Research Journal of Chemical and Environmental Sciences
Res J. Chem. Environ. Sci. Vol 4 [2] April 2016: 01-07
Online ISSN 2321-1040
CODEN: RJCEA2 [USA]
©Academy for Environment and Life Sciences, INDIA
Website: www.aelsindia.com/rjces.htm

RJCES

REVIEW ARTICLE

Automobile Waste and Its Management

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ABSTRACT
Waste management is one of the most emerging issues all over the world. This is because of the large amount of waste that is being generated daily and the impact of such waste is hazardous for the environment and living beings. Waste management is the organized way of managing the waste through pathways to guarantee that they are disposed off with attention to least negative impact to the environment. With the rapidly increasing volume of vehicles, there is a parallel need to increase waste management initiatives by governments across the world and also of modern facilities for reuse and recycling of waste materials like metal, solvents, batteries, plastics etc. when the vehicle reaches its end of life. Waste recycling can help eliminate and thus minimize wastes. This review article reveals the management strategies adopted by automobile industries to minimize waste generated from end of life vehicles.
Keywords: *Waste Management, Hazardous, Metal, Plastics, Automobile.*

Received 01.01.2016 Accepted 21.02.2016 © 2016 AELS, INDIA

INTRODUCTION

The automobile is a major material consumer. Nowadays, everything is become changes and having a vehicle is very popular. Increasing production of vehicles is the key driver for the growth of automobile market. The production of automobiles results in generation of waste materials; these waste materials are recycled by many manufacturers as it helps to resolve supply shortage during the manufacturing process. Automotive waste management involves the reuse and recycling of waste materials like metal, solvents, batteries, plastic, and glass. Recycling of these materials helps address environmental concerns and also allows them to address the issue of resource depletion. Currently, approximately 75% of the total vehicle weight is recycled. The End-of-life vehicles try to push the recycling process further: it fixed the percentage of recyclability (85%) and recoverability (95%) [1, 2, 3]. The remaining 25% go to landfill, and is known as Auto Shredder Residue (ASR). ASR is mainly composed of foams and fluff (40-52%), plastics (20-27%), rubbers (18-22%) and metals (4-15%) and there is currently no cost-effective recycling technology for plastics and foam [4].
Many recycle experts of modern automotive put forward a number of procedures in order to achieve a better performance in recycling of end-of-life vehicles (ELVs) which is very useful for recovering valuable resources and materials from end-of-life vehicles [5, 6].

COMPOSITION OF VEHICLES

The average vehicle is a mix of materials: steel body frame, glass windows, rubber tyers, lead batteries, copper wires, as well as traces of metals like zinc, magnesium, tin, platinum and cobalt (figure 1.1) [7]. In recent years, the composition of the vehicles has changed considerably. The concentration of ferrous metals has declined considerably as vehicle producers have opted for lighter and fuel efficient materials such as aluminum and engineering plastic in designing new vehicles. The energy used in production of metals is very high as compared to that used in plastics manufacturing. The percentage of plastics used in vehicle production has risen considerably in recent years because they are corrosion resistant, as well as low weight and cheaper. The most important feature of the use of plastics in vehicle production is that it is cost efficient on fuel and energy sources. However, for domestic vehicles, the percent weight of steel and iron has dropped recently. Metals such as steel, aluminum and metal alloys were the raw materials for the manufacturing of vehicles many years ago, but to overcome the release of CO_2 by reducing vehicles weight with the intension of cutting down the amount of fuel consumption some of the steel has been

replaced by lightweight aluminum. Steel is one of the most important materials in automobiles because of its toughness, durability and malleability, but it remains very heavy, and for this reason manufacturers have been trimming down its use. Composite materials are extending the horizons of designers in all branches of engineering. The significance of composites is the material properties like high stiffness to weight ratio and high impact strength compared to the conventional materials. The major applications of composites are Aerospace applications in which most of parts require low weight and high strength [8].
The weights of old vehicles have been greatly reduced by replacing traditional metals with lighter density metals or with plastic or other composite materials. An example of this is the replacement of cast iron engine block with aluminum or magnesium. This shows weight reduction and may only be one of the few parts of automobiles that cannot be replaced with plastics. Plastics help to achieve the greatest weight saving with the body panels which form about 60% of the total weight of a car.

