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Waste Tyres in Zawia City, Challenges and shortcomings

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ABSTRACT

With the rapid increase in number of cars on the streets - and their non-degradability, waste tyres are considered as a significant part of the urban waste stream that is growing in quantity every day and - present a major waste management problem in Libya where it has not received adequate interest, as the waste tyres processing, treatment and disposal are still nascent. Waste tyres dumps present a serious threat to both of environment and human health as they promote the growth of pests and diseases, burning of tyres can also cause several environmental problems such as air, water and soil pollutions. The study found that despite the Libyan laws forbid the dumping of waste of all tyres in any public places and punches the incineration of waste by a fine. However, there is no known judicial rulings issued in application of these laws, either due to a lack of environmental awareness among individuals or because most cases have ended in reconciliation, or because of the failure of the competent administrative authorities to apply and monitor the implementation of these laws. Due to the lack of previous studies and the scarcity of data regarding this problem in Libya, this study had been conducted to estimate the number of tyres generated in the city of Zawia which was found to be approximately 370,000 scrap tyres per year, amounting to 5050 tons per year. According to these findings, there are nearly 7.349 million waste tyres residing in environmentally unsound stock piles in Libya per year.

This paper aims to shed a light on the problem and discuss their environmental impact.

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Keywords: Waste tyres, waste tyre management, environmental impact, environmental legislation.

الإطارات المستهلكة في مدينة الزاوية: التحديات وأوجه القصور

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الملخص

تعد الإطارات المستهلكة جزءا كبيرا من النفايات التي تزداد بكميات كبيرة كل يوم.ومع الزيادة السريعة في عدد السيارات في الشوارع وعدم قابليتها للتحلل، تمثل الإطارات المستهلكة مشكلة كبيرة في إدارة النفايات في ليبيا حيث لا توجد تشريعاتوقوانين بشأن هذه المسألة، . يهدف هذا البحث إلى تسليط الضوء على المشكلة ومناقشة تأثيرها البيئي.تمثل نفايات الإطارات تهديدًا خطيرًا لكل من البيئة وصحة الإنسان لأنها تعزز نمو الآفات والأمراض التي تحملها الحشرات والقوارض، كما أنها تشكل خطرًا كبيرًا لنشوب حرائق قد يكون من الصعب إخمادها. يمكن أن يسبب حرق الإطارات عدة مشاكل بيئية مثل – تلوث الهواء، تلوث المياه، وتلوث التربة.توصل البحث إلى أنه على الرغم من أن القوانين الليبية تحظر إلقاء النفايات بكافة أنواعها في أي مكان عام وتعاقب حرق النفايات بكافة أنواعها بالغرامة، إلا أنه لا توجد أحكام قضائية معروفة صدرت تطبيقا لهذه القوانين، إما بسبب قلة الوعي البيئي لدى الأفراد أو لأن معظم القضايا انتهت بالتصالح، أو بسبب تقاعس الجهات الإدارية المختصة عن تطبيق ومراقبة تنفيذ هذه القوانين.ونظراً لقلة الدراسات السابقة وندرة البيانات المتعلقة بهذه المشكلة في ليبيا، فقد أجري هذا البحث لتقدير عدد الإطارات المنتجة في مدينة الزاوية حيث وجد أن ما يقرب أن ما يقرب من **370,000** من الإطارات المستهلكة يتم تراكمها سنويًا في مدينة الزاوية،أي ما يقارب من **5050** طن سنويًا. بناء على هذه الدراسة، يمكن تقدير عدد الإطارات المستهلكة سنويا في ليبيا بحوالي **7.349** مليون إطار ترمى في المكبات والشوارع.

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الكلمات المفتاحية: الإطارات المستهلكة، إدارة نفايات الإطارات، الأثر البيئي، التشريعات البيئية.

