2021

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Citation Details

Published as: Conlon, K. (2021): Plastic roads: not all they're paved up to be, International Journal of Sustainable Development & World Ecology, DOI: 10.1080/13504509.2021.1915406

Plastic Roads: Not all they're paved up to be

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Abstract
The growing, global plastic waste crisis is sparking a myriad of solutions from disparate fields. One such end-of-use solution is the application of plastic waste for paving roads. This solution is marketed as a win-win option for plastic waste, use the single-use waste material to pave roads and save money, and simultaneously tackle the accumulated plastic waste. Paving with plastic is occurring globally, but has been especially appealing in the global south contexts where waste management infrastructure is lacking, and pressure to do something about the plastic waste is high. However, there are several environmental and social considerations to paving with plastic that are overlooked, such as: where the inherent chemicals in the plastics end up; the environmental impact of road deterioration; the safety of roadworkers; the long-term impact of such projects; discrepancies between recovery vs. end-of-pipe solutions; the downstream emphasis that distracts from critiquing plastic production; and how such projects place the burden of responsibility on citizens and municipalities, rather than on the producers. These ideas are explored in this perspectives piece, as a way to open up more dialogue and research on the caveats of paving with plastics.

Introduction

Rising streams of plastic waste draw the attention of waste management, politicians, businessmen, citizens, and environmentalists alike. Plastic waste links to several of the SDGs including Sustainable Cities and Communities (SDG 11) through how waste is managed; Responsible Consumption and Production (SDG 12), to how plastic is used in the economy; and Climate Action (SDG 13), as plastic derives from fossil fuels. Calls for solutions are many, and the idea that plastic waste can be used to pave roadways is an idea gaining attention globally, especially in global south contexts where single use plastic use is rising, and waste management is often lacking. Paving with plastic is the process by which a mixture of waste plastic is used in the paving process. Each operation uses their own ratio of specific waste plastics, replacing between 5-10% of the bitumen (Sasidharan et al., 2019). At first glance, paving with plastic appears to be a brilliant idea: use up existing plastic waste, reduce waste sent to landfill, save money, and pave roads at the same time (Advanced Plastiform, 2020; Appiah et al., 2017; Dawale, 2016; Dwivedi et al, 2017; MacRebur, 2020b; Poulikakos et al., 2017). However, there are more points to consider beyond merely being able to have the engineering capability to pave with plastics (Jayaraman, 2015).

Caveats on plastic roads to consider

1. Plastic paving companies claim that the only concern by environmentalists is the breakdown of microplastics (Advanced Plastiform, 2020). Scientists show us that plastics degrade in the

environment, especially under intense UV conditions (Andrady, 2015). However, this is only part of the story, as plastics are comprised of a 'cocktail of chemicals,' where each type of plastic has its own mixture of chemicals (with unmonitored mixtures), and additives include plasticizers flame-retardants, phthalates, and other stabilizing agents (Rochman, 2015). Numerous chemicals used in making plastics fall under the banner of POPs or 'forever chemicals,' these chemicals bioaccumulate in the food chain and are known to cause harm to species (Clukey et al., 2018) as well as humans (SCP/RAC, 2020).

What will happen to this chemical mixture as the roads break down, exposed to wear and tear, sun, and the elements? At present, longitudinal studies have not been conducted by either paving companies or researchers. One company tested the leaching of chemicals from a piece of their plastic road in a lab setting, but only over the course of less than twenty-four hours. They concluded that no chemicals were leached during 24 hours (MacRebur, 2020c), and extrapolated from this overnight study that plastic roads are environmentally safe for years of road use. Moreover, in other environmental assessments, plastic paving companies say that the paving mixture temperature is intentionally kept below the threshold that would burn off chemicals (Lombardo, 2020; MacRebur, 2020a; Parson, 2021). Yet, where will the chemicals go? If the inherent chemicals in plastics such as phthalates, vinyl chloride, ethylene dichloride, lead, cadmium and other toxic chemicals are not burnt off, then these chemicals are in the roadways and susceptible to wear and tear. If mixtures are not properly monitored and get too hot (for instance in global south contexts), then the chemicals burn off and generate harm for roadworkers and adjacent communities. Either way, a third party study is needed for trusted results on immediate harms of paving and longitudinal harms (chemical loads, leeching microplastics, third-party assessments, etc.). Currently, no longitudinal assessments have been made, despite for instance countries like India that have already paved over 60,000 miles of plastic roads. and most plastic road projects have come about in the last seven years (Parsons, 2021). Longitudinal studies under normal wear and tear of roadways will also face the challenge of distinguishing between microplastics and leachate from the road and tires, as tires are a major source of microplastic pollution (Sutton et al., 2019).

