Waste Oil Management in the Auto-Repair and Maintenance Workshops in the Informal Sector of Harare, Zimbabwe

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Introduction

The aim of this study was to analyse the waste oil management practices in the auto-repair and maintenance workshops in the informal sector of the city of Harare in Zimbabwe. Current knowledge on waste oil management is limited to the formal industrial sector and this paper augments this knowledge by focusing on the informal sector that is employing over 80% of the economically active population of Zimbabwe. The study places special focus on Siyaso home industries in the high density suburb of Mbare in Harare because of the concentration of informal enterprises that include auto-repair and maintenance workshops. According to the Scottish Environment Protection Agency (SEPA), oil is a highly visible form of pollution when it is allowed to go into the environment. It causes harm to plants and animals, damages surface and ground water sources and can also cause severe soil contamination. Oil can destroy the natural habitat and drinking water supplies. It is the most commonly reported type of pollution and causes over 16% of all pollution incidents in England and Wales. Oil spreads very fast, for example, it is estimated that one litre of oil into the environment can contaminate a million litres of water. It is derived from mineral or synthetic sources, therefore, it is considered to be hazardous waste. Proper waste oil management at all stages of usage (generation, collection, processing and end use) is a challenge the world over especially in developing countries where environmental legislation is still weak and not being holistically enforced and Zimbabwe is not an exception.

Key words: Waste oil, autorepair, maintanance, informal sector, Harare

Auto repair and maintenance workshops generate used oil which creates environmental pollution if not disposed properly. There is a possibility that the substances contained in the waste oil may enter natural cycles through the food chain via water, soil and air. The used oil at times contains hydrocarbons, heavy metals (e.g. lead, cadmium, chromium, arsenic and zinc), polychlorinated biphnls (PCBs) and other halogenated compounds (USEPA 2013; El Fadel and Khouy 2001; IEC 2013), detergents and lubrication additives. Low molecular weight Polycyclic aromatic hydrocarbons (PAHs) and volatile compounds, such as the mono-aromatics and various halogenated alkyl substances, comprise the largest fraction of waste crankcase lubricant oil (WCOs) lost by volatilisation (Joel 2013; Metzler and Jarvis 1985 and Ruzvidzo 2013). Used lubricating oil must be disposed of properly since, if burnt as a low grade fuel, harmful metals and other pollutants may be released into the air (EMA 2012; USEPA 2013; IEC 2013).

In Zimbabwe, especially in the informal sector auto-repair and maintenance workshops, there are no proper waste oil management systems available and the level of public awareness is low in respect to environmental impacts. This study takes a bird's eye view on the waste oil management practices in the informal auto workshops since these generate substantial quantities whose management is vital in reducing environmental pollution. The project is important in that waste oil constitutes a serious pollution problem and may contaminate the water and soil if discharged into the environment. Not much attention has been given to the impact of used oil generated in the informal sector of Zimbabwe. It is expected that this project will assist in ensuring compliance to legal requirements for a healthy environment. Additionally, if managed properly, used oil is a valuable resource that can be re-used either as a base stock for new lubricants or as a fuel.

Methodology

A detailed analytical study was undertaken involving the all the 43 informal sector auto repair and maintenance enterprises identified in the preliminary survey undertaken at Siyaso home industries in Mbare. Focus is on Siyaso since it provides the largest concentration of auto-repair home industrial enterprises in Zimbabwe. Twenty water samples were collected from boreholes close to the auto repair workshops to determine if the water is being polluted by waste oil and PCBs. PCBs presence is to be determined using the simple chlorine test. The chloride analyzer uses the principle of total organic chlorine detection with a chloride specific electrode to measure the amount of total organic chlorine in the extract and displays the results on a screen. The chloride analyzer was applied on twenty samples of soil contaminated with oil from the various enterprises. Chlorine is used as a parameter which according to WHO and SAZ standards should not exceed 10mg/kg. High concentrations of chlorine in the water indicate contaminants of waste oil. Any value below 10mg/kg would show that the boreholes are not being polluted and any low concentration of chlorine usually results from the fact that chlorine is used as a disinfectant in boreholes. PCBs also increase the acidity and toxicity of oil, and their concentrations in oil should not exceed 0.5mg/kg (UNEP 2014). Therefore, the increase in PCB concentration above 50ppm or 0.5mg/kg would indicate that the oil is contaminated beyond the regulated contamination level. Twenty soil samples at average weights of 100g were obtained from three different depths on the sample locations at 10cm intervals and tested for contamination with waste oil. A small soil auger (with carbon steel bits) were used to obtain soil samples by augering at sampling points to depths of 0- 15 cm at top layer, 15- 30 cm at the middle sub surface and 30- 60 cm at the bottom layer at each of the 20 sample sites. Samples were then analyzed using portable detection kits kept in small polythene sealed bags. Interviews were also targeted at the City Chemist and the Senior Environmental Health Officer in the Harare City Council, the Environmental Management's Education and Publicity

