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Reuse of end-of-life personal protective equipment in hot asphalt mixtures: an environmental evaluation

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Abstract

In the present global health emergency, face masks, gowns, caps, gloves play a key role in limiting the diffusion of the COVID-19 pandemic, by acting as physical barriers to avoid droplets and filtrate exhalations coming from infected subjects. Since the most widespread devices are disposable products made of plastic or rubber materials, this means that relevant quantities of fossil resources are consumed, and huge amounts of wastes are generated. Currently the end of life of personal protective equipment (PPE) represents a problem in environmental, economic, and social terms. The market considers two possible disposal scenarios: incineration with energy recovery or landfill. In both cases, significant impacts are achieved both on the environment and on human health. This study aims to propose and validate a new scenario for PPE based on material reuse for bituminous conglomerates. The Life Cycle Assessment methodology and the experimental tests has been used to assess the environmental impacts in terms of both ReCiPe midpoints and endpoints and for demonstrate the technical feasibility of this new scenario. From an environmental point of view, relevant benefits were observed in comparison with the standard incineration for energy recovery or disposal in landfill.

Keywords: "Enviromental impact; Reuse; DPI; Circula Economy."

Nomenclature

SDGs	Sustainable Development Goals
PPE	Personal Protective Equipment
SFM	Shredded Face Masks
HMA	Hot Mix Asphalt
LCI	Life Cycle Inventory
LCA	Life Cycle Assessment
PET	Polyethylene Terephthalate
PU	Polyurethane
PAN	Polyacrylonitrile
RAP	Reclaimed Asphalt
ITA	Indirect Tensile Stress

1. Introduction

In 1993, the International Union for Conservation of Nature has defined sustainable development as that 'improving the quality of human life while living within the carrying capacity of supporting ecosystems' [1]. After decades, the United Nations (UN) set a milestone for the world's sustainable development in 2015. The UN's report Transforming our World: The 2030 agenda for Sustainable Development consists of 17 Sustainable Development Goals (SDGs)[2].

It is clear from the beginning of 2020 that Personal Protective Equipment (PPE) are indispensable in mitigating the spread of SARS-CoV-2, the global pandemic that has

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accompanied the life of every human in the last years. Their importance grows, in fact the global demand in volume of PPEs increased by 300-400% between 2019 and 2021 [1] and, consequently, the environmental problem that derives from them also increased. As a matter of fact, PPEs are difficult to recycle due to the composite materials with which they are made and due to regulations aimed at containing the risk of spreading the virus. Therefore, PPEs are generally incinerated or disposed of in landfills. Considering that an estimated worldwide monthly use of 129 billion masks and 65 billion gloves since the start of the pandemic [3] and that most of these PPE contain plastic and its derivatives, it is easy to conclude that their large use generates millions of tons of plastic waste in a short period of time, posing a threat to both the terrestrial and marine environment.

Consequently, cases of incorrect disposal of PPE have also increased. Many studies analyzed the quantities found along the coasts of cities such as Lima, Peru [4] and Adagir, Morocco [5], where it was found that most PPE thrown into the environment are face masks (96.81%). The reason can be explained in the fact that the use of protective masks was recommended to the entire population throughout the pandemic period, even imposed in certain periods of time [6].

Therefore, masks were driving the increase in PPE demand. In fact, masks have increased by 2.500-3.000% in just one year, going from representing 2-4% of the PPE market in 2019 to representing 25-30% in 2020 [1]. However, the largest market share among PPE is not masks but gloves which accounted for 65-70% in 2019 and 60-65% in 2020, growing by 30-35% in one year. It is estimated that those numbers are expected to return to 2019 levels by 2025, with the level of gloves that is expected to remain stable while that of gloves fall below 5% of the total volume of the PPE market [1]. Considering that a single use disposable mask has a carbon footprint (CF) of 0.059 kgCO2eq. and that a reusable mask has a CF of 0.036 kgCO2eq. [7], it is necessary to study an effective solution to limit, reduce or eliminate such emerging environmental issue.