Essentially, paving miles of road with plastics and then waiting to test the environmental impacts for microplastics or chemical leachate after some time is a recipe for disaster. Myers (2019) Chief Scientist of Environmental Health Sciences says: "Roads degrade because they get abraded by vehicular traffic. That becomes massive amounts of micro and nano plastic particles as plastic dust. Storm runoff would carry it into the wastewater system or directly into surface waters. Air currents would transport it in the wind … Sooner or later a lot of it would wind up in the oceans. It would become even more of a problem than what we have today. Exactly how much of a problem would depend upon what mix of polymers were used and what additives might be in the plastics, as that would determine the particles' toxicity. It's terrifying to think about, frankly." Or, as one environmental professional in India explains, "You are hiding your plastic waste for some time and converting all your roads into toxic land" (Yashwant, 2019). With this frightening scenario, it's best to adopt the precautionary principle and not further amplify the release of plastics and their chemicals into the environment.

One material that can be used without the chemical or microplastic risks, and is also available in-site, is recycled glass as a material for paving (EPA, 2001; World Highways, 2019). This method is especially effective for reducing glass bottle accumulation in areas without recycling facilities, or reducing carbon footprints for municipalities that would otherwise have to transport heavy glass long distances to reprocess.

2. Plastic waste generation is increasing exponentially. Current estimates say this waste stream could rise four-fold by 2030 (Geyer et al., 2017). Already, the majority of the plastic waste burden falls on the global south (Lebreton et al., 2017). Yet, paving with plastics will only 'hide/bury the evidence' of failed waste management systems, and does not use technology to address the production of plastic. The right use of technology to manage increasing plastic waste streams will be through redesigning packaging and departing from the linear packaging-to-waste stream model, not designing more efficient ways to bury increasing waste streams.

Ultimately, plastics in roadways is not sustainable. Using roads as a plastic sink continues to allow for linear 'end of pipe' waste solutions and **distracts** attention from upstream approaches. Upstream means focusing on policy and redesigning the system, for instance through zero waste management approaches, so that the output can be reduced (Connett, 2013); downstream means managing the output without deconstructing the cause of the overall waste flows. Downstream focus avoids for instance, the difficult questions related to plastic production, oil extraction, and climate change (Azoulay et al., 2019).

3. Most municipalities - especially in the global south - are fraught about solutions for increasing waste (Kaza et al, 2018). When plastic paved roads are marketed as a win-win solution, glossing over long-term environmental harm, municipalities feel that they are doing something positive for the environment (ANI, 2021; Appiah et al., 2017; Chaturvedi, 2020; Indian Roads Congress, 2013; MacRebur, 2020; Sasidharan et al., 2019). Plastic paving companies are lobbying so that plastic paving becomes a part of transportation policy (Parson, 2021), for instance as is the case in the city of Gurugram in India (Chaturvedi, 2020). The state of India also allows for paving with plastics to be one of the prescribed management techniques for company EPR – where companies pay to collect their plastic waste, which is used in road building (CPCB, 2016). Yet, at present, no governments appear to be initiating their own testing on this practice. Once these roads are paved, this is an environmental impact trajectory that is set for the locality.

