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The Impact of the Cutting Oil Waste Discharges on the Activated Sludge Centrifugal Dehydration

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ABSTRACT

This research examines the impact of cutting oil waste (COWE) from the metallurgical industry on the centrifugal dehydration process of activated sludge. It is crucial to treat these industrial discharges in situ, either through biological processes or physio-chemical methods, before directing them towards surrounding ecosystems or urban wastewater plants. Various treatments generate sludge that retains a significant proportion of these oils. We investigated the effect of three types of cutting oils on the centrifugal dehydration of activated sludge collected from a biological reactor. These types include cutting oils in their raw state and prepared at a concentration of 4% (COWE1), used oils (COWE2), and oils stored after use (COWE3). COWE1 presents an organic load of 29.246 g. L^{-1} of COD_T, decreasing by 27% after use and 41% after storage. These oils demonstrate biodegradability measured by respirometric tests, expressed by the maximal exogenous respiration of 24.6, 6.906, and 3.222 mg. $L^{-1}.h^{-1}$ for COWE1, COWE2, and COWE3, respectively. The latter reduces the efficiency of the centrifugal dehydration of activated sludge, reaching 21.44%, as evaluated by the percentage of solid cake.

Keywords: Metallurgical industries, Cutting-oil, Centrifugal dehydration, Biodegradability

1 Introduction

Metal cutting emulsions, or cutting fluids, play a crucial role in the machining process. They are commonly used in metallurgical industries for various reasons, such as lubricating and cooling the machine. They also contribute to increasing the efficiency and lifespan of cutting tools, improving the surface of parts, and protecting them from corrosion. Among the various types of cutting emulsions, oil-in-water emulsions (Cutting-oil in water emulsions, COWE) are the most preferred in the industry due to their longer lifespan and easier preparation. These emulsions are formed by mixing oil and water at an oil concentration of approximately 3 to 15%, and emulsifiers are added for a more stable emulsion [1]. The significant volume of residues generated (2 Mm^3/year) [2], along with the difficulty of breaking the emulsion and treating this wastewater, makes COWE an environmental threat that needs to be addressed adequately. Since they are effluents with very low biodegradability, physico-chemical processes must be applied before their disposal. The most commonly used processes for treating COWE are coagulation or electrocoagulation, followed by dissolved air flotation or membrane filtration; adsorption has also been employed [2]. The untreated portion of these oils, following various individual or combined treatments, will be stored in the recovered primary and secondary sludges, potentially compromising the dehydration stage following the treatment and liquid-solid separation phases. This research focuses on studying the impact of cutting oil residues after the treatment of effluents from metallurgical industries rich in COWE, located in the industrial zone of Ain Smara, on the centrifugal dehydration of activated sludge (AS) recovered from a biological reactor.

2 Experimental

Samples of activated sludge, taken from a biological reactor incubated in the laboratory, were subjected to increasing doses of cutting oil prepared at **4%,** with varying contact times. These oil-contaminated sludges simulate scenarios such as an illegal discharge into the sewage networks carrying wastewater to urban

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treatment plants or a residual fraction after the physico-chemical and biological treatment of these effluents. The cutting oils were characterized by various parameters, including conductivity, pH, salinity, viscosity, refractive index, and organic load assessed by chemical oxygen demand (COD). A laboratory centrifuge (ROTOFIX 32) was used to dewater various AS samples, the dewatering efficiency was evaluated by quantifying the solid cake percentage , the capillary suction time (CST) and microscopic visualization.

