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INVESTIGATION INTO TOXICITY CHARACTERISTICS OF USED CUTTING FLUIDS ON ECOLOGY

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ABSTRACT

Disposal of used cutting fluids in machining operations has been a major concern to the management of Challawa industrial estate in Kano state of Nigeria, as components identified to be hazardous must be disposed by a permitted applicable federal and state legislations. To address this problem, this study introduced the Toxicity Characteristics Leaching Procedure (TCLP) to identify the hazardous component in the wastes. The soil sample in the area was collected, the liquids and solids waste were separated by filtration through a fiberglass. The particle size was reduced by filtering through a 9.5mm sieve and the cut into 1cm. Sodium hydroxide (NaOH) (was used as reagent in conformity with the specification of the committee on Analytical Reagents of American Chemical Society) which leaches through the solid the same way water seeps through landfill. Having separated the liquids and solids wastes component, TCLP results showed higher concentration of toxic contaminants such as Arsenic, Barium, Cadmium, Chromium, Lead, Heptachlor, Hexachlorobenzene, Methoxyclor, Choroform and Vinyl Chloride. The waste failed the TCLP test and is characteristically hazardous. The study concluded by recommending eco-friendly machining and fluid management program that would maintain fluid performance and extend fluid life among other recommendations.

KEYWORDS: Toxicity, TCLP, Hazardous, Waste, Machining.

1.0 INTRODUCTION

Traditionally, the mineral oil and sulfonates have been the basic source of cutting fluid formulations.[1] The petroleum based lubricating oil and sulfonates as emulsifier are hydrocarbons consisting of naphthalene, paraffins, aromatic and unsaturated hydrocarbons.Additives such as chlorine and sulfur which are environmentally banned chemicals are added to the soluble oil to improve their physico-chemical properties and performance of cutting fluids.[2] New cutting fluid contains fresh and lighter hydrocarbons that would be more of a concern for short-term (acute) toxicity to aquatic organisms, whereas used cutting fluid contains more metals and heavy polycyclic aromatic hydrocarbon (PAH) that would contribute to chronic (long-term) hazards including carcinogenicity.[3] Metal of concern include lead, zinc, chromium, barium, and arsenic. For example, chronic effects of naphthalene a constituent in used cutting fluid include changes in the liver and harmful effect on the kidneys, heart, lungs and nervous system. When inappropriately discharged, used cutting fluids from mineral oil affect soil fertility, vegetation and water resources.[4] The important of cutting fluid in metal cutting process is to improve the characteristics of the tribological processes which always occur on the contact surfaces between the tool and the work piece.[5] Metal–machining processes is critical to the aerospace, automotive, electronics, defense, furniture and domestic appliance industries through metal shaping, surface preparation and surface finishing. Increasing in environmental consciousness in the society and government legislations are putting pressure on manufacturing industries on the varieties of environmental liabilities associated with manufacturing processes. The environmental Protection Agency (EPA) introduced the Toxicity Characteristics Leaching Procedure (TCLP) to determine the mobility of both organic and inorganic analytes present in liquid, solid and multi-phase wastes. The intent of this leachate procedure is to simulate the condition that may be present in a landfill where water may pass through the land-filled waste and travel into the ground water carrying the soluble waste with it.[6]

This study investigated various hazardous constituents of used cutting fluid in Challawa industrial estate in Kano state of Nigeria as it affects health and environment.

2.0 LITERATURE REVIEW

Toxicity to aquatic lives is used to reveal potential adverse environmental effect of compound or product.[7] He noted that the toxicological of fully formulated lubricants are related to those of base fluid and additive components. The measure toxicity of mixtures is found to be close to the sum of component toxicities.[8] It is widely recognized that the ecotoxicological effects of the used cutting fluids components (biocides, corrosion, inhibitors, extreme pressure and antiwear agents, emulsifier, and surfactants) cause a major problem regarding disposal of used cutting fluids and their environmental impacts.[9] Toxicity of a substance is generally evaluated by conducting an acute toxicity test. The most common test methods used by lubricant industry for evaluating the acute toxicity and European ecolabelling board of their products are EPA 560/6-82-002 and algea growth inhibitor test, daphnia acute immobilization test and fish acute toxicity test.[10] The tests are used to determine adverse effects after long period of time.

3.0 MATERIALS AND METHODS

Materials used in this study are as follows: 100g of soil sample was collected in the area, Sodium Hydroxide (1N), NaOH, made from America Chemical Society (ACS), Deionized water prepared according to American Society of Testing and Materials (ASTM) Type II water and the waste extracts.