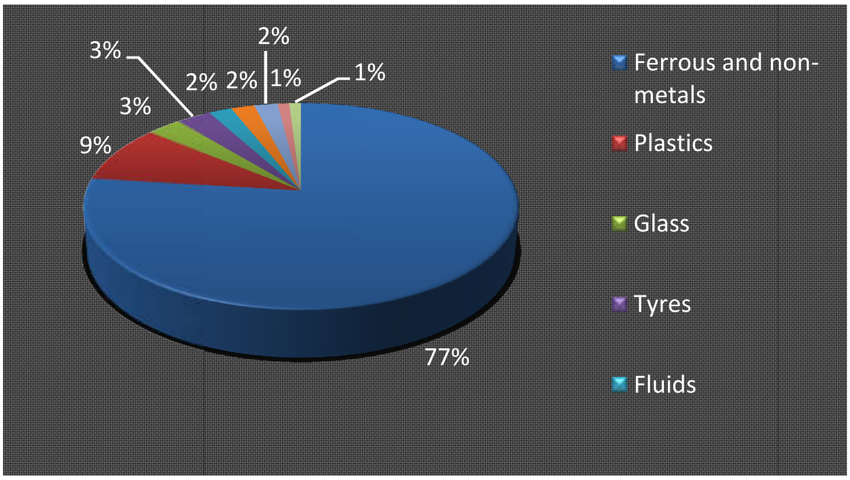

Figure 1.1: Average breakdown of materials present in vehicles

MANAGEMENT OF WASTE
Several initiatives in many counties have been proposed and are used for management of solid waste all over the world. Experts initiated and proffered strategies to reduce the volume of waste generation. Reduction, prevention, recovering, repackaging, composting, recycling, reused, landfill, incineration, etc. are some of the major ways currently used to manage wastes generally [9, 10, 11].
Reuse or recycling has been used interchangeably while discussing about waste management. Waste recycling can help eliminate and thus minimize wastes. It is possible to minimize waste through the fabrication of machines from the used off disposed metals from the industries and metal scrap markets. From the components fabricated, it is apparent that these metals have become feeds stocks [12].
The problem of waste generated by automobiles is yet to attract attention although the number of vehicles have increased enormously only over the last decade. No formal regulations are still made regarding recyclability and disposal of ELV and there is no infrastructure, organized system for collection, dismantling, shredding and processing auto scrap. Currently, scrapped vehicles are cut and sold by low-tech units leading to low recoveries and environment pollution. It is estimated that by the year 2020, proper recycling procedures and systems can lead to recovery of over 15,00,000 tonnes of steel scrap, 180,000 tonnes aluminium and 75,000 tonnes of each of recoverable plastic and rubber. The residue will be of about 25,000 tonnes to be disposed and this is rising at a rate of 10 per cent per year [13].
In many developing countries, Pollution Control Board is planning to control hazardous waste disposed from automobile service stations besides tackling air and noise pollution caused by motor vehicles [14].

Draining
This is the first thing done as vehicles come to ELV. The outside and the engine area have been cleansed and the tyres removed, the automobile is drained by doing away with vehicle or automotive fluids and the parts surrounding fluids. Draining is important because of the danger involved in likely pollution as fluids finish on the storage area, together with the danger of subsequent soiling of remaining waste. The parts which are not difficult to access from the exterior are dismantled after draining, which includes body parts that can be retrieved, for example bumpers, plastic fuel tank and auxiliary compilations.

MANAGEMENT OF PLASTIC WASTE
Plastics are cheap, lightweight and durable materials, which can readily be molded into a variety of products that can be used in a wide range of applications. As a consequence, the production of plastics

and percentage of plastics used in vehicle has increased markedly over the last years (figure 1.2). However, current levels of their usage and disposal generate several environmental problems. Around 4 per cent of world oil and gas production is used as feedstock for plastics and a further 3–4% is expended to provide energy for their manufacture. In addition, because of the stability of the polymers involved, substantial quantities of rejected end-of-life plastics are accumulating as debris in landfills and in natural habitats worldwide.