Introduction:

The focus of this study is waste tyres. Scrap tyres are a very common and significant solid waste and its production is increasing due to the increasing number of vehicles in both developed and underdeveloped countries. Dumping of waste tyres is an environmental challenge in several countries due to their non-biodegradability and because they occupy a lot of space due to their shape and volume. Every year millions of tyres are discarded, thrown away or buried all over the world, representing a very serious threat to the ecology. Also, the illegal dumping of tyres is a serious threat to public health through the release of chemicals and pollutants into surrounding soil and groundwater. Globally, in developed countries, waste tyres are recycled and used in multiple different applications due to their unique structure and make-up, those applications include cement manufacturing [1], fuel and energy recovery [2] and road resurfacing [3] among many others. This was helped by passing regulations banning tyres from being put into landfills like in the EU forcing countries to search of alternative methods to deal with waste tyres. According to the European Tyres and Rubbers Manufacturers Association (ETRMA) in 2016 Europe has been able to recycle and treat almost 94% of the scrap tyres collected that year, with countries like Germany, Norway, Denmark and Belgium reaching 100% [4]. In an attempt to alleviate the on-going waste accumulation problem, various technologies have been researched in order to convert waste materials into useful products. One suggestion is the use of the gasification process to convert any kind of organic waste materials into an energy vector. Studies have indicated that from known technologies such as incineration, pyrolysis and gasification, the gasification technology has proven to be the cleanest due to the absence of an incineration or burning processes and the versatility of the end product “Syngas” [5].

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It's difficult to implement such waste management systems in underdeveloped countries like Libya due to lack of data and previous studies regarding this issue. Therefore, there is a need to investigate and study the scope of the problem and its environmental impact first, before searching for applicable solutions.
The aims of this paper are to highlight the waste tyre problem in Libya and the lack of existing related legislations, as well as academic research exploring stakeholder views towards the problem, to explain the environmental impact of waste tyres and to estimate the amount of waste tyres generated per year in the city of Zawia.

History of tyres

In 1839, Charles Goodyear [6] discovered the Vulcanization Process that led to the development of vulcanized rubber for which he received patent [3633] from the United States Patent Office on June 15, 1844. [7] The invention of vulcanized rubber by Goodyear had huge ramifications on the manufacture of goods. It was durable, moldable and it paved the way for the first rubber tyres.
In 1946, Michelin developed the radial tyre method of construction. Because of its superiority in handling and fuel economy, the use of this technology quickly spread throughout Europe and Asia [8]. Radial tyres had many advantages including longer tread life, better steering characteristics, and less rolling resistance, which increases gas mileage [8].
Vulcanization is a chemical process for converting polymers into more durable materials by introducing cross links. During the manufacturing process sulfur can be added to the rubber to change the properties of the tyre, whereby at certain temperatures, C–H bonds are broken and replaced sulfur atom chains. Figure (1) shows the Natural Rubber and the Vulcanized Rubber.

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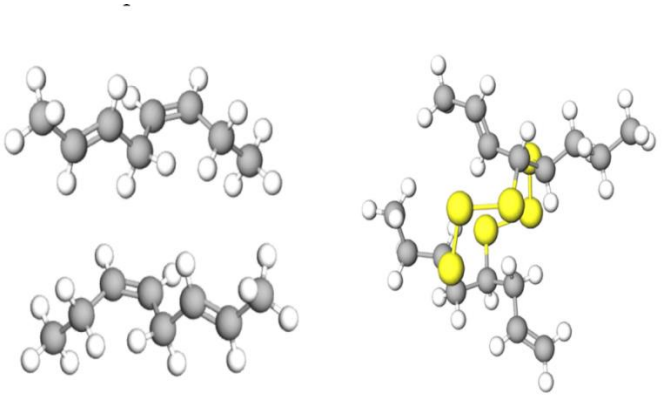

Figure 1. Natural Rubber on left, and Vulcanized Rubber on right , Grey = carbon, White = hydrogen, Yellow = sulphur

Tyre Structure and Composition

As demonstrated in Figure 2, most steel belted radial passenger and light truck tyres are composed of an inner liner, polyester reinforced body plies, steel beads, bead reinforcing strips, anti-chafing strips, steel belts with belt edge wedges or wrap, the sidewalls, and the tread. Many tyres also include one or two layers of nylon or polyester constricting belts or strips over the steel belts (safety belts or cap plies) [9].

