

Production, Re-use and Recycling of used engine oil in Pakistan: A Case Study

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Abstract- The study was conducted during 2023–24 at Peshawar Capital City in Khyber Pakhtunkhwa with the objective of knowing the status of used engine oil (UEO) production, reuse, recycling, and disposal. Information related to the number of vehicles was obtained from the motor registration office of the study area. To quantify used engine oil production status, 70 (25%) workshops were surveyed. Besides, 336 vehicles' owners and drivers were also interviewed to learn about their perceptions and practices related to the use, re-use, and recycling of used engine oil.

By comparing the production of used engine oil in 2011 and 2024, it was found that 38.19 million liters of used engine oil have been produced annually in Khyber Pakhtunkhwa province and 287.2 million liters in Pakistan. For most owners and drivers, using engine oil is not an environmental problem. This is why they always leave the workshops. Only 27% goes to recycling plants, and 61% is used directly as commercial fuel. 4%, equivalent to 1.53 million liters goes into the environment. It was concluded that the increasing trends in used engine oil pose a potential threat to the environment. It was therefore recommended that the production and disposal of used engine oil be reflected in environmental laws. Re-cycling of the used engine oil in a scientific manner should be encouraged to save the environment.

Key words: Re-use, Recycling, point and non-point pollution sources, Environmental Impact Assessment (EIA), Lubricant, Diesel and petrol vehicle

I. INTRODUCTION

Butler and Mason (1997) define engine oil as a complex mixture of hydrocarbons and other organic compounds, including some organometallic constituents that are used to lubricate some parts of the engine operation (Hagwell et al., 1992). Spent lubricant oils or used engine oil are usually obtained after servicing and subsequently draining from automobiles [1] (Anoliefo and Vwioko., 2001).

Used engine oil is a universal waste produced in every country in the world. Its negative impacts have been studied by various researchers. It has been observed that used engine oil has a negative impact on the environment (Odjegba & Sadiq, 2002; Rațiu et al., 2020). Lubrication oils are used in all forms of machinery and vehicles (Lee et al., 2009; Bloch & Nannister, 2020). The purpose of lubrication oil is to avoid overheating the engine and other potential damages such as fraction and corrosion. Therefore, it is an important part of the engine to perform efficiently for a long duration. This is why lubricant is unavoidable (Klaman, 1984). Chybowski et al., (2023).

Throughout the world, each day, new vehicle are added to the roads. The use of engine oil also increases in the same proportions, which are added to the environment in one way or another. Used engine oil, when released into the environment, contaminates water and soil. One quart of oil is enough to contaminate 6 million liters of water, or one change of used oil can ruin the supply of clean water for fifty people for one year, and one quart of used oil can pollute 40730 square feet of soil, making it unproductive for farming or plant growth for up to one hundred years (USEPA, 1996; Hamad et al., 2004). On one side, it is important; on the other, it has negative environmental impacts (Bartz., 1998; Ishaya et al., 2023).

Just like other parts of the world, Pakistan also produces lube oils, which are supplied to petrol pumps, gas stations, workshops, and other outlets for consumers. These are referred to as virgin oils. After use, engine oils are collected by mechanics and sometimes stored in large containers to be supplied to the factory directly for recycling or other purposes. These oils are recycled in a recycling plant and supplied to the same outlet for sale. These oils are termed re-cycled oils. It is a general perception that recycled oil is of low quality, with ultimate impacts on engine efficiency and some contribution to air pollution as well. Besides, some people sell the used engine oils for other purposes, such as fuel, and they are also used for the lubrication of household items, this is termed re-use (Ahmad, et al., 2012).

It is estimated that each year billions of gallons of used engine oils are generated. A significant portion of this is utilised and disposed of improperly or burned in the boilers of industries, brick kilns, and industrial furnaces (Mouche, 1995; Yu et al., 2012). In addition, large quantities of oils are being dumped onto the grounds, discarded in ordinary household trash, or poured down drains (US-EPA, 1994). The production, application, and disposal of lubricants must meet requirements to the best of their ability to protect the natural environment and living organisms. Used engine oil-related health hazards more often follow indirect routes and ask for regular monitoring (Shah et al., 2021).

In Pakistan, there is no specific law or regulation for the management of used engine oil [i]. For used engine oil users, there is no tracking or record system. Recyclers and burners of used oils must comply with certain requirements, keeping in mind the minimum environmental standards.

Pollution sources are categorised as point and non-point sources. Non-point sources are difficult to manage and control (Khan et al., 2023). Environmental Impact Assessment (EIA) addresses mostly point sources. Such as industry, roads, dams, and such mega-scale projects (Nazish et al., 2021). In this way, non-point

sources are totally ignored with the idea that they are scattered, and due to large-scale dilution, the impacts are not visible or are difficult to control (Li et al., 2011). Waste engine oil is a non-point source of pollution. If produced in small quantities, it may not create problems. But on a large scale, production can harm environmental impacts, as observed in developed and developing countries.