Table 1: Equipment & Apparatus.

Equipment/Apparatus	Uses
Agitation apparatus	To rotate the extraction vessel at 30rpm
Borosilicate glass bottles	Extraction vessel
Polytetrafluoroethylene	To fitter all samples and extracts
Pressure pump	For pressure filtering of sample and extracts
pH meter	For measuring acidic and alkanity of the waste
Watch glass	To cover beaker or Erlenmeyer flask
Magnetic stirrer	For stirring aliquot of waste

4.0 Methodology

The soil sample in the area was collected in wide –mouth glass container with Teflon-line cap and was refrigerated at4^{0}C for 12hours according to the Scientific, Engineering, Response and Analytical Service (SERAS); the liquids containing less than 0.5% solid material was filtered through 0.6 to 0.8µm glass fiber to create TCLP extract wastes. And for wastes containing greater than or equal 0.5% solids, the liquid was separated for later analysis. The particle size was reduced by filtering through a 9.5mm sieve and cut into 1cm. The solid phase was extracted for 18 hours with an amount of extraction fluids equal 20times the weight of the solid phase. The materials are placed in a tumbler to simulate the leaching action of water seeping through waste in the land fill. Having separated the solid and liquid wastes, the solid and liquids wastes were assessed, Hence, inorganic and organic material were identified according to EPA method SW846/131.The extraction fluid employed is a function of the alkalinity of the solid waste. Sodium hydroxide (NaOH) was used according to Analytical Reagents of American Chemical Society (ACS).

5.0 RESULTS AND DISCUSSION

5.1 Results

Table 2: TCLP Test results for metals

Metal	TCLP Limit	Exp. value
Arsenic	5.0	8
Barium	100	150
Cadmium	1.0	2
Chromium	5	7
Lead	4	7
Mercury	3	5
Selenium	2	2.5

Table 3: TCLP Test results for inorganic compound.

Metal	TCLP Limit	Exp. value
Arsenic	5.0	8
Barium	100	150
Cadmium	1.0	2
Chromium	5	7
Lead	4	7
Mercury	3	5
Selenium	2	2.5

6.0 Discussion of results

During the TCLP test, the solid test sample was diluted with extraction fluid that is 20times the weight of the sample, then, the total concentration was divided by 20 and compared to TCLP limit, where the number is lower than TCLP limit, the waste cannot leach enough chemical into soil and ground water to be considered as "Toxicity characteristics hazardous waste, where number is higher than the TCLP limit, the waste is considered hazardous and can leach chemical into the soil and ground water. The data obtained indicate that all analytical results are above the regulatory limits, high volatile were detected inform of herbicide and pesticides .The results of TCLP parameter detected in the samples analyzed were o-m, and p-isomers of cresol and metals such as Arsenic, Barium, Cadmium, Chromium ,lead and selenium..Various isomers of cresol were present in the analyzed samples .The highest cresol concentration detected was 20.5mg/l in the extract sieved wastes in the sample, while the regulatory limit for cresol is 15.5mg/l. Arsenic was present in the samples. The highest concentration was 8.0mg/l in the extract of the sieved wastes from the analytical results, while the regulatory limit for Arsenic is 5.0mg/l. Barium was present in all samples. The highest barium concentration was 150.0mg/l in the extract of the waste sample, while the regulatory limits for barium is 100.0mg/l. In all cases, the result of the tests must fall below TCLP limit to ensure that the waste is TCLP complaint and able to be processed into landfill without special consideration for public health and safety. Refer to Table 2 and 3, the wastes failed the TCLP test and is characteristically hazardous. This study suggested possible solution such as dry machining, minimum cutting fluid application strategies, mist reduction and eco-friendly lubricants from vegetable origin as alternative cutting oil for metal machining.

7.0 CONCLUSION

Cutting fluids perform varieties of functions in manufacturing industries however, conventional cutting fluids have inherent environmental and health liabilities associated with them that are of concern to industries. These liabilities can be viewed as opportunity to re-evaluate the functionality and also give a chance for other promising lubricants from renewable sources for an improved performance and environmental compatibility.

8.0 RECOMMENDATIONS

For a successful plan to be implemented, all personnel including owners, upper management, engineers, shop foremen, machine operators e.t.c must be conscious of waste fluid management to make significant reduction in their operating costs and mandated environmental waste handling.

Educate fluid management personnel on processes that affect fluid performance that contribute to fluid failure and environmental pollution.

Provide management personnel with useful reference for implementing an effective fluid management program.

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