officers, at the NSSA Principal Factories Inspector, the occupational health services promoters at NSSA, the occupational health promotions officer and officials in the Ministry of Medium and Small Scale Enterprises. Personal observations were also used to establish the likely causes of oil spillages, the emergency action plans that are in place as well as other waste oil management practices that are employed by the enterprise operators at Siyaso enterprises in Mbare, Harare.

Results and discussion

Types of auto-repair and maintenance workshops at Siyaso and the oil products

The major source of used oil at the informal sector enterprises at Siyaso in Mbare are the auto-repair and maintenance workshops. The types of auto-repair and maintenance workshops at Siyaso in Mbare include garages involved in the servicing of cars that include changing oils and replacing the used oil with virgin oil. The types of oils used in the enterprises therefore include engine oil for lubricating engine block pistons and parts, brake fluid used in repairing and maintaining the condition and efficiency of brake pads so as to lessen risk of accidents due to brake failure, hydraulic oil for suspension purposes and aiding shocks, transmission oil (gear box oil) for the lubrication of gear boxes and gear flexibility, power steering oil also called ATF, engine cleaner used for cleaning the engine, spanners and other vehicle tools and grease used on nuts to prevent friction between the bolts and nuts.

The major functions of the lubricating oils include reducing friction, carrying away the heat, protecting against rust, wear and removing contaminants from the engine and bearings (Durrani, 2010). The oil is used to ensure the smooth performance of the engine as well as to prolong the condition of the automobile. The lubricant oils play a vital role in reducing friction and wear since they interpose a film of martial between rubbing to reduce friction and wear. Lubricant oil therefore acts as the coolant in the automatic transmission and engine since it takes away the heat from the combustion of fuel as well as from friction. Engine performance greatly depends on the quality of the lubricant oils and these oils are derived from the refining of distillate or as residual frictions directly from crude oil. In the modern world lubricating oil is made of base stock or base oil (71.5 -96.2 wt %) blended with few parts per million of chemical additives as per its grade and specific duty (Durrani, 2010). The role of additives is to fulfill the specific requirements for the optimal lubrication levels by way of combating the combustion by-products. The burning of gasoline or diesel fuel generates acids, moisture, soda, ash and other contaminants and the detergents help in inhibiting the build-up of the sludge and other vanishes. The optimum performance specification can be achieved by the use of a specific additive package so as to prolong the life as well as the protective quality of the oil. Table 1 shows the major automobile oil lubricating additives and their functions.

Table 1 Types and functions of lubricating oil additives at Siyaso in Harare

Type	Function	Examples
Detergent	Neutralise the deposits formation from combustion of high sulphur fuel or acidic combustion material, helps to prevent deposition of lacquer resulting resulting from oxidation	Metallo-organic compounds, calcium, magnesium sulphonates
Dispersent	Disperses or suspends any potential sludge forming material in oil	Ash less dispersants and polymetric succinimides
Viscosity index improver	Increases the relative viscosity of an oil at high temperature	Methacrylates polymers and acrylates polyers
Oxidation inhibitor	Fors protective film on metal to prevent acid from reaching its surface	Zinc dithiophoshate
Rust inhibitor	Forms tenacious film by high polar attraction towards the metal surface	Neutral material; ethioxylated alkyl phenils
Antifoam	Attaches to air bubbles in foam, which coalesce into larger bubbles and rise to the foam surface and collapse	Silicon type chemicals; polymethyl siloxanes
Pour point depressant	Inhibits formation of wax crystal structure that prevents oil flow at low temperature	Alkylaromatic polymers, methacrylates polymers
Antiwear	Reduces friction, wear scuffing/ scoring under boundary lubrication conditions	Esters , acids

Source: Gergel (1992).

