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Reduction of dielectric oil present in Fuller soil by applying Micro-nanobubbles of air at laboratory level

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Resumen

La presente investigación consistió en reducir la presencia de aceite dieléctrico en tierra fuller utilizando las micro-nanoburbujas de aire a nivel de laboratorio. Se pesaron 3 envases 500 gramos de suelo con aceite dieléctrico en cada uno. Pasado las 48 horas se realizó el tratamiento con micro-nanoburbujas de aire. Se llevó al laboratorio para medir los parámetros: pH, CE, mv y T en 30, 60, y 90 minutos luego se analizaron hidrocarburos totales. El mejor resultado fue la muestra número 3 con un tiempo de 90 minutos con el 59.6% de reducción de la presencia de aceite dieléctrico, considerando significativo para el trabajo de investigación

Palabras clave: Tierra Fuller, aceite dieléctrico, Micro-nanoburbujas, aire.

Abstract

The present research consisted of reducing the presence of dielectric oil in fuller ground by using air micro-nanobubbles at laboratory level. Weighed 3 containers 500 grams of soil with dielectric oil in each. After 48 hours the treatment with air micro-nanobubbles was carried out. It was taken to the laboratory to measure the parameters: pH, CE, mv and T in 30, 60, and 90 minutes after total hydrocarbons were analyzed. The best result was sample number 3 with a time of 90 minutes with a 59.6% reduction in the presence of dielectric oil, considered significant for the research work.

Keywords: Fuller earth, dielectric oil, Micro nanobubbles, air.

1. Introduction

The electrical industry uses power transformers whose main additive is dielectric oil, which has advantages such as: electrical and thermal insulation, compared to other oils of a lower hierarchy. The life of power transformers is a matter of interest to electricity service companies, transformer manufacturers and insurance companies (Flores et al., 2007). However, the treatment, known in the environment as regeneration, turns out to be a complicated process, of high cost and especially polluting because it is a petroleum derivative.

Hydrocarbons and their derivatives in the soil block the gas exchange with the atmosphere, initiating a series of simultaneous physical-chemical processes such as evaporation and penetration, which, depending on the quantity, toxicity of the hydrocarbon, temperature, humidity and texture of the soil can cause a great event of contamination. In addition, we must take into account the levels of salinity generated that hinder their treatment by reducing the ability to survive in the environment of certain microorganisms used in remediation processes. Faced with this

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scenario, an alternative is the use of Fuller Earth remediation technologies contaminated with dielectric oil suggest processes involving separate physicochemical and biological technologies resulting in moderately efficient processes.

Agudelo and Cardona (2011) evaluated two techniques to eliminate contamination of the Fuller Earth with dielectric oil. The authors proposed the use of two technologies: one physical-chemical and one biological. For the first, they used hexane as a solvent and achieved a removal level of 87%. However, the quality of the recycled dielectric oil was not suitable for use in electrical equipment, because its dielectric rigidity and density decreased considerably. In addition, the colouring was not very favourable for the maintenance of the equipment. Using biological technology, the contaminated Fuller soil was treated in a biological reactor of activated earth, evaluating the agitation speed and the degradation time necessary to reach contamination levels that allow the waste to be disposed of in a conventional sanitary landfill.

Fuller soil is an inorganic adsorbent material (mainly aluminosilicate mineral), used in the electrical industry for the regeneration of dielectric oil. After the oil regeneration process, the content of Polycyclic Aromatic Hydrocarbons (PAH) presented by Fuller soil turns it into a hazardous waste that requires adequate treatment to reduce its contamination and allow its reuse or safe final disposal in a sanitary landfill (Beltrán et al., 2013).

The presence of aromatic hydrocarbons in a soil causes a notable reduction in the diversity of the communities that inhabit it (Castle et al. 2006; Laura, 2011). At the biological level, hydrocarbons are a stressful factor for the microorganisms present in the soil, since they condition the development of the various members of the microbial community, allowing only the development of communities or populations with adequate metabolic characteristics that adapt to the presence of external agents in the environment. In this way, the most sensitive and intolerant are quickly eliminated. We can find two categories of contaminated soils: acutely contaminated soils and chronically contaminated soils, which are classified based on the type and time of exposure to the pollutant agent.