However, the problem of managing plastic wastes deriving from post-consumer single-use products is not new and many applications have been investigated in the scientific literature. One of them is the reuse of plastic in asphalt mixes, with proved benefits in terms of lifespan extension due to the improvement of some characteristics such as fatigue resistance, fracture and deformation resistance and, therefore, environmental profile [8][9][10][11]. More in detail, MacRebur company and engineer Toby McCartny in Scotland used 3 to 10 kg of recycled plastic per ton of asphalt, experimenting the reinforced asphalt at bus stops and on the A7 Lake District motorway. The results showed that the asphalt was more resistant to wear, so it lasted longer than conventional asphalt [12]. Another interesting example was the use of textile fibers deriving from the disposal of end-of-life tires for the production of reinforced asphalt, tested in different studies. The application has shown that the use of fibers increases asphalt drainage, leading to a significant increase in fatigue resistance[13][14]. Two recent studies have focused on the adoption of PPEs to reinforce bituminous conglomerates. The first study used 10% to 20% of PPEs waste, using polypropylene (PP) gown waste, to replace the bituminous binder in the mix, with an improvement of the main mechanical characteristics. The second study only used shredded face masks (SFM) with dimensions of 0.5 cm in width and 2 cm in length and mixed with recycled concrete aggregate (RCA). The mix with 1% SFM in RCA was the best in terms of improvement of compressive strength resilient modulus [15] [16].

Starting from this context, the technical and environmental feasibility of the use of waste PPEs as reinforcement in bituminous conglomerates was studied in an innovative circular economy scenario. Such research started from the analysis of the reference scenario of the PPEs market to find the most representative mixtures of PPEs waste that can be included in the mix for preparing a bituminous conglomerate. Subsequently, tests at laboratory level were carried out to define a hot-mix asphalt (HMA) mixture with promising performance, to confirm technical feasibility of the proposed scenario. And finally, an environmental assessment has been carried out to quantify the increase in sustainability.

Therefore, the purpose of this paper is to quantify the environmental impact of the proposed scenario, namely the use of HMA reinforced with a mix of PPE, composed by masks and gloves. Such impact has been also compared with the results obtained for a standard HMA with the same characteristics and performance. The study is based on the Life Cycle Assessment (LCA), used as standard methodology to assess in a quantitative way the potential impacts and damages on the natural environment, on the depletion of resources and on the human health [20] [21].

After this Introduction, the paper is structured as follows. Section 2 presents the DPI characteristics and valorization. Section 3 illustrates the Goal and Functional Unit and the LCI definition of the proposed LCA analysis. Section 4 set out and discusses the LCA outcomes. Lastly, Section 5 provides conclusions and proposals for the future.

2. DPI characteristics and valorization

Considering the main streams of PPEs, only gloves and face masks were considered. Gloves are generally made of latex or nitrile equally distributed in terms of quantity on the market [1]. Surgical masks typically contain three polymer sheets; an internal part, based on soft fibers, an intermediate layer consisting of the main filter, and an external sheet, based on non-woven fibers, with hydrophobic properties. They are generally developed from synthetic thermoplastic polymers such as PP, polyethylene terephthalate (PET), polyurethane (PU), polyacrylonitrile (PAN), polystyrene (PS), polycarbonate (PC), polyethylene (PE) or other polyesters [17]. The dominant polymer is PP which makes up about 72% of PPEs on the market, with the second flow represented by PET [18]. By considering the market context illustrated in Section 1 and the masks/gloves characteristics discussed here above, the following representative PPE mix has been used for this research, which includes 4 different products: Surgical mask in PP: Outer layer: 100% PP white or colored non-woven fabric, intermediate layer (filter): 100% PP meltblown, contact layer: 100% PP white or colored non-woven fabric. 2. Surgical mask in PET with outer layer: PET spunbond, intermediate layer (filter): PET meltblown, contact layer: PET spunbond. 3. Latex gloves: 100% latex, 4.Nitrile gloves: 100% nitrile

2.1. DPI valorization: use in bituminous conglomerates

The laboratory study aimed at evaluating the possibility of introducing PPE in hot mix asphalt (HMA) without penalizing (or improving) the mechanical performance. The experimental program involved different types of PPE (only face masks or a mix of face masks and gloves), dosages (0.5% and 1% by mix weight) and HMA production temperatures (150 °C or 120 °C), comparing the mix compact ability and strength.