Soil pollution levels

Soil samples in the enterprises reflected high levels of oil contamination with the top layers recording the highest average levels of contaminants as shown in Figure 1. The top and middle layers had oil contaminants which exceeded the maximum permissible limits of the Standard Association of Zimbabwe recording 9.3 and 7.6 respectively. Oil pollution increased the soil pH by 24% in the top soil and a slight increase by 5.3% in the middle layer. The top layer had the highest levels of contaminants varying from the general pH value of the area and these decreased

down the profile. The lower levels of contaminants in the middle and bottom layers was probably due to the fact that it was prior to the rain day so the waste had not leached much to pollute the soil layers.

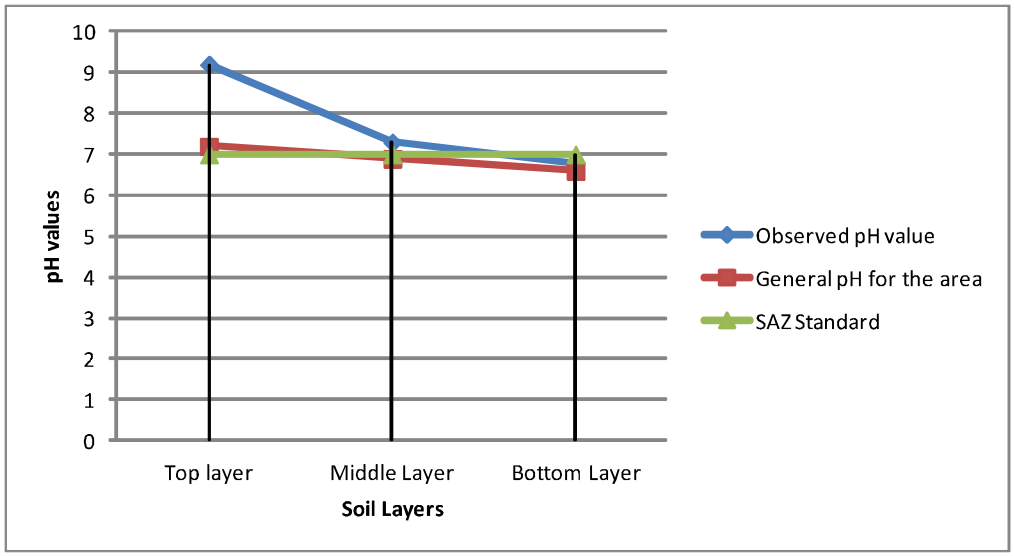

Figure 1: Observed soil pH against SAZ recommended standards

Water pollution levels

All the tests for water pollution indicated that the water around the informal enterprises was oil and PCBs contaminant free. The water samples from the boreholes showed no evidence of oil pollution and PCBs contamination and the chlorine densities and pH values were within the recommended standards by WHO and SAZ ranging between <10mg/kg and 6-9.5 respectively. Figure 2 shows the observed chlorine densities of water samples from the boreholes near the enterpries. Figure 2 also shows that the chlorine density in water from the boreholes near Siyaso enterprises in Mbare were not polluted by and oil and or PCBs. This was shown by a very low density of chlorine which was observed in all the samples. The water was safe to drink since it was within the WHO and SAZ expected standards. Any presence of waste contaminated oil would increase the chlorine density in water by >10mg/kg since PCBs contain high amount of chlorine for example one molecule of PCB can contain up to ten atoms of chlorine. The detected chlorine in the samples

was as a result of the applied chlorine by the local residents who used the chlorine to disinfect their borehole water. The noted differences in the chlorine densities was because of the differences in water quantities of the boreholes.