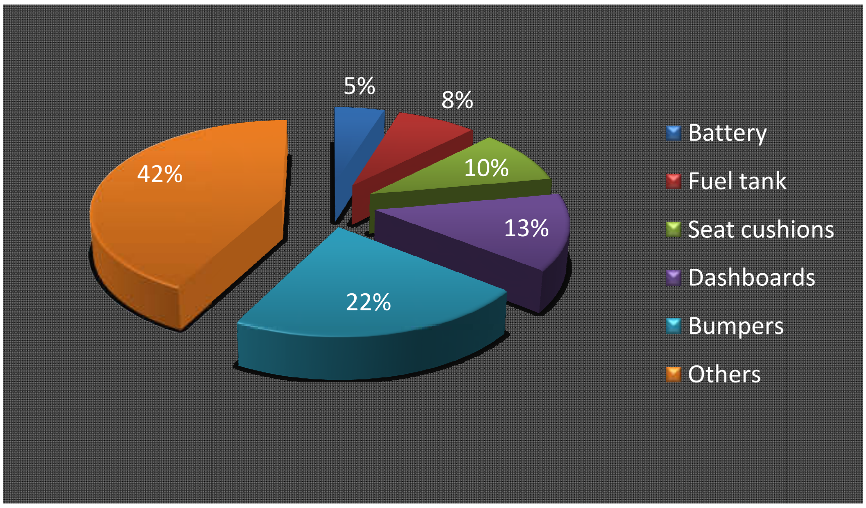

Figure 1.2: Average distribution of plastics in vehicles

The plastics industry has developed considerably since the invention of various routes for its production from petrochemical sources. Plastics have substantial benefits in terms of their low weight, durability and lower cost relative to many other material types [15, 16].

The selection of the parts can only be manually done at least on the primary stage but there must be some sort of training for the people to sort them in the right. A first step of improving the plastic waste in automobiles is to control the amount of imported parts into the country and instead reuse the old parts from ELVs. Many vehicle dealers import parts like bumpers, lights, dash-board to mention but a few in view of making profit but do not carefully consider how these parts will be disposed or managed after serving useful purposes.

Recycling is one of the most important actions currently available today to reduce these impacts and exhibits one of the most dynamic areas in the plastics industry. Recycling provides opportunities to reduce oil usage, carbon dioxide emissions and the quantities of waste requiring disposal. Recycling can be done by decrease in material use through down gauging or product reuse, the use of alternative biodegradable materials and energy recovery as fuel.

Natural resources are preserved when waste are re-cycled or re-use; as extracted raw material can be re-melted, grinded or molded into new forms. This phenomenon goes a long way to benefit the whole world as gases know no boundary and petroleum globally will be reserved for the future if the little extracted are re-used or re-cycled again and again into new products [17, 18, 19, 20, 21].

MANAGEMENT OF GLASS WASTE

Glass is a high-tech material vital to the safety, security, comfort and sustainability of modern life which is used in building, transport and automotive applications. The average glass content in a vehicle is 3% by mass. Motor vehicles contain two different types of safety glass: toughened and laminated. Typical glazing parts consist of glass together with functional materials such as plastic inter-layers in laminated safety glass, ceramic inks, silver printing electrical connectors, encapsulation materials, fixing clips and others – according to vehicle manufacturer's requirements for glazing modules [22].

Automotive glass is thinner than constructional flat glass and therefore intrinsically more fragile although it is toughened to improve durability and safety. Although safety is the primary consideration, one of the major reasons for using thinner glass is to minimize the weight of their vehicles. All materials and components have to contribute to this. In addition automotive glass is subject to very close scrutiny. In the vehicle, occupants sit very close to the glazing for long period of time, thus any defects will be much more apparent. Even very small optical defects can result in structural weaknesses and hence premature failure. In automotive applications wastage arises during the production of shaped side glasses and windscreens. This wastage is trimmed off and recycled. Very little work has been performed till date on the recovery of these waste streams. In domestic arising, glass forms only one part of the overall material

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profile in end of life vehicles, estimated to be in the order of 3% by mass. Nationally, this could amount to as much as 45,000 tonnes per annum most of which is currently landfilled.
Glass is an environmentally compatible material that can be re-melted and used as a secondary aggregate material after appropriate treatment. The treatment and recycling of glass is difficult, expensive and unfeasible. Hence, it is possible to dismantle the glass from ELV, collect and transport the glass to treatment units, purify the glass and obtain clean and reusable glass raw material called cullet. Cullet can be reused in making glass products, and is a substitute in other raw material markets. The glass production industry uses cullet to two advantages: firstly it is relatively cheaper than raw material (Silica) and consumes less electrical energy in the furnaces for melting [23]. Secondly it saves tons of natural resources from being exploited, transported, treated and consumed to make glass products. Thus, the reuse of cullet positively contributes in several ways to the environment. The principal methods involved in the recycling of ELV glass are Dismantling, Cullet Processing and Shredding [24, 25, 26].
Dismantling: The glass must be removed from the vehicle and sorted by type according to the proposed end use i.e. laminated, silver printed rear windows etc. The average time for this operation is around five minutes per vehicle.
Cullet Processing: The cullet processor selects from the range of waste glass that is available taking into account factors such as level of contamination, continuity of supply and financial factors e.g. costs and selling prices.
Shredding: In this operation the whole vehicle is crushed and shredded into pieces, which are sorted into product streams. Glass left in the vehicle passes into a mixed aggregate stream consisting of stone and brick etc. [27].