4. Paving with plastics is not safe for roadworkers. The heating of plastics is carcinogenic, and releases carbon monoxide, acrolein, formic acid, acetone, formaldehyde, acetaldehyde, toluene and ethylbenzene (Jayaraman, 2015; Tsai et al., 2009). Certain plastics, such as PVC, if accidentally added to the road mix, are particularly harmful for health when heated (Yuan & Cheng, 2017). Currently paving companies use a mixture of plastics. Depending on the location of the project, for instance India, Kenya, Indonesia, if PET recycling infrastructure is not nearby then these bottles could end up into the paving mix to reduce plastic waste accumulation. As PET plastic bottles often contain PVC labels, a vigilance to sorting and processing is required for the road projects. Those who process PET for recycling know that labels need to be removed for recycling; however, those who pave with plastics do not necessarily know that PET bottles and their labels are two different kinds of plastics. This can expose workers to health harms they might not be aware of or protected against.

5. Diverting material from the existing collected streams would further diminish recycling rates. Globally, only 14% of plastic is collected for recycling, with 4% lost in the production processes, 8% downcycled, and 2% fully recycled (World Economic Forum et al., 2016). One of the reasons why single-use plastics litter roadways and end up in water bodies is that they have no value. If this material had value, it would not be designed for 'single-use,' but for reuse and recirculation. If plastic paving projects use existing streams of collected plastic waste (i.e. HDPE, PET), this means this plastic would be diverted from recycling, thus not adding to waste recovery solutions but taking from existing efforts for end of pipe solutions.

6. Downstream approaches to waste management place the burden of waste on municipalities and citizens, and absolve companies of responsibly addressing the waste their products create. Using the waste that these companies create for plastic roads takes pressure off the brands for changing their packaging. When a package or bottle is melted, it no longer is identifiable by brand, and brand packaging is what environmental action groups use to advocate for policy through their brand audits (Break Free From Plastic, 2020). For instance, multiple years in a row Coke, Nestle, Pepsi, Unilever, etc. have been shown to be top global polluters with their packaging (ibid; Franklin, 2019). If the companies are not held accountable, the environmental burden falls on localities, disproportionately on the global south, and creates issues of both environmental injustice and adaptive injustice (Conlon, 2020).

Looking beyond downstream solutions to rising plastic waste

Solutions to plastic waste need to consider the full picture of the plastic lifecycle from generation to disposal. Companies should responsibly deal with their packaging through:

-Supporting the collection of the plastic they produce through EPR;
-Investing in R&D to phase out single-use plastics;
-Funding research that examines single-use plastics alternatives;
-Catalyzing the reusable packaging markets;
-Piloting new ways to distribute their goods in zero waste/zero plastic methods;
-Funding recycling systems (i.e. through CSR);
-Supporting waste picking cooperatives (i.e. through CSR); and
-Rehabilitating nature areas that have suffered due to waste accumulation.

Ultimately, the responsibility for waste needs to be placed on the producers, which will help catalyze a shift away from the linear waste generation system to more circular, regenerative systems of materials use. Paving roads with plastics is an environmental disaster in the making, and paves over the question of responsibility for continued plastic waste generation.

Advanced Plastiform, Inc. (2020). How Plastic Asphalt is Paving the Road of the Future. Advanced Plastiform. Retrieved on Dec. 30, 2020, from: https://advancedplastiform.com/plastic-asphalt-for-new-roads/

Andrady, A. L. (2015). Persistence of plastic litter in the oceans. In *Marine anthropogenic litter* [M. Bergmann, L. Gutow, M. Klages, Eds.]. Springer, Cham. 57-72.

ANI. (Feb., 23, 2021). Tripura gets first-of-its-kind road constructed using plastic waste. ANI. Retrieved on Feb. 23, 2021, from:
https://www.aninews.in/news/national/general-news/tripura-gets-first-of-its-kind-road-constructed-using-non-recyclable-plastic-waste20210222225924/

Appiah, J. K., Berko-Boateng, V. N., & Tagbor, T. A. (2017). Use of waste plastic materials for road construction in Ghana. *Case studies in construction materials*, *6*, 1-7.

Azoulay, D., Villa, P., Arellano, Y., Gordon, M., Moon, D., and Miller, K. (2019). Plastic and Health: the hidden cost of a plastic planet. *CIEL.* 1-76.