The reference HMA was a mix for binder layer made with limestone virgin aggregate, 20% of reclaimed asphalt, 4.8% by mix weight of 70/100 pen bitumen. The HMA were produced in the laboratory through an automatic mixer by introducing the PPE on the hot aggregate, before bitumen addition. Cylindrical specimens were prepared using a gyratory compactor. The air voids content and the indirect tensile strength of the specimens were measured according to EN 12697-8 and EN 12697-23.

The results (Fig. 1) showed that the presence of 0.5% of face masks tended to reduce the mix compact-ability, entailing a higher air voids content. This effect was attenuated in the case of PPE including both masks and gloves, as the latter partly melted and increased the binder volume, which filled the air voids. The partial digestion of the gloves polymers into the bitumen also determined and increase of the HMA strength and stiffness. Negative results were obtained in the case of higher PPE dosages (1%) and reduced HMA production temperatures (120 °C). These mixtures showed a significantly higher air voids content, which affected the mechanical properties of the HMA.

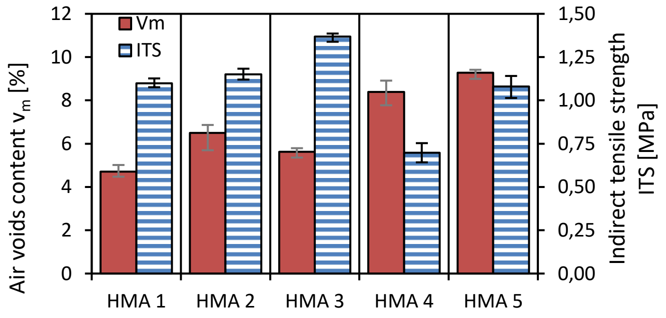

Fig. 1. Results of the laboratory tests on the HMA mixes containing PPE.

In conclusion, the laboratory study confirmed the feasibility of recycling waste PPE in HMA. In particular, the mix showing the most promising results was that including both face masks and gloves, with a total PPE dosage of 0.5% by aggregate weight. This solution allows achieving a higher mix strength with a negligible decrease of the mix compact-ability.

3. Environmental analysis: the LCA methodology

As a way to address these concerns, several methodologies for Life Cycle Assessment (LCA) have been proposed, which primary goal is to evaluate a product or service throughout its life, considering the direct and indirect impacts. The ISO 14040 and 14044 [20] [21]. Standard divides the process of Life Cycle Assessment in four phases: (1) The goal and scope definition, (2) the inventory analysis, (3) the life cycle impact assessment, (4) the result interpretation.

3.1. Goal and functional unit

This study presents a life cycle assessment (LCA) with two different scopes. The first LCA focuses is the environmental impact evaluation of the new asphalt reinforced with personal protective equipment. This new scenario of end of life for the PPE, produces a reduction of material destined for landfill or incineration with a reduction of environmental impact. In this context, the second aims of LCA study are to evaluate the potential environmental benefits of re-using such PPE in asphalts in Italy, with “asphalt” used to refer to “asphalt mixture” hereafter. According to the ISO standards, the functional unit (FU) is defined as “the realization and maintenance of 1 m^2 of HMA mixture for a motorway road, composed of three layers (base, binder, wearing course), during a time lapse of 30 years and disposal PPE necessary to load the asphalt of 0.5% in weight”. Such time lapse has been chosen since it represents the maximum value of service life for the considered layers and HMA mixture typologies (in particular it refers to the duration of the base layer in case of ELT reinforced asphalt mixture).