To handle the environmental impacts of a particular project, the Pakistan Environmental Protection Act was approved in 1997. Under this act, it was mandatory to have a detailed EIA/IEE for all types of industries and developmental activities. For this, EIA Rules Regulation 2001 and Monitoring Rules 2005 were developed (Nafees, et al, 2021). But the recycling plant for engine oil is not mentioned. In 2004, EIA guideline Performa was developed for small projects, such as marble factories and petroleum pumps; again, no EIA Performa was developed for used engine oil and its recycling or worship (Nafees and Shah Rukh, 2024).

On the basis of the aforesaid information, used engine oil is a growing hazard and must be studied. This study is an attempt to explore the present production status of used engine oils with the objective of answering two basic questions and seeking an appropriate solution. These questions are: What types of vehicles are contributing more towards the production of used engine oil? And what percentage of the spent oil is re-used or recycled? For this purpose, an average-sized district has been studied as a unit. An attempt has been made to quantify used engine oil and its present trends in reuse and recycling.

2. RESEARCH METHODOLOGY

This article is based on both primary and secondary data. Primary data was collected from vehicle workshops. For proper identification of sample size and estimation and quantification of used engine oil, it was required to have an exact number of workshops. For this, a pilot survey was conducted.

The pilot study revealed that there are four different types of workshops in the study area, i.e., rickshaws, motor cycles, petrol vehicles, and diesel vehicles. Therefore, for the detailed survey, 70 workshops (25%) were randomly selected from each category (Table 1).

Table 1: Sampling for Questionnaire Survey

S. No	Type of workshop surveyed	Total no of workshops available	Workshop selected for interview & questionnaire @25%
1	Rickshaws	60	15
2	Motorcycle	100	25
3	Diesel	50	13
4	Petrol	70	17
5	Total	280	70

To know about the production of used engines per vehicle per year, a total of 336 vehicle owners and drivers were interviewed about used engine oil (Table 2). To find out the amount used to enjoin oil per category per year, secondary data related to vehicle numbers was collected from the motor registration office. The

used engine oil in each category was quantified separately and summed up. To learn about the trends in ruse and recycling, the concerned workshop owners and visitors (vehicle owners and drivers) were interviewed. For data analysis, a sampling worksheet was used.

Table 2: Sample selection for interview from vehicles owners visiting different workshops

Serial No	Type of workshop	No of workshops visited	No of Number of visitor per month	No of vehicle owners interviewed @ 25%	
1	Rickshaws wheels	3	15	240	60
2	Motorcycle		25	576	144
3	Diesel		13	240	60
4	Petrol		17	288	72
5	Total		70	1344	336

3. RESULTS AND DISCUSSION

Present status of vehicles in Peshawar

In 2011, the total number of registered vehicles was 966 thousand, out of which 1606 thousand (16.6%) were diesel and 8054 thousand (83.4%) were petrol. With the passage of time, the equation changed, and an increase in diesel vehicles was observed. During 2023, the total number of vehicles registered in Khyber Pakhtunkhwa reached 2.21 million, of which 1.86 million (84.5%) were diesel and 0.35 million (15.5%) were petrol. At the national level, the total number of vehicles was 30.76 million, out of which the number of diesel vehicles was 2.39 million (7.7%) and the number of the number of petrol vehicles was 28.4 million (92.3%). This data revealed that the increasing ratio at the national and provincial levels is different (Table 3).

At the national level, a 3.1-fold increase was observed, while at the provincial level, the increase was 3.4-fold. As the increasing trend was, the total number of vehicles was very close to each other, but there was a difference between diesel and petrol vehicles, therefore the production of used engine oil would be different.

Diesel vehicles comparatively caused more pollution than petrol vehicles. United Kinddom has planned to ban diesel vehicles by 2040 (Shammut et al., 2019). The annual increase in transport vehicles is 6.41% (Asghar et al., 2021). To cope with air pollution and energy conservation, Pakistan has introduced hybrid electric vehicles and electric vehicles. Till 2022, there were 8 thousand electric vehicles (Hassan, 2023). Pakistan has given economic incentives in the form of concessions in tax and duty, and the number of electric vehicles is increasing (Khan et al., 2020). Those include Rickshaws, motorbikes, and large passenger buses. It was hoped that with the passage of time, there would be some decrease in diesel vehicles. But engine oil is also used in hybrid vehicles, and no decrease in used engine oil is expected. Research is also under way to introduce electric vehicles or solar vehicles, but it will take time.

