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Response of Different Types of Soil Exposed to Cutting Oil Contamination

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ABSTRACT

Soil in the vicinity of various industries, particularly in the oil and metal sectors, is at risk of contamination either directly from the release of pollutants such as hydrocarbons, oils and metals, or indirectly from residues generated during waste treatment processes. In this study, we tested the influence of 4% prepared cutting oils on the physicochemical parameters of different soil types. The soils were contaminated with 10% (v/w) cutting oils. We found that the soils reacted differently to the cutting oils. In the case of the first soil type (Soil 1), the organic carbon percentage decreased from 3.78% to 3.2% two weeks after contamination. Conversely, the second soil type (Soil 2) exhibited an increase from 4.36% to 4.9%. Furthermore, conductivity, water content, and C/N values increased for both soil types. The different soils analyzed showed changes in soil texture and particle size distribution after contamination. In particular, in the case of soils 1 and 2, there was an increase in the percentage of clay, associated with a decrease in the percentage of silt after contamination, while the percentage of sand remained constant throughout the study period.

Keyword: Soil, Metallurgical Industry, Cutting Oil Contamination, Particle size distribution.

1 Introduction

In recent decades, soil pollution has increased dramatically, posing potential risks to human health and ecosystem well-being. Soil pollutants encompass a wide range of contaminants, including organic and inorganic chemicals. These contaminants may originate from industry or exist naturally in the soil [1], leading to their accumulation in the soil to worrying levels [2]. The metallurgical industry uses petroleum-based cutting fluids to reduce friction, improve surface finish, prevent burr formation, evacuate chips from the cutting zone and protect the work piece from wear [3]. However, cutting fluids can potentially contaminate the soil through various pathways linked to their use in machining and metalworking processes. The main concerns relate to the health risks associated with this contamination. These risks include direct contact with contaminated soil, exposure to fumes from contaminants in cutting fluids, and the potential for secondary contamination of internal and underground water supplies [4]. The area under study involves a recovery tank located in the ground near a metallurgical industry. This is a poorly designed site that collects all quantities of used cutting oils, potentially causing infiltration and/or evaporation of the recovered liquid. The aim of this experimental study is to analyze the response of different soil types to cutting oil contamination and to assess the impact of this pollution on specific physical and chemical properties, in order to guide the choice of an appropriate remediation method.

2 Material and Methods

In this experiment, three types of soil with varying particle sizes were chosen from different locations in Constantine, Algeria. Each soil type, one kilogram in weight, underwent drying at room temperature and sieving to 2 mm before contamination. Various soil parameters such as pH, conductivity, organic carbon, organic matter, phosphate, total nitrogen, moisture, and particle size were measured both before and after contamination. Additionally, Fourier transform infrared spectrometry was employed to identify functional groups in the soil types before and after contamination, utilizing a Jasco FT/IR-4600 device. The soil was

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mixed with cutting fluids at 10% concentration and left for 15 days in a natural environment before analysis.

3 Results and Discussion

3.1 Influence of cutting oils on soil physicochemical parameters

Table1 shows the physico-chemical properties before and after contamination of one soil type with cutting oil. The results indicate that pH and percent nitrogen decreased slightly in all soil types after contamination, while water content and conductivity increased. Organic carbon levels varied, increasing in some soil types and decreasing in others.

Table 1: *Physicochemical characteristics of soil before and after contamination*

		Moisture %	pH	Conductivity (µs/cm)	Organic carbon %	Organic matter %	Nitrogen %	C/N
Soil 1	Before	2.70	8.75	178	3.78	6.52	0.16	23.63
	After	4.14	7.70	368	3.2	5.52	0.12	26.67
Soil 2	Before	3.68	8.18	214	4.36	7.52	0.18	24.22
	After	5.02	7.7	324	4.9	8.45	0.16	30

3.2 Influence of cutting oils on particle size distribution

Figures 1 illustrates alterations in soil particle size due to cutting oil contact, reflecting diverse physical and chemical soil processes. Notably, an increase in clay percentage coupled with a decrease in silt percentage is observed, possibly due to silts dispersing under cutting oil influence, while sand percentage remains stable. Infrared spectroscopy meticulously characterizes the shift in soil composition pre- and post-contamination, identifying new functional groups formed after contamination (**Figures 1**).

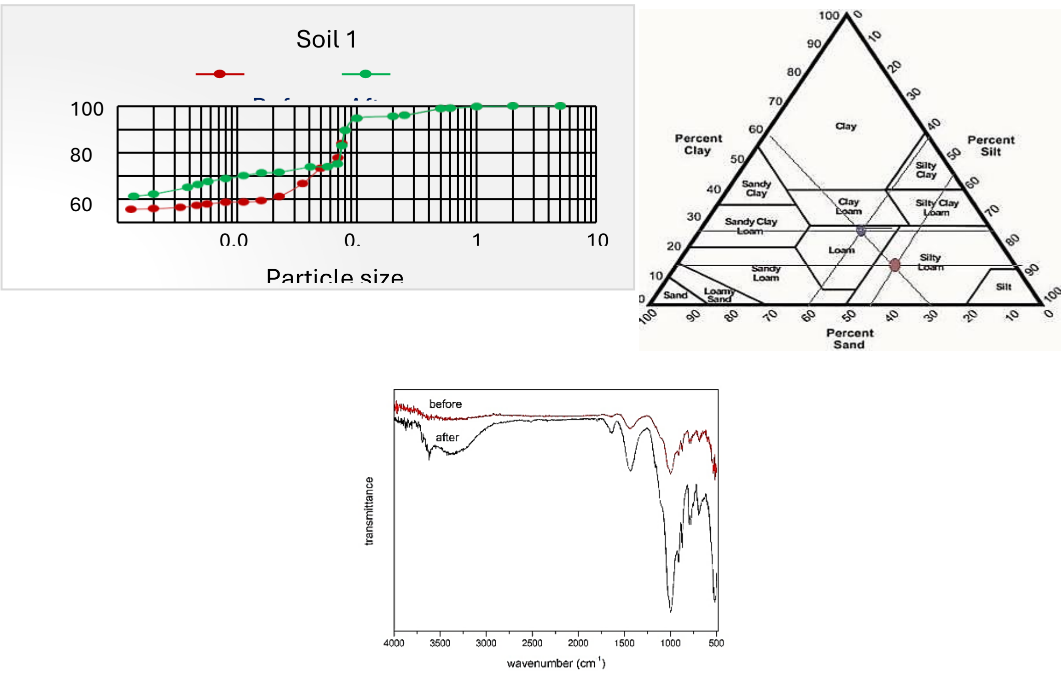

Figure 1: The Soil 1 particle size curve and characterization by infrared spectroscopy before and after contamination.

4 Conclusion

In conclusion, our study delved into assessing the influence of regenerated cutting oils from metallurgical industries on soil particle composition and distribution. The diverse responses observed across the three soils underscore the need for customized remediation approaches to combat pollution effectively. Future investigations exploring soil behavior regarding pollutant dispersion depth would provide valuable

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extensions to our initial findings, enhancing our understanding of environmental contamination dynamics.

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