3.2. System description and boundaries

The present study can be classified as a "gate to gate" analysis, which means that it refers only to specific phases of the asphalt cycle. All the processes necessary to obtain the functional unit described have been included in this study. The impacts for the production and laying of the bituminous conglomerate are considered, while the management of the end of life of the asphalt produced after 30 years of life is not considered [5]. **Errore. L'origine riferimento non è stata trovata.**The different transports of all stages of procurement of raw materials and transport of the conglomerate to the paving site were also considered. Fig. 2 show the HMA pavement construction and maintenance for the standard asphalt and reinforced PPE scenario.

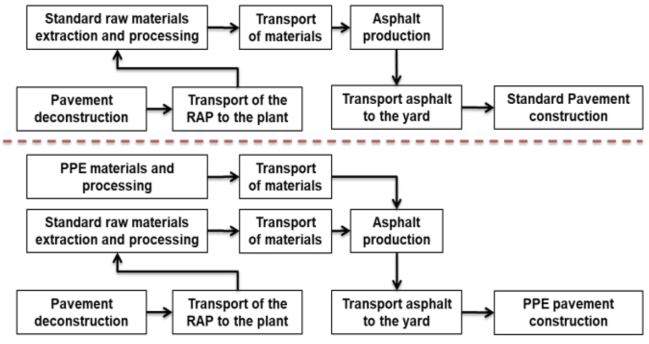

Fig. 2. System boundaries, above HMA standard, below PPE pavement.

The process starts with the extraction and processing of raw materials (such as limestone, gravel and bitumen) which are subsequently transported to the HMA production plant. In the case of reinforced HMA mixtures, the PPE materials are processed for obtaining a homogenous mix and transported to the HMA plant. As indicated in previous studies [7], realistic pavement construction scenarios include the use of reclaimed asphalt (RAP), together with standard raw materials.

In the HMA production sites, the incoming raw materials are mixed following specific dosages describe in previous chapters. Since the object of the study is on HMA, during this phase it is also necessary to heat the mixture at a temperature in the range 150–200 °C to ensure the fluidity of the bitumen. Finally, the HMA mixture is transported to the road construction site, laid by means of finishing machines, and compacted through roller machines. There are no substantial differences in the production processes of the 2 asphalt types, the principal difference is the quantity of row material describe in the next section. For the next phases, the following assumptions were made:

- A cut-off was applied to all those processes that consume energy with an incidence of less than 1% of total electricity consumption.
- The shredding of the PPE takes place directly in the landfill.
- The average transport distance of production materials is assumed to be 150 km, including the distance from the extraction to the production site and from the production site to the asphalt laying site.
- As shown by literature studies and laboratory analyzes, the fibers from PPE consist of 45% polypropylene, 15% PET, 20% latex and 20% nitrile.

3.3. LCI definition

Life Cycle Inventory is the phase that involves creating an inventory of input and output flows for a product system. Such flows include inputs of water, energy and raw materials and releases into air, land and water. Data can be primary if they are collected directly through measurements, interviews, etc., or secondary, if retrieved from studies, standard databases, etc.

The collection of the inventory data has been carried out through interviews and data collection cards delivered to the main actors of the study. The set of inventory data used in the study is shown in the next tables divided by scenario. In particular, Table 1 shows the input materials for the FU considerate, while the Table 2 shows the resource consumed for producing of 1 m^2 of HMA for 30 years. The impacts arising from the production and maintenance of the equipment, for the different step, have not been considered.

Table 1. Input raw materials used for producing standard HMA

Row material	Quantity Standard HMA	Quantity PPE HMA	Unit
Gravel	240.64	240.712	kg
Limestone	441.58	442.64	kg
Sand	281.91	278.62	kg
Inert Filler	50.82	50.79	kg
Bitumen	28.35	28.32	kg
RAP	148	148	kg
Recycled PPE	/	3.637	kg

Table 2. Resource consumed for producing of 1 m2 of HMA mixture for 30 years of service life.