Table 3: Total Petrol and Diesel vehicles in Pakistan and Khyber Pakhtunkhwa Province 2011-2020

Year	Total Petro Pakistan	Total Petrol KP Province	Total Diesel Pakistan	Total Diesel KP Province	Total Vehicle KP Pakistan	Total Vehicle KP Province
2011	8054554	442559	1606441	205039	9660995	647598
2012	10061519	510238	1727050	216489	11788569	726727
2013	11976424	603069	1808507	227896	13784931	830965
2014	14055765	694234	1884796	233551	15940561	927785
2015	16523514	797519	1978595	238644	18502109	1036163
2016	19006790	1038131	2061060	242330	21067850	1280461
2017	21648873	1132413	2163803	248248	23812676	1380661
2018	24306575	1231024	2259592	252835	26566167	1483859
2019	26795125	1341809	2342437	258009	29137562	1599818
2020	28364368	1431437	2393171	261533	30757539	1692970

Status of Used Engine Oil Production

The survey revealed that driver of different vehicles change the engine oil with different frequently. It is general practice that most of the driver changed oil after 3000 Km. Therefore a survey was conducted to have an average value for calculation of engine oil used per vehicle/year.

It was observed that Rickshaw drivers change engine oil more frequently. As per the survey, 91.67% of rickshaw drivers change engine oil every 15 days. This frequent change can be attributed to their heavy use of the rickshaw, traffic jams, and rush hour in the city. For the motor cycle, the interval ranges from 30 to 90

days. It was observed that 54.86% of drivers changed engine oil after a one-month interval, 27.77% changed after two months, and 17.37% changed engine oil after three months.

As per the interview survey, the amount of used engine oil calculated for rickshaws is estimated at 36 liters per vehicle per year. There were about 107 thousand Rickshaws (Table 4). Therefore, the annual productions of used engine oil is estimated at 3.8 million liters per year in 2023. Similarly, the contribution from motorcycling was 2.9 million liters per year for the Khyber Pakhtunkhwa province only. At the national level, these values increase almost 10 times (Table 4).

Table 4: Comparison of Used Engine Oil Produced during 2011 and 2024

S N	Type of vehicles	Engine oil/ Year	Khyber Pakhtunkhwa		Pakistan			
			Number of vehicle	Engine Oil Used Liters/Year	%age	Number of vehicle	Engine Oil Used Liters/Year	%age
1	Car, Jeeps and Wagons	12	317040	3804480	9.9	4005078	48060936	16.7
2	Buses and Trucks (Diesel)	120	151855	18222600	47.7	548869	65864280	22.9
3	Motor cycle	2	1441997	2883994	7.6	23407865	46815730	16.3
4	Rickshaws 3 wheels	36	106579	3836844	10.1	951425	34251300	12.0
5	Other Diesel Vehicles	50	189004	9450200	24.7	1844302	92215100	32.1
6	Total		2206475	38198118	100	30757539	287207346	100
				38.19 Million			287.2 Million liter	

The total annual production in 2020 is estimated at over 38.19 million liters in Khyber Pakhtunkhwa province and 287.9 million liters at the national level. Contribution from diesel is 72.4% (47.7 + 24.7), followed by petrol with a contribution of 27.6%. At the national level, the contribution from diesel was 55% (22.9 + 32.1) (Table 4). Studies conducted in 2012 revealed that 6.3 million metric tons of used engine oil was produced in Khyber Pakhtunkhwa province (Ahmad et al., 2012). By comparing the present Khyber Pakhtunkhwa used engine oil production, the increase is six times. If the increase is

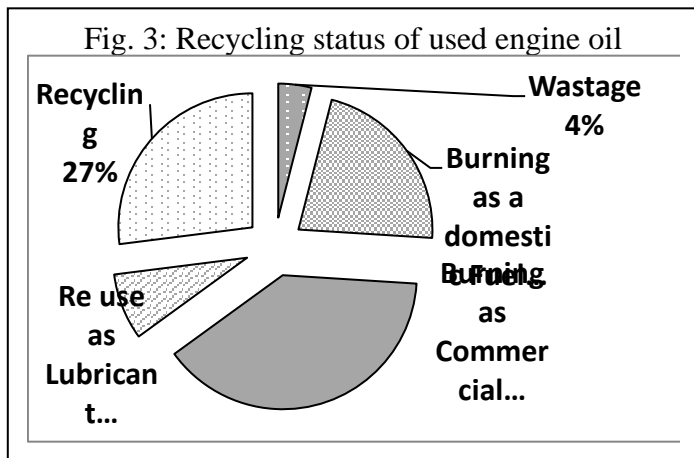
continued at this rate, it will be a big environmental problem in the future.