Break Free From Plastic. (2020). The Brand Audit Report. Break Free From Plastic. Retrieved on Dec., 30, 2020, from: https://www.breakfreefromplastic.org/globalbrandauditreport2020/

Central Pollution Control Board. (2016). Preparation of Action Plan for Producers/Importers/Brand Owners (PIBOS) for Plastic Waste Management. CPCB. Retrieved on Feb. 24, 2021, from:
https://cpcb.nic.in/uploads/plasticwaste/Preparation_Action_Plan_PWM_25.06.2019.pdf

Chaturvedi, A. (July 10, 2020). 1km of road built using plastic waste, gov plans to double it. Hindustan Times. Retrieved on Dec. 30, 2020, from:
https://www.hindustantimes.com/india-news/1-lakh-km-of-road-built-using-plastic-waste-govt-aims-to-double-it/story-iwmkiKjlG86BYIDlg2aLtM.html#:~:text=Plastic%20roads%20consist%20of%206,of%20road%20in%2011%20states.

Clukey, K. E., Lepczyk, C. A., Balazs, G. H., Work, T. M., Li, Q. X., Bachman, M. J., & Lynch, J. M. (2018). Persistent organic pollutants in fat of three species of Pacific pelagic longline caught sea turtles: Accumulation in relation to ingested plastic marine debris. *Science of the Total Environment*, *610*, 402-411.

Conlon, K. (2020). Adaptive injustice: Responsibility to act in the plastics economy. *Resources, Conservation, & Recycling, 153,* 104563.

Connett, P. (2013). *The Zero Waste Solution: Untrashing the Planet One Community at a Time.* White River Junction, VT: Chelsea Green Publishing.

Dawale, S. A. (2016). Use of waste plastic coated aggregates in bituminous road construction. *International journal of advancement in engineering technology, management and applied science*, *3*(6), 118-126.

Dwivedi, A., Mattoo, M., Prabhu, J., Dwivedi, A., and Jain, P. (2017) A survey on Cost Comparison of Sustainable Plastic Road with Regular Bitumen Road. *Int. Journal of Innovative Research in Science, Engineering and Technology, 6(2),* 1500-1506.

EPA. (2001). Development of Recycled Glass Paving Materials. EPA. Retrieved on Dec. 30, 2020, from:
https://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/1260

Franklin, M. (2019).Coca-Cola, Nestle and PepsiCo named top plastic polluters for second year in a row. *Break Free From Plastic.* Retrieved on Sept. 8, 2020, from:
https://www.breakfreefromplastic.org/2019/10/23/brand-audit-report-2019-press-release/

Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science Advances*, *3*(7), e1700782.

Jayaraman, N. (Dec., 20, 2015). Heard about miracle "plastic roads"? Here's why it's not a solution to our plastic problem. *The News Minute.* Retrieved on Dec. 30, 2020, from: https://www.thenewsminute.com/article/heard-about-miracle-plastic-roads-heres-why-its-not-solution-our-plastic-problem-36927

Indian Roads Congress. (2013). Guidelines for the use of waste plastic in hot bituminous mixes (dry process) in wearing courses. Retrieved on Dec. 31, 2020, from : https://www.tce.edu/sites/default/files/PDF/IRC-Spec=Road-with-plastic-waste.pdf

Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). *What a waste 2.0: a global snapshot of solid waste management to 2050*. Washington, DC: World Bank Publications.

Lebreton, L. C., Van der Zwet, J., Damsteeg, J. W., Slat, B., Andrady, A., & Reisser, J. (2017). River plastic emissions to the world's oceans. *Nature communications*, *8*, 15611.