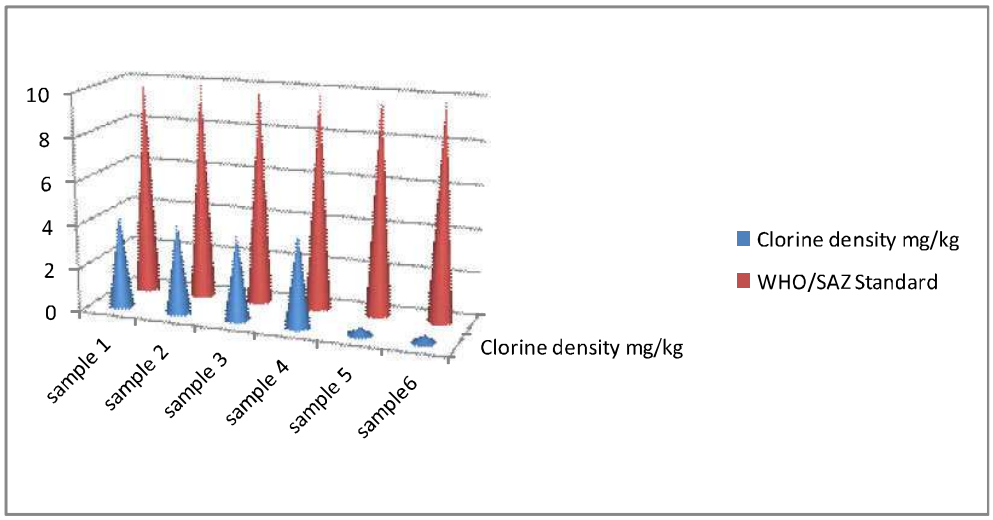

Figure 2: Observed Chlorine Densities against WHO/SAZ recommended standards.

Water pH levels

The water pH values of all samples from the boreholes close to the enterprises and residential area were not polluted by and oil and or PCBs(Figure 3). Waste oil contains contaminants which have acidic properties for instance PCBs and furans so any appearance in water sources would indicate a very low pH value. The water pH values ranging from 7.5 to 6.8 observed in all the samples show that no acidic properties resulting from oil contamination were present. The water was safe to drink since it was within the WHO and SAZ expected standards. Any presence of waste contaminated oil would decrease the pH value in water beyond the expected standards since PCBs contain high amounts of chlorine (acidic) for example one molecule of PCB can contain up to ten atoms of chlorine.