Process	Quantity Standard HMA	Quantity PPE HMA	Unit
Drying	8.67	8.69	m3
Electricity Dry	2.11	2.11	MJ
Electricity Mix	1.68	1.68	MJ
Diesel	40.3	40.6	MJ

Regarding the deconstruction of the old pavement and the laying and finishing of the new HMA, the considered data are not reported because the times and consumption for the preparation and maintenance of the road are the same for both scenarios.

3.4. Life cycle impact assessment (LCIA)

The third phase involves quantifying the environmental impacts related to each process and flow considered through the use of characterization factors that 'transform' the inventory data to environmental indicators. The construction and maintenance of a HMA pavement involve different typologies of impacts. It is necessary to consider impact categories that measure the potential environmental damages. LCIA (life cycle impact assessment) method used to calculate environmental impacts is the intermediate point ReCiPe - Hierarchical version (H) – Europe and ReCiPe end point [8]. Another relevant environmental metric in the context of LCA of HMA pavements is the emissions of Green House Gas (GHG). In particular, the impact assessment method described in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has been adopted (IPCC, 2007) [22]. The environmental impact evaluation of the two different scenarios have been calculated by the support of the SimaPro 9 as LCA tool and Ecoinvent 3.6 as database.

4. Results and discussion

Life cycle impact assessment calculated by using the life cycle inventory data and the specific environmental impact categories described above is shown in this section. Fig. 3 shows the environmental impact in terms of ReCiPe 2008 LCIA method. At midpoint level, this method allows to assess 18 different impact categories as in Fig. 3. It is possible to note that the use of PPE in the HMA does not produce an increase in impacts. In general, it is possible to have a strong reduction of impacts for some categories. The avoided impact due to the reuse of personal protective equipment produces a significant reduction in term of eutrophication and toxicity.

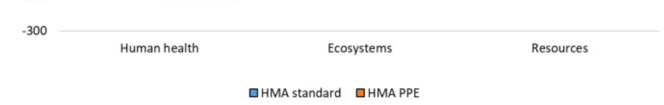

Fig. 4. In this figure a single score (expressed in [EcoPt]), after a normalization and another weighing, is highlighted. It is

evident how the reuse of PPE produces a strong reduction of damage to human health.