Lombardo, J. (Nov. 2, 2020). Use of Plastic Additives in Asphalt Mixtures Increasing. Fo Construction Pros. Retrieved on Feb. 3, 2021, from: https://www.forconstructionpros.com/asphalt/article/21196132/use-of-plastics-in-asphalt-mixtures-increasing

MacRebur. (2020). Case Studies. MacRebur. Retrieved on Dec. 30, 2020, from: https://www.macrebur.com/case-studies/

MacRebur. (2020a). Do microplastics from the road get washed off into the environment? MacRebur. Retrieved on Dec. 30, 2020, from: https://macrebur.com/pdfs/product/MacRebur_MicroPlastics_Leaflet_v3.pdf

MacRebur. (2020b). It's the end of the road for waste plastic. MacRebur. Retrieved on Dec. 30, 2020, from: https://www.macrebur.com/

MacRebur. (2020c). Technical Data: Leaching of MR modified asphalt. MacRebur. Retrieved on Dec. 30, 2020, from: https://macrebur.com/pdfs/product/Leaching.pdf

Meyers, P. (2019). Can our recycling problem be solved by using plastic for roads? Plastic Pollution Coalition. Retrieved on Sept. 8, 2020, from: https://www.plasticpollutioncoalition.org/blog/2019/2/13/can-our-recycling-problem-be-solved-by-using-plastic-for-roads

Parson, A. (Feb., 11, 2021). How Paving with Plastic Could Make a Dent in the Global Waste Problem. *Yale Environment 360*. Retrieved on Feb., 23, 2021, from: https://e360.yale.edu/features/how-paving-with-plastic-could-make-a-dent-in-the-global-waste-problem

Poulikakos, L. D., C. Papadaskalopoulou, B. Hofko, F. Gschösser, A. Cannone Falchetto, M. Bueno, M. Arraigada et al. "Harvesting the unexplored potential of European waste materials for road construction." *Resources, Conservation and Recycling* 116 (2017): 32-44.

Rochman, C.M. (2015). The Complex Mixture, Fate and Toxicity of Chemicals Associated with Plastic Debris in the Marine Environment. *Marine Anthropogenic Litter* [M. Bergmann, L. Gutow, M. Klages, Eds.]. Springer, Cham. 117-140.

Sasidharan, M., Torbaghan, Dr. M.E., & Burrow, Dr.M. (2019). Using waste plastic in road construction. *K4D*. retrieved on Dec. 30, 2020, from: https://assets.publishing.service.gov.uk/media/5d41b34040f0b60a86a5e5dc/595_Use_of_Waste_Plastics_in_Road_Construction.pdf

Sustainable Consumption and Production Regional Activity Center (SCP/RAC). (2020). Plastic's toxic additives and the circular economy. SCP/RAC. Retrieved on Oct. 8, 2020, from: http://www.cprac.org/en/news-archive/general/toxic-additives-in-plastics-hidden-hazards-linked-to-common-plastic-products

Sutton, R., Lin, D., Sedlak, M., Box, C., Gilbreath, A., Holleman, R., Miller, L., Wong, A, Munno, K., Zhu, X. (2019). Understanding Microplastic Levels, Pathways, and Transport in the San Francisco Bay Region. SFEI Contribution No. 950. *San Francisco Estuary Institute:* Richmond, CA.

Tsai, C. J., Chen, M. L., Chang, K. F., Chang, F. K., & Mao, I. F. (2009). The pollution characteristics of odor, volatile organochlorinated compounds and polycyclic aromatic hydrocarbons emitted from plastic waste recycling plants. *Chemosphere*, *74*(8), 1104-1110.

World Economic Forum, Ellen MacArthur Foundation, McKinsey & Co. (2016). *A New Plastics Economy: Rethinking the Future of Plastics*. Retrieved on October 13, 2019, from: www.ellenmacarthurfoundation.org/publications

World Highways. (Nov. 4, 2019). Recycling glass for use in asphalt. World Highways. Retrieved on Dec. 30, 2020, from: https://www.worldhighways.com/wh6/feature/recycling-glass-use-asphalt

Yashwant, S. (June 14, 2019). Paving roads in Kerala with ocean plastic. India Climate Dialogue. Retrieved on Feb. 3, 2021, from: https://indiaclimatedialogue.net/2019/06/14/paving-roads-with-ocean-plastic/

Yuan, J., & Cheng, B. (2017). A strategy for nonmigrating highly plasticized PVC. *Scientific reports*, *7*(1), 1-6.