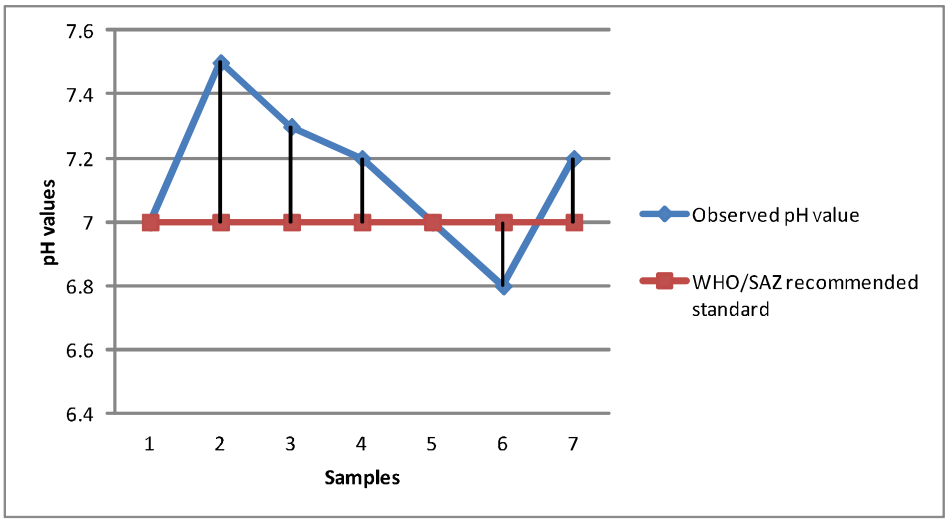

Figure 3 Observed pH values against WHO/SAZ recommended standards

Human health and eenvironmental effects of waste oil

There were no specific examples of the employees' human health problems related to waste oils and their contaminants to cite. This may be explained by the ignorance of the enterprise operators who failed to link some of their health problems to the waste oils and PCBs. Also PCBs are carcinogenic, so the effects are long term, thus the infected ones might not be aware of the harm they were exposed to (IARC 1987). However several environmental effects were and included water pollution, eye sight pollution and death of grass around the spillage areas. Oil is a visible form of pollution that changes the aesthetic value of the environment i.e. whenever oil spillages occur on the surface, it looks dirty.

The other notable effect of waste oils was the destruction of grass around the waste oil storage areas in and around the enterprises. The optimum pH range for plants is 5.5 to 7.5 and oils increase the pH of soil beyond this optimum range that destroying them. According to Uzoho and Onweremadu (2004), primary way in which oil pollution reduces crop growth and performance is through reduction of their seed germination and direct suffocation of plant roots by changing their redox potential and oxygen diffusion rates between soil system and the atmosphere. This explains death of the grass around the oil spillage areas. From the observations made, groundwater pollution was the other effect of oil pollution. Waste oil is associated with a number of important, short-term and long term impacts on the environment if disposed in an uncontrolled manner (UNEP, 2006;

UNEP, 2008). As an example, water that contains 1-2 mg of lubricating oil is not suitable for human consumption and is hence dangerous (Museic and Basic, 2011). Lubricating oil has the tendency of preventing oxygen from penetrating into the water hence inhibiting the flourishing of fauna and flora. After the discharge of waste oil into soil and water, it takes many years to reach its natural degradation. Despite the fact that the hydrocarbon components oil can be easily degraded by biological processes within the natural environment, the degree of degradation depends on many factors which include temperature, medium with which the oil is in contact, environmental pH, other physical and chemical parameters, as well as the amount of oil discharged itself. Regardless of what the basic components of a hydrocarbon oil can be completely degraded biologically, many other pollutants such as heavy metals, remain permanently in the soil or end up in surface or groundwater. PCBs and persistent organic pollutants have the impact of affecting human tissue with negative health implications. People become less fertile, less immune and become easily susceptible to cancerous diseases.

Conclusion and way forward

Used oil is a very dangerous polluting product due to the high content of heavy metals mercury, potassium, zinc, cadmium, chromium and nickel. Used oil also has high concentrations of PAH (poly-nuclear aromatic hydrocarbons) such as benzo and pyrene and these are carcinogenic compounds and the PAH content of used oil motor can be 670 times greater than that of new motor oil. The spillage of used motor oil onto the soli can induce a drastic change in the microbial communities. Such changes can affect the biological cycles in the soil. The presence of used motor oil inhibits plant development and the metal content of surviving plants is increased. In aquatic environments, used motor oil provokes a change in the microbial communities and decreases the primary production of phytoplankton. According to Environmental Management Agency officers in Harare, the common challenge facing almost all institutions and organisations in waste oil management is the absence of waste oil collection and disposal facilities in the country. There are no adequate waste oil collection and disposal facilities in Zimbabwe except for individual companies that require used oil for own purposes. This has resulted in some enterprises keeping waste oils at their backyards and some illegally dumping and burning it which explains why poor waste oil storage has choked enterprise operators. With mounting pressure from different stakeholders who are demanding more environmental accountability, enterprises have kept waste oils containing PCBs in unsafe and unlicensed storage drums for long periods. It is due to this reason that negligence towards the area of waste oil management has been initiated, explaining why several unattended oil spillages have been occurring at the substation lately.

Sustainable management of waste oil in the informal sector enterprises of Harare could be implemented through the imposition of fines and enforcement of legislation on the illegal dumping of used oil in order to internalize the resulting negative externalities on water resources and ecosystems. This method cold also be enforced by a subsidy to promote recycling and pay for potential damages caused by improper disposal. However, economic instruments by themselves cannot solve the problem especially in terms of environmental quality. Education is essential to teach the informal sector operators about the potential damages from improper ways of waste oil disposal.

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