MANAGEMENT OF RUBBER WASTE
Rubber can be of two types: Natural rubber and Synthetic rubber. Synthetic rubber can be made from polymerization of monomers such as styrene, chloroprene, isobutene and 1,3-butadiene. Synthetic rubber is often preferred over natural rubber because synthetic rubber has higher thermal stability and compatibility with petroleum based products. Furthermore, synthetic rubber can be modified by using various combinations of monomers. Unlike natural rubber, synthetic rubber contains no traces of contaminants, allowing the addition of other materials in order to change its properties [28]. Commonly, additives such as carbon black or zinc can be used to alter the mechanical properties of the product. As a result, synthetic rubber is often used to produce more durable products such as hoses, belts and tyres. For example, changing the percentages of sulfur or additives will produce different types of tyres to suit various applications [29].
Tyres: Automotive tires are made of synthetic rubber which is obtained from petroleum. The development of tires was based on improving the performance of natural rubber which is obtained from the liquid latex secreted by certain plants.
The growing demand for automobiles has generated huge amount of waste tyres and disposing it economically and in an environment friendly manner has become a challenge for many local and central governments around the world. The continuous increase in the management cost of waste tyres has led to illegal dumping and stockpiling, which are inherent costs to local authorities [30, 31, 32, 33]. Mostly they are either disposed off in landfills or in some inappropriate way such as illegal dumping. Waste minimization includes recycling, reusing and developing new process of toxicity reduction [34]. The waste management hierarchy includes reduction, reuse, recycling, landfilling and recovery of waste by physical, biological and chemical process.
Current Disposal Methods of Automobile Tyres
The current disposal methods of waste tyres include landfill, crumbing, devulcanization, remould, incineration, tyre derived fuel and energy recovery through pyrolysis.
Landfill: Shredding of the waste tyres before disposal has been done for size reduction before disposal. Presently about 50% of the waste automobile tyres are used for landfill in every country. Buried tyres in landfill sites cause fire hazards at several places. Such fires lead to uncontrolled pyrolysis of tyres which produces a complex mixture of chemicals. Further knowledge of long-term leaching of organic chemicals at the landfill sites is quite limited at the moment.
Crumbing: Crumbing is another method of disposal. In this method, the tyres are cut at several stages until rubber attains crumb form which can be used in several applications. Although several outlets for tyre crumb are possible, only around 25% is being used at present. It potentially provides the most effective solution for recycling without causing any other direct pollution problem [35].
Devulcanization: Devulcanization means reverting rubber from its thermoset, elastic state back into a plastic, moldable state. This is accomplished by separating the sulfur bonds in the molecular structure.

With the proper devulcanization method, a much higher percentage of crumb rubber old tires can be used as compounding [31].
Remould: It is a costly process for the manufacturer both in terms of economy and physical work. Further only few designs, about 20% of tyres are suitable for remoulding which may increase by 5% in future [35].
Incineration: Electrical power can be generated by incineration of waste tyres. However, this method requires high investment costs and further causes a lot of pollution. Thermal recovery in cement kilns and power plants is an important route for disposal of scrap tyres hence legislators may insist on refurbishing of emission systems of certain users [36].
Tyre Derived Fuel: Since waste tyres are originated from rubber which is an organic matter and has high energy content, tyre can be used to generate heat and electrical power. The usable substance obtained from tyre for this purpose is referred to as Tyre Derived Fuel (TDF). TDF is mainly used for heating purpose in cement kilns [37].
Pyrolysis: Tyre pyrolysis is a process of converting waste plastic and tyres into Pyrolysis oil, Carbon black and hydrocarbon gas. Pyrolysis is process of molecular breakdown where larger molecules are broken down into smaller molecules [38, 39]. Heat and catalyst are required for the reaction. The decomposed tires transformed into oil gas. By pyrolysis of polymer waste, it is possible to recover value from waste in the form of Pyrolysis oil, Hydrocarbon gas and charcoal [40].