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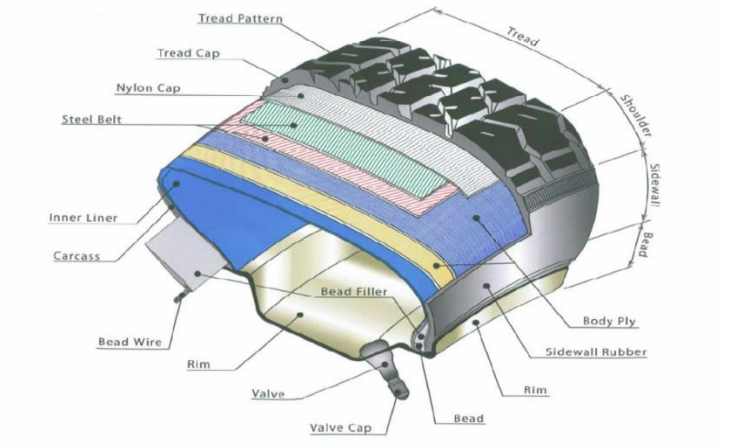

Figure 2. Components That Make Up a Tyre

Over 100 raw materials are used in the production of tyres, which include raw rubber, tyre cord, carbon black, bead wire and compounding ingredients among many others. Approximately half of these materials are chemical products based on petroleum, primarily naphtha. Different natural and synthetic rubber formulations are used to produce passenger and truck tyres; the tyres are mainly a blend of both rubbers. The rubbers used in tyre manufacturing are thermoset polymers. The most commonly used - synthetic rubber is the styrene-butadiene copolymer (SBR) with a styrene content of about 25 wt.%. However, there are some other rubbers used in tyre manufacturing such as natural rubber (NR-polyisoprene), Butadiene rubber (BD), nitrile rubber (NTR) and chloroprene rubber (CPR) [10]. Sulphur is also added to the tyre to form cross-links between the rubber polymer chains thus also hardening the rubber to prevent excessive deformation at elevated temperatures. The cross-linking of the elastomers gives the rubber materials their thermoset characteristics; the sulphur content is normally up to 1.5 wt.%[11]. In 2022, the global demand for tyres reached nearly USD 314.07 billion, and its expected growth in the forecast period of 2023-2028, will reach USD 453.13 billion by 2028[12].

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End of Life Tyres

An end-of-life tyre (ELT) is a used tyre that cannot or is not reused for its originally intended purpose and is not retreaded. European regulations define end-of-life tyres as those that should either be recycled or have their usefulness extended owing to their physical state and security regulations. End-of-life tyres are also called scrap tyres or waste tyres.

Global Waste Tyre Generation

Approximately 1.5 billion tyres are categorized as having reached their end-of-life annually weighing approximately 17 million tones with almost another 4 billion already existing in stockpiles and landfills worldwide, this amount includes passenger car tyres which account for 75% of the total while the remaining 25% is composed of truck tyres and other categories[4]. The increase in population coupled with economic growth of many nations promote the growth of the automotive industry which in turn increases the number of tyres and subsequently the number of waste tyres discarded annually. In 1990, about a billion scrap tires were in stockpiles in the U.S. By 2021, over 95% of those tires have been cleaned up! Figure (3) shows that only 50 million more stockpiled tires still to go [13].

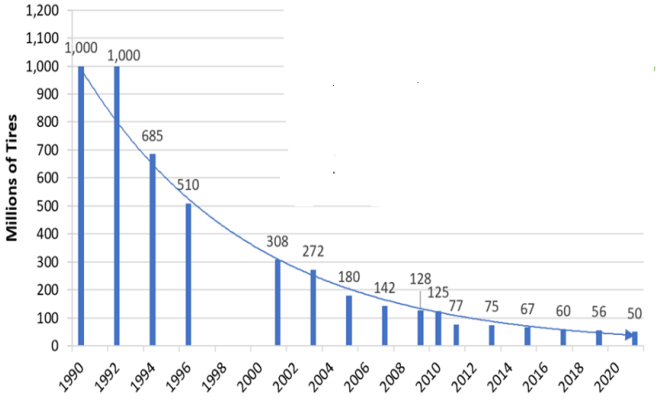

Figure 3. U.S. Stockpiled Scrap Tires 1990 – 2021[13]