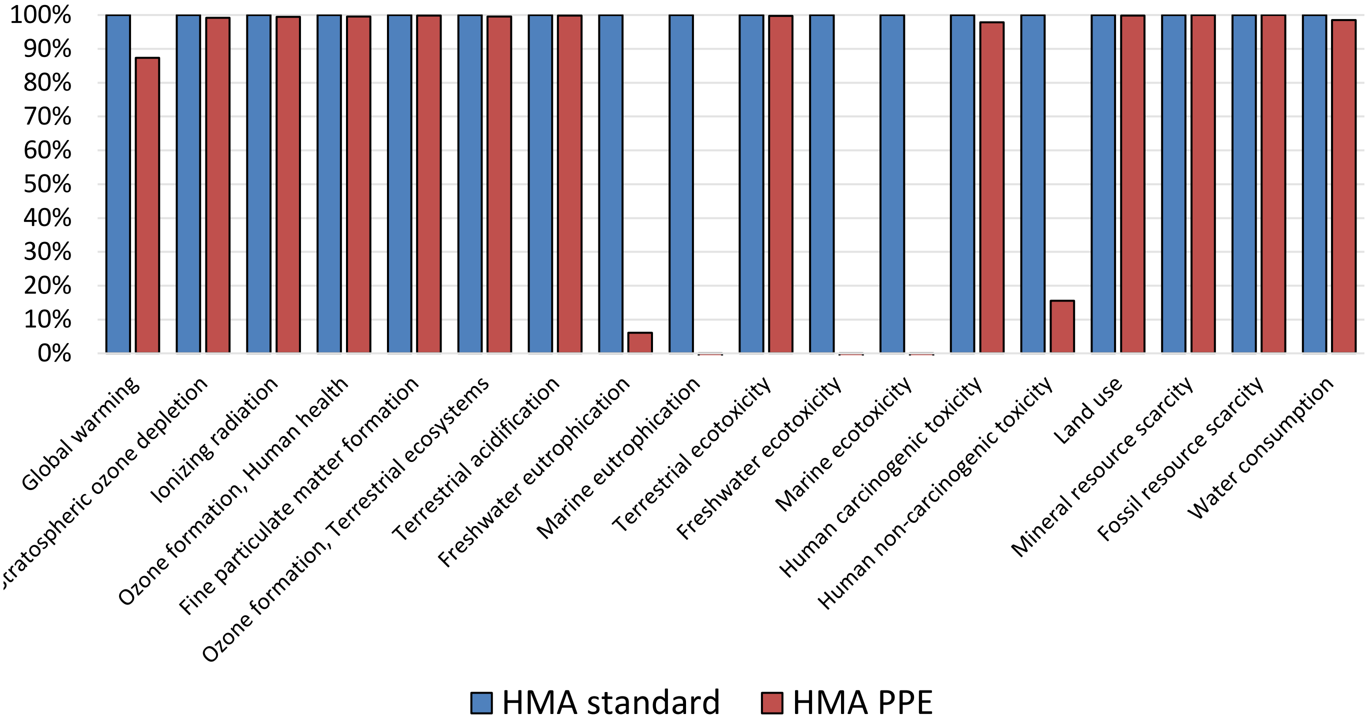

Fig. 3. LCIA in terms of characterized ReCiPe Midpoint H (normalization applied)

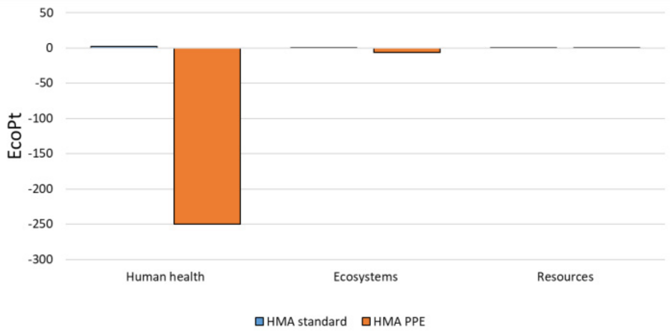

Fig. 4. LCIA in terms of characterized ReCiPe End point

Fig. 5 shows the environmental impact, considering the Global Warming indicator [$kgCO_2eq$.]. The results have been split between the different HMA production phases: raw material extraction and processing, HMA production, and yard operation. Production phase consists in the drying and mixing of aggregates, bitumen and reinforcing PPE, where present. The yard operation are the steps necessary to create the new street, milling process for to remove the end asphalt, finishing process for create the paving and the rolling to compact the fresh asphalt undeterred. The transport phases refer both to the procurement of raw materials and to the transport of the bituminous conglomerate to the construction site. From Fig. 5 it is evident that the use of PPE does not produce variations in the HMA production process and the yard operation, while the different impacts are due to the avoided material to landfill or incineration. The value of avoidant impact (tot avoided in fig.5) it is comparable to the impacts produced during the production and asphalt paving phase (drying, mixing, milling and finish).