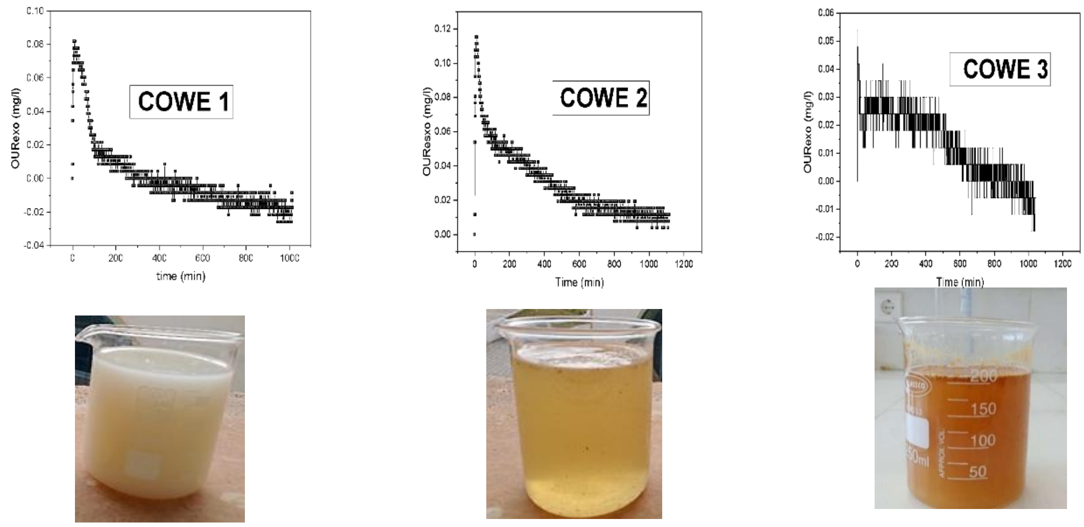
3 Results and Discussion

3.1 Characterization of cutting oils in their various forms

Three cutting oils samples were retrieved from the metallurgical industry. Prepared at a concentration of **4-5%,** the cutting oil was used in a closed circuit. Once the oil changes color after use, the operator disposes of it in a canal connected to a recovery tank. The cutting oil duration use varies depending on the lubricant quality and operations performed, potentially reaching up to **15 days**. The characterized samples are, respectively, the oil before use (**COWE 1**), the used cutting oil taken from the machining station (**COWE 2**), and finally, the used oil taken from the storage basin (**COWE 3**). (**Table 01**). The biological degradability of these oils was also assessed using liquid-phase respirometric tests of the LFS type (**Figure 01**)

Table 01: *COWE Characterization*

	pH	Conductivity**mS.cm^{-}**	Salinity **(%)**	T°**C**	Viscosity **pas/s**	COD_T **(g.L^{-1})**	COD_S **(mg.L^{-1})**	COD_S/COD_T	Refractive index	OURexoma **mg.L^{-1}.h^{-1}**
COWE1	8.2	1.877	0.9	25	2	29.244	23.383	0.799	1.33356	24.6
COWE 2	8.2	3.07	1.6	26	2	21.349	17.760	0.831	1.48475	6.906
COWE 3	8.2	3.52	1.9	27	2.5	17.245	14.820	0.859	1.33456	3.222



COWE1 **COWE2** **COWE3**

Figure 1: Respirograms characterizing the biodegradability of the different COWE samples along with their corresponding photos.

3.2 Characterization of raw activated sludge

The raw activated sludge (RAS) extracted from the biological reactor before any contamination by COWE has also been subjected to characterization (**Table 02**).

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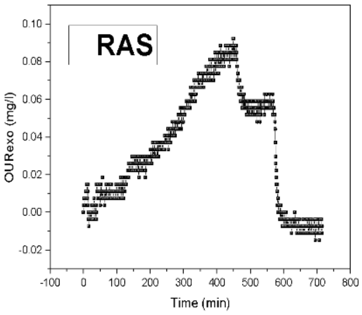
Table 02 *Raw sludge characteristics and composition*

	DO**(mg.L^{-1})**	Conductivity **mS.cm^{-1}**	Salinity **(%)**	T °C	pH	SS**(mg .L^{-1})**	Turbidity **(NTU)**	CST **(s)**	CSTS **s.L.g^{-1}**	IF	IB**(m L.g^{-1})**
RAS	7.2	1.217	0.5	14.7	7.2	1930	18.9	10.2	5.28	0	135



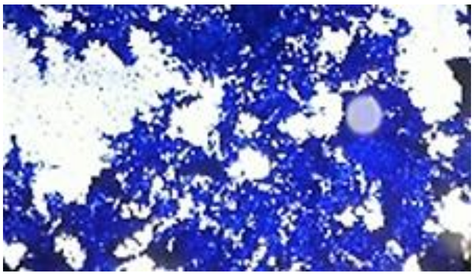


Figure2: Morphological presentation of raw activated sludge (RAS) and correspondence activity.

3.3 The COWE concentration effect on sludge dewatering

The activated sludge was exposed to a progressive contamination with an increasing volume of cutting oil, at an agitation speed of 100 rpm. The characteristics of the activated sludge were evaluated after a contact time of 2 hours (**Table 3**). and then the COWE samples were characterized.

Table3: *The sludge dehydration characterization after progressive contamination by COWE*

Volume (%) (V_{AS}-V_{COWE})	RAS	90-10	80-20	70-30	60-40	50-50	40-60	30-70	20-80	10-90
Solid cake **(%)**	7.04	7	6.64	6.38	6.18	5.99	5.96	6.18	5.54	5.53
CST **(s)**	7.2	33	32.5	20.3	16.85	22.85	19.45	12.05	12.5	13.25
CSTS(**s.L.g^{-1})**	2.86	13.14	12.9	8.08	6.71	9.10	7.74	4.80	4.98	5.27

4 Conclusion

The impact of the activated sludge contamination, recovered from a biological reactor, by cutting oil in water emulsions (COWE) on its centrifugal dewatering has been studied. The effect of contamination becomes more significant with an increase in the dose of COWE, leading to a reduction in the efficiency of dewatering. However, the contact time with these oils does not show a very apparent effect. The biodegradability of these oils has been explored by comparing it with non-contaminated raw sludge.

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