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Environmental Impact

Tyres are designed to withstand harsh mechanical and weather conditions and their complex nature makes them difficult to recycle and/or process further. Due to their design, waste tyres resist degradation (non-biodegradable) when in landfills and their bulky nature (75% void space) and resistance to compression and folding makes them taking up a lot of land filling space. Thus, making getting rid of them is a huge environmental challenge. Waste tyres dumps present a serious threat to both the environment and human health as they promote the growth of pests, disease carrying insects like mosquitoes and rats. Waste tyres also pose a high risk of fires that can be difficult to extinguish, an example to that is the 9-month Rhinehart tyre fire in Winchester Virginia, and could have environmental impacts due to uncontrolled emissions of potentially harmful compounds into the atmosphere, soil and groundwater. Significant pollution such as thick, black, foul smelling smog from the burning rubber is produced. The burning of tyres can cause several environmental problems such as:

- **Air Pollution**: Complete combustion of a tyre, will produce carbon dioxide that contribute to greenhouse effects. . Water vapor and inert residues that may contain sulphur dioxide. Incomplete combustion releases dioxins gases. Furthermore, volatile organic compounds and hazardous air pollutants such as polynuclear aromatic hydrocarbons (PAHs), dioxins, furans, hydrogen chloride, benzene, polychlorinated biphenyls (PCBs), arsenic, cadmium, nickel, mercury, zinc, chromium and vanadium are released into the atmosphere [14].

- **Water Pollution**: Tyre combustion causes pyrolysis of the rubber, resulting in oily decomposition waste. The oily discharge can flow into nearby streams, ditches and waterways or can leach into the ground water. In cases where water is used to put out the fire, chemical compounds like aromatic liquids and paraffin may be carried by the water. Then the used water needs to be treated, before it is disposed of, which does not often happen in practice. The

situation can pollute nearby streams or may seep into the ground water.

- **Soil Pollution**: Residues that remain on the soil after a fire can have an impact on the environment in two ways:

1. Immediate pollution resulting from decomposing liquid products penetrating the soil.
2. Gradual pollution caused by leaching of ash and unburned residues.

Gradual leaching of oily discharge can occur and the toxic residues of the burnt tyre such as zinc salts can cause harm to the environment. It usually takes long time for the contaminated soil to recover unless remediation and or rehabilitation measures are taken [15].

Hazardous Waste Composition

Hazardous components make up 1.5% of the tyre weight. These compounds, outlined in Table 1, are found in the rubber or present as an alloying element [9].

Table 1. Hazardous Waste Constituents

Chemical name	Remarks	Content (% weight)
Copper compounds	Alloying constituent of metallic reinforcing material	Approximately 0.02%
Zinc compounds	Zinc oxide retained in the rubber matrix	Approximately 1%
Cadmium	On trace levels, as cadmium compounds attendant substance of the zinc oxide	Maximum 0.001%
Leadcompounds	On trace levels, as attendant substance of the zinc oxide	Maximum 0.005%
Acidic solutions or acids in solid form	Stearic acid, in solid form	Approximately 0.3%

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Management of Waste Tyres

Waste management can be defined as the process in which the different kinds of wastes are being collected, processed or recycled in order to convert them into useful materials or to dispose them in an environment friendly way. The waste management hierarchy indicates an order of preference for action to reduce and manage waste from most favorable to least favorable actions as illustrated in Figure [5].

Figure 5. Waste management hierarchy

Due to the environmental impacts and relevant health hazards, waste tyre disposal has turned into a major issue and an operational decision needs to be taken to deal with the huge amount of waste tyres produced every year. It is worth while mentioning that end-of-life tyres are a potential source of raw materials and as such, several processes have been used for material recovery and recycling from waste tyres.Various processes or methods have been used as alternative pathways for dealing with the problem of waste tyre generation [15]. These pathways are:

1. Landfilling
2. Energy Recovery

3. Material Recycling
4. Retreading
5. Reuse/Export

Due to the implantation of several laws and directives in Europe (The European Landfill Directive/Produce Responsibly Initiative) over 26 million tons of waste tyres has been recovered either through material or energy recovery, this led to a substantial decline in landfilling with the numbers of waste tyres in landfills reaching all-time lows. As shown in figure (5), only 4% of waste tyres in Europe are either landfilled or have unknown recovery routes, while recycling, reuse and retreading now contribute to a substantial 96% of used tyres recovery[16].