From these analyses, it is clear that the number of vehicles has increased, due to which an increase has been recorded in the production of used engine oil.

It is a general perception that commercial vehicles produce comparatively more used-engine oil. To have an exact idea, used-engine oil coming from commercial vehicles was quantified separately. As given in Table 4, the total number of commercial vehicles registered in the study area is over 341 thousand (buses, trucks, and other diesel vehicles), for which the engine oil requirement is 27.67 million litres per year (72.4%). Therefore,

the focus area for monitoring and mitigation is commercial and diesel vehicles, which need more attention.

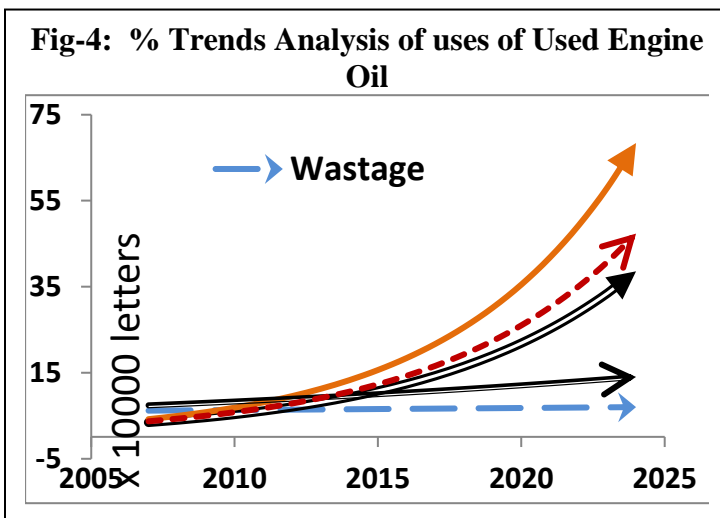
Present Status of Used Engine Oils: The responses of the workshop owners are summarized in Fig. 3. A big part of the used engine oil goes to burning in factories and brick kilns (39%) and domestic use as a fuel (22%). Recycling is 27%, but it is



recycled in a non-professional manner and finds its way into the market as fake lubricant. Only 4% of the total goes into waste (Fig. 3).

To know about the attitude of vehicle owners and drivers, a total of 336 owners were interviewed. The question was asked about what they think: how should the used engine oil be disposed of? Small fractions (29.46% of respondents) were with a view to recycling used engine oil. Surprisingly, 54.46% preferred burning it as fuel, and 10.71% suggested reusing it as lubricant in industry.

Interestingly, the response of various vehicle owners towards the disposal of used engine oil was almost the same, with a percentage range of 5.3-5.6%. Re-use in its original form was second from the bottom, with a limited scope for re-use. The standard deviations came out for different workshops as 0.51, 1.94, 0.43, 0 and 0.12, respectively, for the recycle, reuse, burn, and waste options, which validate similarity in the data (Table 6). As is clear from the above discussion, the majority of the respondents want to use it as fuel. But what are their practices, was also evaluated. Out of the total, 78.58% don't care and leave



the used engine oil with the mechanic. It was observed during the survey that most of the owners were unaware of the fate of the used engine oil. 5.06% reported dumping the used engine oil into the open environment. Only 7.14% of the respondents take their used engine oil with them for re-use for domestic purposes as lubricant in non-critical machines such as bikes, water pumps, etc. Another 7.14% reported that they use the used engine oil as fuel. 2.08% of the respondents said that they had no idea.

Comparing 1999 and 2012, the interview surveyed revealed that about 25% of the used engine oil was disposed of as waste (Ahmad, 2012). With the passage of time, there was some improvement, but at present, only 4% is wasted. The amount used as a fuel for domestic purposes has increased from 15% to 22%. Similar increases have been observed for industrial usage. In 1999, only 15% was used as a fuel in industry; in 2012, this percentage went up to 35%, which is not a good sign (Ahmad, 2012). The trend in recycling was observed as positive. In 1999, only 15% of used engine oil was recycled; now, 27% of used engine oil goes to recycling. This is a good indication and needs further improvement.

4. CONCLUSIONS AND RECOMMENDATIONS

Since 2011, about 2.6 times increases have been recorded in the number of vehicles with an ever-increasing increase in used engine oil. Although all the workshops and recycling plants are not registered, 94.85% of used engine oil has been collected. A major portion (61%) of the collected lube oil goes to direct burning. And only 27% has been recycled in a conventional manner.

A comparison of used engine oil production between 1999 and 2024 shows that direct disposal has been reduced to 4%. It means that there is potential for improvement. It is therefore recommended to register used engine oil-related businesses, improve recycling, and tune direct burning.

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