MANAGEMENT OF METAL WASTE

Metals specifically are solid wastes that come from solid industrial wastes (e.g., industrial retooling, broken or grounded equipment, etc.) construction wastes, automobile scraps, office scraps, rejected spear parts, etc. Most machines, equipment and tools are made from the metals, which forms the major material used to produce the world infrastructure. The metallic parts consist of more than 70% of the total amount of components found in the vehicle with steel and aluminium being the dominant materials used for structural applications [41]. Steel of various grades is used as a major component for the frame, chassis and body parts of the vehicle. Aluminium is used also for the body, parts of the chassis and engine, interior parts, airbags etc. The rest of the metals and other materials are found in smaller amounts and are used to produce the auxiliary parts of the car. For example cables, radiators, connectors etc. are made from copper [42]. Lead and zinc are also materials used in the car. The main application for lead is the vehiclebattery but it is also used as alloying element in steel and aluminium for machining properties. Zinc on the other hand among other purposes, is also used as steel coating for corrosion prevention [43].
After the utilization phase the vehicle becomes waste as every other product. More than 90% of end-of-life vehicles are collected and treated, as recent regulation measures impose [44]. A series of processes follow in order to extract reusable and recyclable parts and materials and also reduce the volume of the waste. A vehicle today is reused and recycled at an average rate of 80% by weight. Around 65% to70% of this rate corresponds to its metallic components while the rest 10% to 15% corresponds to the parts that are dismantled and reused or recycled [45, 46]. The stages followed in the end of life treatment facilities in consecutive order are: pretreatment, dismantling, shredding and shredder residues treatment [47, 48].
Pre-treatment: During pre-treatment vehicle components that contain dangerous and toxic substances are removed. Examples of such components are the operating fluids like different oils and fuels, the battery, the oil filters, components containing mercury and devices like the airbags which contain explosive substances. Most of the parts removed in this stage are recycled or further treated and disposed according to regulation [42].
Dismantling: The next step is dismantling where the vehicle is disassembled to its major components and the individual parts that can be recycled or reused directly are removed. Parts that have an economic value like the engine or other parts of the body could be directly recovered and reused after some repairing processes. Furthermore, as the vehicle is dismantled different parts are divided into different material and components fractions and then recycling takes place. Examples of most commonly found components of this fraction include tyres, parts made of glass, catalytic converters etc. [45].
Shredding: The goal of shredding is to reduce the volume of the remaining waste and at the same time separate the materials in more homogenous fractions in order to make their recycling easier. The vehicle parts are shredded into smaller pieces and then mechanical and physical processes like magnetic separation, eddy current belt and sink-floating methods are used to separate further the different materials according to their type and properties. After these processes the materials are divided to three general categories: ferrous metals (iron, steel), non-ferrous metals (aluminium, copper) and shredder residues. Ferrous and non-ferrous materials are directly recycled as scrap metals.
Shredder residues treatment: Shredder residues (SR) constitute the remaining 25% by weight of the vehicle that is not recycled. Materials from the SR fraction are more difficult to be extracted as it is a

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mixture of substances with different properties [49]. Extraction and recycling of these substances is possible but most of the times it is not economically feasible. The majority of the SR fraction ends up in landfills after some last treatment process. Post shredding processes aiming to achieve higher separation and recycling levels by extracting the remaining metals and other parts like plastics and minerals from the SR. Again mechanical and physical separation methods are used. The remaining residues highly consistent of polymers are disposed in landfills in most of the countries worldwide. Taking into account the fact that concentration of plastics and composites in new vehicles is increasing [50], the SR treatment would become much more inefficient. Increasing the possibilities for SR utilization and higher recovery rates is therefore becoming urgent [51].

CONCLUSION

The present review article presents emerging strategies for recycling automobile waste to minimize its negative impacts on environment by upgrading the technologies and thus developing a healthy and prosperous environment. Strict regulations should be made to solve the problem of disposal of old vehicles which have no utility. Use of waste hierarchy like recycling, reuse and reduction provide a framework for managing the waste. The suitability and benefits of these methods depend on nature, time required and cost of the operation. Mono-materials that save carbon and which can be eventually recovered for reuse at end of life should be used to combat the problem of automotive waste management faced by the whole world.

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CITE THIS ARTICLE

P Sharma, A Sharma, A Sharma and P Srivastava. Automobile Waste and Its Management. Res. J. Chem. Env. Sci. Vol 4 [2] April 2016. 01-07