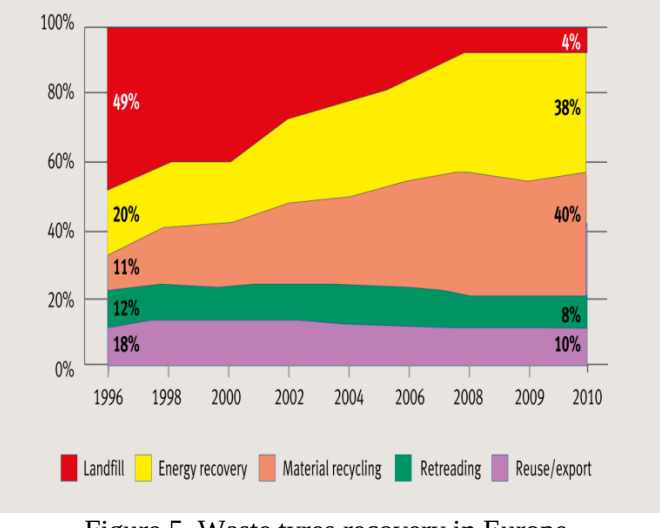

Figure 5. Waste tyres recovery in Europe.

Waste tyres Situation in Libya

Waste tyres present a serious problem in underdeveloped countries such as Libya due to lack of implementation of rules and legislations that prevent this problem from accumulating in addition to absence of specific waste management systems and recycling plants that takes advantage of this problem by removing waste and creating revenue. It was difficult to find data relating to waste tyres problems

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not only in Zawia city but in whole Libya, a visit to Polymers Research Center in Tajoura City was made and found just one research paper published in 2016 regarding the issue with few information and data [17].

Tyre Imports and Production in Libya

Table 2 shows the number of tyres imports in Libya in 2003 and 2007 where imports of small cars have dramatically increased by 273.4%.

Table 2: Imports of Tyres and Rubber Products in Libya [18]

Import Type	Imports	
	2003	2007
	Quantity	Quantity
Small Car tyres	432662	1615500
Trucks & Busses Tyres	150131	149648
Aircraft Tyres	452	907
Motorcycle Tyres	2710	4744

AMAN Co for Tyres and batteries was established in 1976 in city of Tajoura to produce mainly tyres and batteries and was considered one of major companies in Libya. The company has suspended its operations due financial problems before 2011. Table 3 shows the tyre production in Libya by AMAN company which had branches in Tripoli and Benghazi.

Table 3: Tyre Production in Libya; AMAN Company data [18]

Product Type	The Design Capacity	Detective in Production		Total Sales	
		2008	2009	2008	2009
Small Tyres	323310	7510	6	4767	2228
Light Transport Tyres	61787	6377	1779		
Heavy Transport Tyres	86222	1729	916		
Tractors	21588	226	20		

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Waste Tyres Rules and Legislations in Libya

There are several laws and legislations implemented in developed countries like the European Landfill and the Produce Responsibly Directives that are made specifically to counter the tyre waste problem, as the EU outlawed the practice of dumping tyres into landfills as early as 2003, due to its environmental concerns and potential leakage of dangerous chemicals [19].

The Libyan legislator issued Law No. (7) Of 1982 regarding environmental protection, which was replaced by Law No. (15) Of 2003 regarding protecting and improving the environment but with no mention of countering waste tyres, add to that the executive regulation of the law No. (15) Of 2003, was issued unfortunately six years later by resolution No 448 of 2009, which means the law has not been applied for the whole six years. The Libyan environmental protection law forbids the dumping of waste of all types in streets, parks, beaches and any public places as stated by Article 3 in law (13) regarding "Public Health" for year 1984 and punished by a fine between fifty dinars (10 USD) and one hundred dinars (20 USD) and for violating Article 13.The Libyan Laws also forbid the incineration of waste of all kinds as stated by article 14 in law (15) regarding "Environment Protection & Preservation" for year 2003 which states " It is forbidden to set fire to rubber, petroleum, garbage as well as other organic materials for disposal in or adjacent to populated areas." Article 65 in the same law punishes whoever violates the Articles 14 by a fine of not less than one thousand dinars (about 200 USD) and not exceeding five thousand dinars (1000 USD).However, The Libyan legislator has opened the door for reconciliation in crimes punishable under law No. (15) Of 2003, this would reduce the effectiveness of the criminal protection provided by law. Law No. (15) Of 2003 stipulated the formation of the Environmental Police in Article (9) to carry out environmental inspection tasks. However, the establishment of this body did not occur until 2022 when the Council of Ministers of the National Unity Government issued Resolution No (42) of 2022 regarding the establishment of the Environmental Police, its first article stipulates the establishment of an Environmental Police, with its main

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headquarters in the city of Tripoli, which will have a public legal personality and independent financial liability, and be affiliated with the Ministry of the Environment.