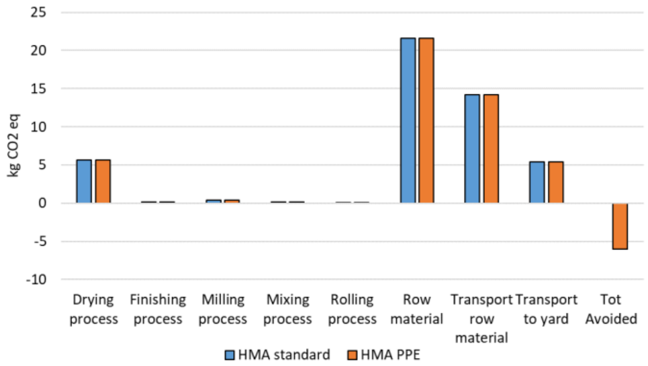

Fig. 5. LCIA in terms of Global warming for HMA production and yard operation

The obtained results are in line with data derived from other relevant literature studies about the environmental performance of standard HMA mixtures. In particular, Landi et.al. [14] calculated an impact of 62,5 kgCO2eq. per ton of standard HMA, in line with the results obtained in this study, about 47,5 kgCO2eq. As already mentioned above, the reuse of PPE produces significant advantages in terms of eutrophication and toxicity, both human and marine. This result is highlight in Fig. 4 where the impact for the HMA with PPE are negative. Fig 6 shows the impact in term of human toxicity. From this indicator it is evident how the impacts avoided thanks to the reuse of a waste material produce benefits on humans.

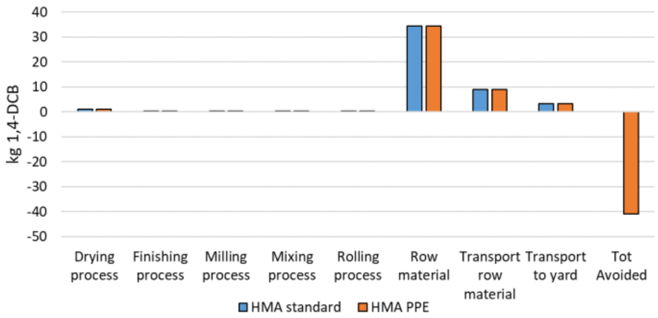

Fig.6. LCIA in terms of Human non-carcinogenic toxicity for HMA production and yard operation

5. Conclusions

Waste from personal protective equipment today represents an economic, environmental, and social problem. With the Covid 19 pandemic, the consumption and use of masks (surgical and FFP2, FFP3), gowns, caps, gloves have increased significantly and very quickly, but at the same time adequate disposal and recovery systems have not been developed.

In general, extending the life of a product / material reduces its environmental footprint on the ecosystem. Starting from this consideration, an application was sought to extend the life of the PPE without having to "spend" in environmental terms for disposal.

Through the Life Cycle Assessment methodology, the impacts of two different types of bituminous conglomerate, standard and reinforced with fibers from PPE, were assessed.

Mechanical and technological tests have shown the feasibility of using PPE in HMA asphalt, achieving the same performance as a standard asphalt.

The environmental assessment has shown a clear improvement in the case of asphalt reinforced with raw material from waste with a reduction in the impacts on both human health and the ecosystem.

It should be noted that this is an analysis based on data obtained in the laboratory. Better shredding and metering of the waste material could increase the life of the bituminous mix.

This would result in a further advantage in environmental terms, as in addition to disposing of a material destined for an incinerator or landfill, it would also extend the life of our roads.

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References

[1] FCDO. (2020). Covid-19 – PPE demand & supply perspectives. Foreign, Commonwealth and Development Office, December.

[2] Transforming Our World: the 2030 Agenda for Sustainable Development, Resolution Adopted by the General Assembly. Seventieth Session on 25 September 2015.

[3] Prata, J.C., Silva, A.L.P., Walker, T.R., Duarte, A.C. & Rocha-Santos, T. (2020) COVID-19 pandemic repercussions on the use and management of plastics. Environ. Sci. Technol., 54, 7760-7765. DOI:10.1021/acs.est.0c02178.

