kg. This becomes a good employment.

The government is also taking measures under **Swachh Bharat**, which has become useful to collect the waste plastics. A system is to be developed to collect the waste plastics, shredding and construction of road. Cooperation from the engineers and the contractors is very much needed. If the system works well, the problem of disposal of waste plastics is almost solved.

The present project also insists on the practice of good garbage culture among the public. The project can become successful if the segregation of waste plastics at source is practiced in all over the country. When the waste plastics mix with the MSW, the segregation becomes a tough job. The project also suggests various possibilities in collecting the waste plastics at source, like two bin system, awareness camps for the public and own your ownership technique. Awareness camps and lectures are being organized to educate the school students to motivate them and help to collect the waste plastics at the source. It is partly successful too.

The roads constructed using this technology was well **appreciated both by the government and in the private sector**. In India almost 11 states implemented this technology. The government is using funds under the The Pradhan Mantri Gram Sadak Yojana (PMGSY) scheme for laying plastic incorporated roads in the rural sector. The Central Pollution Control Board published guidelines for laying plastic incorporated roads in the year 2006 itself (Fig. i).

**Fig. i)**: Plastic tar used in Erode road, Tamil Nadu

## Project overview

Plastics are common man's friend. It finds its use in every field and the consumption of plastics increases day by day. Nearly 50% of the plastic consumed is used for packing. The most used plastic materials for packing are carry bags, cups, thermocol and foam. These materials are made from polymers like polyethylene, polypropylene and polystyrene. (The tubes and wires are made out of polyvinyl chloride)

The materials, once used, are thrown out or littered by us more because of wrong culture. They mix with Municipal Solid Waste. As they are non-biodegradable, the disposal is a problem and they cause social problems contributing for environmental pollution, as they are disposed either by burning or by land filling.

Yet these packing materials (either mono-layer or laminated multilayers made out of polyethylene, polypropylene and poly-styrene) can be easily used for various purposes like road construction and block making, without affecting the environment. The polyvinyl chloride is not used in such cases and it is the best way to dispose the waste plastics.

These plastic materials when heated to around $120^0$C to $150^0$C, melt and in their molten state can be used as a binder. Only if they are heated to temperatures more than $250^0$C they may decompose producing gaseous products which results in air pollution. Coating molten plastic over granite stone chips can be done around $150^0$C and the coating helps to bind with bitumen strongly resulting in better mix for road construction and the quality of the stone also improves by closing the voids. PVC is not used due to its toxic nature.

Plastic waste (carry bags, cups, thermocol and foam) is shredded into small pieces (between 1.6 mm – 2.5 mm). The granite stone chips are heated to around $170^0$C. The shredded plastic waste is added to the stone chips. It melts and creates coating over stone chips in just 30 seconds. Then the bitumen is added and mixed with the coated chips. The final mixture is used for road construction. From rural roads to national highways all types of roads can be laid using this technique.

Waste plastics like carry bags, disposal cups, thermocol, multilayer films and polyethylene and polypropylene foams can be used without segregation and cleaning. The process needs no new machinery and it is in situ process. The overall consumption of bitumen is less by 10 to 15% and thus the road coating is reduced. By laying 1 Km single lane plastic incorporated road, 10 lakhs of carry bags are consumed with a saving of 1 ton of bitumen (Rs 40,000/-).

It also helps to avoid the entry of 3 tons of $CO_2$ in the atmosphere, if it is otherwise disposed by burning. Value addition to waste plastics is being created. Use of pavement scrap waste for plastic tar road reduces the cost by 50%.

Plastic tar road has double strength, compared to ordinary bitumen road. It can withstand both heavy load and heavy traffic. It is not affected by rain or stagnated water. And hence no pot hole is formed. There is no rutting and raveling. The life of the road is not less than seven years and there is no need for maintenance

expenditure. Performance studies of the plastic tar road were carried out as per Central Road Research Institute specification and the results are very good. It has been published by CPCB and NRRDA as monographs.

**Table**: A comparative study for 25 mm thickness SDBC-10 mm$^2$

| Material | Plain bitumen process | Plastic-tar road |
|---|---|---|
| **60/70 Bitumen** | 30 kg | 27 kg |
| **Plastic waste** | - | 3 kg |

Monitoring of test roads was carried out using structural evaluation, functional evaluation and conditional evaluation studies. Generally, all the roads laid over a period from 2002 to 2006 are performing well. The results obtained for these roads assure us that these roads are performing very well in spite of their age. Under similar conditions, most of the bitumen roads are not performing well at all. These roads have not developed even small cracking and pothole. The roads were distributed over different localities of states such as Tamil Nadu, exposed to various environmental conditions like temperature, rainfall, etc., yet the roads are performing well.

Reuse of road scrap in road laying is an important finding. Normally, when the road is laid, the existing top layer is scraped out and fresh layer of bitumen etc. is laid, to avoid increase in the height of the road. The scrap is usually disposed off as waste. In our lab, we have developed a modified process for the reuse of scrap in road laying. The scrap is reused by mixing scrap and fresh mix in 50:50 ratio. Polymer coated aggregate can be used in the process of preparation of the fresh mix. By this process we do not waste the scarp. We use only 50% of the raw materials and hence the cost is reduced by 50%. Moreover, the road level is not altered. This technology works very well and was already been implemented in national highways.

We have also developed a cold mix road laying process using emulsion and plastic coated aggregate and this can be used for laying roads in colder regions, where heating of aggregate is not done easily.

Moreover, other products like polymer modified bitumen roofing sheets, corrosion resistant reinforced steel bars for construction purpose are also been developed under this project. All the products use waste plastics as a binder.

Thus the problem created by waste plastics has been addressed by the project called "Utilization of Waste plastics in the construction of flexible pavement" (Fig. ii-iv).

**Fig. ii):** Plastic tar road at Jumbulingam Street Chennai

**Fig. iii):** Plastic tar used in Madurai Kombadi road

**Fig. iv):** Plastic tar used in Lenin street, Kovilpatti

## FORTHCOMING EVENTS

| Event | Date | Place & Correspondence |
|---|---|---|
| National Conference on Advances in Science, Agriculture, Environmental & Biotechnology | 19 Jan 2022 | Hotel Surya International, Solapur, India https://10times.com/ncasaeb-solapur |
| International Conference on Advances in Biosciences and Biotechnology | 20 - 22 Jan 2022 | Jaypee Institute of Information Technology, Noida, India https://10times.com/jiiticabb |
| International Conference on Environmental, Food, Agriculture and Bio-Technology | 22 Jan 2022 | RR Inn, Tirunelveli, India https://10times.com/icefabt-tirunelveli |
| Biofuels International Conference & Expo | 15 - 16 Mar 2022 | Hotel Le Plaza, Brussels, Belgium https://10times.com/biofuels-international-conference |
| 2nd Edition of Euro-Global Conference on Biotechnology and Bioengineering (ECBB-2022) | June 13-14, 2022 | Rome, Italy https://biotechnology-conferences.magnusgroup.org/ |

## QUERY AND FEEDBACK FORM

**Name:**

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**Views on our Newsletter:**

**Suggestion for Improvement:**

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