Article 9 of resolution No (448) of 2009 prohibits the competent authorities - each within its jurisdiction - from granting any licenses to practice any activity that may result in pollution unless the license applicant obtains permission to do so from the environmental Authority. The activities that may result in pollution and the procedures to be followed for the environmental impact resulting from those activities are determined by a decision from the environmental authority. Despite the establishment of the Environmental Police, its role in environmental awareness and taking legal measures against violators with regard to waste tyres remains modest and insufficient. On July 5, 2022, it's Facebook page published news with a picture shown in figure (6) regarding a warning to owners of waste tyres shops, based on a letter from the Minister of the Interior regarding taking measures by obliging the owners of tyre sales and repair shops not to place waste tyres in front of the stores and holding them responsible in the event of failure to comply with these instructions, stressing that burning tyres causes serious damage to the environment and human health.

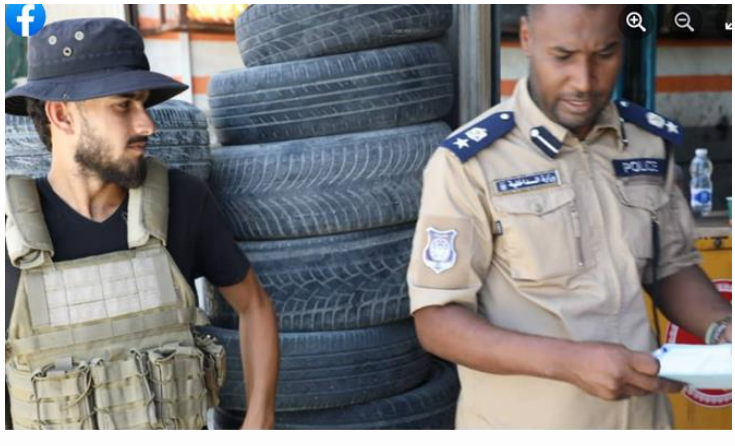

Figure 6. Environmental Police inspecting waste tyres shops in Tripoli, July 2022

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It is noted that despite the existence of a good number of environmental laws issued in Libya regarding the protection of the environment, there is no known judicial rulings issued in application of these laws, either due to a lack of environmental awareness among individuals or because most cases have ended in reconciliation, or because of the failure of the competent administrative authorities to apply and monitor the implementation of these laws or because of the difficulty of proving these crimes [20].

Waste Tyres Generated in City of Zawia

The City of Zawia was chosen as the sample of our study, it is located in northwestern Libya, 45KM west of the capital Tripoli and it has a population of approximately **357,631** as of 2021[21]. Like many other cities in Libya, the city of Zawia suffers from a serious waste epidemic, with tyre waste being a main contributor to the problem as shown in figure (7).

Figure 8. Examples of tyres waste in the city of Zawia.
On the left it shows tyres accumulation in AL-Qanaa Street while on the right: tyres on the side of the Road in AL-haraa Street.

According to The International Rubber Study Group (IRSG), the standard assumption is that waste tyres are generated at a rate of **1.05** tyres per person per year [22]. Therefore, the number of wastes

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tyres produced each year in Zawia is approximately **375,512**tyres. To compare the pervious result with a real number of car tyres in Zawia city, a visit to Zawia Department of Licensing & Traffic was made to collect data regarding the number of vehicles in the city, which was found to be about 140,000 small transport vehicles and over 45,000 heavy transport vehicles[23]. Multiple studies suggested that car tyres should be changed once every 3-4 years but taking into account the poor state of roads, the lack of a solid infrastructure in Libya and the fact that a lot of Libyan citizens opted to buy used tyres, the study assumes that a more acceptable rate in Libya should within 2 years, meaning 2 tyres per year for a single vehicle.