[4] De la Torre, G.E., Rakib, M.R.J., Ortega, C.I.P., Salinas, D.C.D. : Occurrence of personal protective equipment (PPE) associated with the COVID-19 pandemic along the coast of Lima, Peru. Science of the Total Environment. (2021)

[5] Haddad M.B., De-la-Torre, G.E.,Abelouah, M.R.,Hajji,S., Alla,A.A.: Personal protective equipment (PPE) pollution associated with the COVID-19 pandemic along the coastline of Agadir, Morocco. Science of the Total Environment. (2021)

[6] Barbanera, M., Marconi, M., Peruzzi, A., & Dinarelli, S. (2022). Environmental assessment and eco-design of a surgical face mask. Procedia CIRP, 105, 61–66. https://doi.org/10.1016/j.procir.2022.02.011

[7] Microplastics waste in environment: A perspective on recycling issues from PPE kits and face masks during the COVID-19 pandemic, https://doi.org/10.1016/j.eti.2022.102290

[8] 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. https://doi.org/10.1016/j.cscm.2016.11.001

[9] Biswas, A., Goel, A., & Potnis, S. (2020). Performance comparison of waste plastic modified versus conventional bituminous roads in Pune city: A case study. Case Studies in Construction Materials, 13. https://doi.org/10.1016/j.cscm.2020.e00411

[10] del Rey Castillo, E., Almesfer, N., Saggi, O., & Ingham, J. M. (2020). Light-weight concrete with artificial aggregate manufactured from plastic waste. Construction and Building Materials, 265. https://doi.org/10.1016/j.conbuildmat.2020.120199

[11] White, G., & Reid, G. (2019). Recycled waste plastic modification of bituminous binder. Bituminous Mixtures and Pavements VII-Proceedings of the 7th International Conference on Bituminous Mixtures and Pavements, ICONFBMP 2019, April, 3–12. https://doi.org/10.1201/9781351063265-1

[12] Omar Abu Eideh. (2018). Plastica riciclata al posto del bitume: il test del nuovo asfalto ecologico a Londra.

[13] Landi, D., Gigli, S., Germani, M., & Marconi, M. (2018). Investigating the feasibility of a reuse scenario for textile fibres recovered from end-of-life tyres. Waste Management, 75, 187–204. https://doi.org/10.1016/j.wasman.2018.02.018

[14] Landi, D., Marconi, M., Bocci, E., & Germani, M. (2020). Comparative life cycle assessment of standard, cellulose-reinforced and end of life tires fiber-reinforced hot mix asphalt mixtures. Journal of Cleaner Production 248.

[15] Saberian, M., Li, J., Kilmartin-Lynch, S., & Boroujeni, M. (2021). Repurposing of COVID-19 single-use face masks for pavements base/subbase. Science of the Total Environment, 769, 145527. https://doi.org/10.1016/j.scitotenv.2021.145527

[16] Experimental investigation on the use of COVID-19 waste in bituminous concrete, https://doi.org/10.1016/j.matpr.2022.08.055

[17] Pu, Y.; Zheng, J.; Chen, F.; Long, Y.; Wu, H.; Li, Q.; Yu, S.; Wang, X.; Ning, X. Preparation of Polypropylene Micro and Nanofibers by Electrostatic-Assisted Melt Blown and Their Application. Polymers 2018, 10 (9), 959, DOI: 10.3390/polym10090959

[18] Harussani, M. M., Sapuan, S. M., Rashid, U., Khalina, A., & Ilyas, R. A. (2022). Pyrolysis of polypropylene plastic waste into carbonaceous char: Priority of plastic waste management amidst COVID-19 pandemic. Science of the Total Environment, 803. https://doi.org/10.1016/j.scitotenv.2021.149911

[19] United Nations Framework, 1993 United Nations Framework Convention on Climate Change, n.d. Kyoto Protocol, 1993. https://unfccc.int/resource/docs/convkp/kpeng.html

[20] ISO 14040: Environmental Management — Life Cycle Assessment — Principles and Framework (2006)

[21] ISO 14044:2006 Environmental management — Life cycle assessment — Requirements and guidelines

[22] Intergovernmental Panel on Climate Change (IPCC). Visited December 18, 2007. IPCC Secretariat, C/O World Meteorological Organization, 7bis Avenue de la Paix, C.P. 2300, CH - 1211 Geneva 2, Switzerland. http://www.ipcc.ch/. Government Information Quarterly Volume 26, Issue 2, April 2009, Pages 428-429