With approximately 185,000 cars, the city of Zawia produces **370,000** Tyres/Year, resulting in around **1.04** tyres per person, therefore, it has given us an indication that the two results are very close and can be taken as a good data for study. Using these findings, the amount of tyres generated in Libya would be around **7.349**million waste tyres residing in stockpiles per year.

- **Weight Calculations:** The average weight of a passenger vehicle tyre is around 22 lb (10 Kg) and for a heavy transport vehicle it is around 50 lb (25 Kg) [22]. Based on those numbers we can calculate the weight of tyres generated in the city of Zawia:

The weight of waste generated from passenger vehicle tyres

$$= 140{,}000 * 2 \frac{\text{Tyre}}{\text{Year}} * 10 \frac{\text{Kg}}{\text{Tyre}} = 2800 \text{ Tons/Year}$$

The weight of waste generated from heavy transport vehicle tyres

$$= 45{,}000 * 2 \frac{\text{Tyre}}{\text{Year}} * 25 \frac{\text{Kg}}{\text{Tyre}} = 2250 \text{ Tons/Year}$$

The weight of waste generated from passenger vehicle and heavy transport vehicle tyres in the city of Zawia

$$= (2800 + 2250) \text{ Tons/Year} = \mathbf{5050\ Tons/Year}$$

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The weight of waste generated in Libya annually

=5050*7394000/370000= **101918 Tons/year**

The daily waste tyres generation rate for the city of Zawia

$$=5050\frac{\text{Tyre}}{\text{Year}} * \frac{1\,Year}{365\,Day} = 13.8 \text{ Tons/Day}$$

The daily waste tyres generation rate in Libya

= **276.5 Tons/day**

Conclusions

Waste tyres dumps present a serious threat to both the environment and human health as they promote the growth of pests, disease carrying insects, burning of tyres which are happening normally in Libyan streets in public demonstrations can cause several environmental problems such as air pollution, water pollution, and soil pollution. This study has explored various methods that have been used as alternative pathways for dealing with the problem of waste tyre generation such as Landfilling, Energy Recovery, Material Recycling, Retreading and Reuse.

This study found that despite The Libyan laws forbids the dumping of waste of all types in any public places and the legal punishment of the incineration of waste of all kinds is a fine of not less than one thousand Libyan dinars (about 208 USD) and not exceeding five thousand Libyan dinars (1041 USD), there is no known judicial rulings issued in application of these laws, either due to a lack of environmental awareness among individuals or because most cases have ended in reconciliation, or because of the failure of the competent administrative authorities to apply and monitor the implementation of these laws.

Due to the lack of previous studies and the scarcity of data regarding the waste tyres problem in Libya, this study had been conducted to estimate the number of tyres generated in city of Zawia which was found approximately 370,000 scrap tyres is generated per year in city of Zawia, amounting to **5050** tons per year. According to these

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findings, there are nearly **7.349**million waste tyres residing in environmentally unsound stock piles in Libya per year which is equivalent to **276.5 Tons/day**

Recommendations

1. Further studies should be conducted in Libya regarding the waste problem, specifically waste tyres.
2. It is highly recommended to implement waste management systems as they have been shown to have a positive impact on the community creating revenue and jobs while getting rid of waste.
3. Further development of the process especially the cleaning system, also emphasis on getting rid of the generated "Ash" in an environmentally friendly way.
4. Integrating awareness programs on how to protect and preserve the environment within the educational curricula at different academic levels in a way that instills in everyone interest in the environment and taking care of it.
5. Issue new adequate policies, clear legislation and strong regulations to deal with the problem of waste tyres.

References:

[1] Mushunje K , Otieno1 M and Ballim,Y, (2018) , A review of Waste Tyre Rubber as an Alternative Concrete Consituent Material, University of the Witwatersrand, , Johannesburg, South Africa , Sol Plaatjie University, Kimberly, South Africa, https://www.researchgate.net/publication/328636172_A_review_of_Waste_Tyre_Rubber_as_an_Alternative_Concrete_Consituent_Material

[2] Zheng Xiao , A. Pramanik , A.K. Basak , C. Prakash , S. Shankar , Material recovery and recycling of waste tyres-A review,https://www.sciencedirect.com/science/article/pii/S2772397622000752

[3] Mrs Meenu Kalra, Piyush Kumar Lodhi, Shobhit Agrahari, Shubham Yadav, Swatantra Gupta, Vipin Kumar Maurya Galgotias, College of Engineering and Technology Greater Noida, , India, 2023, " Use Of Waste Tyre In Road Construction

تم استلام الورقة بتاريخ: 3/ 1/2024م وتم نشرها على الموقع بتاريخ: 31/ 1/2024م

"https://www.eurchembull.com/uploads/paper/71db992c1462997f34ad4bd9e89b2cc7.pdf,
[4] ETRMA-European Tyre & Rubber Manufacturers' Association.https://www.etrma.org/
[5] D.A.J. Rand, CSIRO Energy Technology, Clayton, VIC, Australia, panel R.M. Dell
[6] Atomic Energy Research Establishment, Harwell, UK, 2009 "FUELS – HYDROGEN PRODUCTION | Coal Gasification", https://www.sciencedirect.com/science/article/abs/pii/B9780444527455003002
[7] Ann Marie Somma, 2014, "Charles Goodyear and the Vulcanization of Rubber", 2014.https://connecticuthistory.org/charles-goodyear-and-the-vulcanization-of-rubber/,
[8] United States Patent Office.
[9] History of Tyres, https://www.jalopyjournal.com/forum/threads/history-of-radial-tires.612393/ (Accessed October 2023).
[10] Tyre, Wikipedia, The Free Encyclopedia, https://en.wikipedia.org/wiki/Tire (Accessed October 2023).
[11] Hita, I., Arabiourrutia, M., Olazar, M., Bilbao, J., Arandes, J.M. & Sánchez, P.C. (2016). Opportunities and Barriers for Producing High Quality Fuels from Scrap Tyres. University of The Basque Country, Spain.
[12] Adhikari, B., De, D. & Maiti, S. (2000). Reclamation and Recycling of Waste Tyres. Progress in Polymer Science. University of Oxford, England.
[13] Global Tyre Market Outlook, https://www.expertmarketresearch.com/reports/tire-market (Accessed October 2023).
[14] 2021 US Scrap Tire Management Summary, October 2022 ,U.S. Tire Manufacturers Association https://www.ustires.org/sites/default/files/21%20US%20Scrap%20Tire%20Management%20Report%20101722.pdf
[15] Ikreedeegh, R.R. and M. Tahir, A critical review in recent developments of metal-organic-frameworks (MOFs) with band

تم استلام الورقة بتاريخ: 3/ 1/2024م وتم نشرها على الموقع بتاريخ: 31/ 1/2024م

engineering alteration for photocatalytic CO2 reduction to solar fuels. J. CO2 Util., 2021. 43: p. 101381

[16] Sharma, V.K., Fortuna, F., Mincarini, M., Berillo, M. & Cornacchia, G. (2000). Disposal of Waste Tyres for Energy Recovery and Safe Environment. Applied Energy Journal.

[17] The European Landfill/Produce Responsibly Directive. (1999). Regulation (EC) No-1882/2003.

[18] October 18th, 2018. A Visit to The Polymer Research Center, Tajura.

[19] Omar Jitlayi, Abd alhakim Al majdop & Wanis Shabish. (2016). Feasibility Study for Waste Tyre Recycle in Misrata City, ICCPGE-2016 Al-Mergib University, Libya.

[20] The European Landfill/Produce Responsibly Directive. (1999). Regulation (EC) No-1882/2003.

[21] Criminal Protection of the Environment in Libyan Legislation, Dr. Muhammad Mahmoud Al-Sharkasi: Assistant Professor of Criminal Law - Faculty of Law - University of Benghazi.Nile Valley Journal of Human, Social and Educational Studies and Research https://jwadi.journals.ekb.eg/article_85290_2222b887ba764f4c387489060be9ac4c.pdf(Accessed October 2023).

[22] Bureau of Statistics and Census Libya.https://bsc.ly/wp-content/uploads/2024/01/%D8%AA%D9%82%D8%AF%D9%8A%D8%B1%D8%A7%D8%AA-%D8%A7%D9%84%D8%B3%D9%83%D8%A7%D9%86-2021.pdf

[23] IRSG (International Rubber Study Group).

[24] Zawia Department of Licensing & Traffic.

تم استلام الورقة بتاريخ: 3/ 2024/1م وتم نشرها على الموقع بتاريخ: 31/ 2024/1م