Inhalation of excessive concentrations of any dust, including this material, can cause lung injury. This product contains crystalline silica. Excessive inhalation of respirable crystalline silica can cause silicosis, a progressive, disabling and fatal lung disease. Symptoms may include coughing, shortness of breath, wheezing, and reduced lung function. The International Agency for Research on Cancer (IARC) has concluded that inhalation of crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans.

PAHs are found mainly in petroleum and petroleum products (mainly fats and oils), in coal and tar deposits, and also as fuel products. As contaminants they have raised concern because some compounds have been identified as carcinogenic and mutagenic. In addition, their final disposal is very costly and difficult due to the nature of the substances that compose them.

Micro-nanobubbles are bubbles with small diameters, i.e. at the scale of micrometers and nanometers, there is no exact agreement on the exact diameters to define them, there are different authors who manage their ranges to identify micro-nanobububbles, "Microbubbles (MB) and nanobububbles (NB) are tiny bubbles with a respective diameter of 10-40µm and < 100 µm for the field of fluid physics (Tsuge, 2014).

Micro-nanobubbles can be applied in environmental issues; and other areas; where a problem is sought to be solved, the fields of application of these tiny bubbles are detailed below. (Valverde, 2016; Abate and Valverde, 2017; Valenzuela and Valverde, 2018).
a) Environmental - In the treatment and improvement of water quality in lakes, lagoons, rivers, wetlands, ponds, coasts, mangroves, groundwater and marine waters.

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b) Industrial: In the treatment of wastewater from industries such as: paper mills, pharmaceuticals, biomedical, petrochemical, dairy, refrigerators, tanneries, laundries, food, textiles, metallurgy, among others. Also in the treatment and improvement of water in those processes with the extraction of oil, gas and minerals.

2. Materials and Methods

The study population consists of approximately 23 kg of Fuller Earth contaminated with dielectric oil from Dielectric Oil Treatment Equipment. For the sample, 2kg of Fuller soil contaminated with dielectric oil were taken.

Stage 1. Sample Collection
Sampling was carried out in the warehouses of a company that treated dielectric oil with Fuller earth to one of the power transformers of the Chavarría Electric substation, district of Los Olivos, Lima.

Figure 1. Weighing of soil samples

Stage 2. Installation of Fuller ground treatment equipment
Installed equipment to start treatment with the respective samples

Stage 3. Fuller Soil Treatment
The inlet container was filled with deionized water. The contaminated soil sample was placed in the outlet vessel.

The micronanobubbles of air were generated in the exit container, achieving a contact with the contaminated soil. Three samples of treated soil of 500 grams were collected.

Table 1. Characterization of parameters of air micro-nanobubbles

Parameters	value	Units
Time of treatment	10	min
Diameter size	2.2	nm
Ascent Velocity	$2.65x10^{-5}$	m/s
Internal pressure	1.32	atm

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Stage 4. Analysis after treatment
Samples contaminated with dielectric oil and 3 samples of soil treated with air micro-nanobubbles were taken to the laboratory.

3. Results

It can be appreciated in the Table that the percentage of reduction of presence of oil in earth fuller is greater in the sample with the treatment in 90 minutes.

Table 2. Results of the Percentage reduction of oil in fuller ground after treatment.

Time (Minutes)	Initial sample (gr)	Final sample (gr)	% reduction
30	500	305	39
60	500	295	41
90	500	202	59.6

The table indicates that the sample treated 3 has the highest pH of 5.8 and the EC of 4.52 ms/cm.

Table 3. Results of physical and chemical properties of soil before treatment

Code	pH	EC (mS/cm)	T (°C)
MST-1	5.6	3.30	19.2
MST-2	5.8	4.14	19.2
MST-3	5.8	4.52	19.2

The table indicates that the treated sample 2 has a pH of 6.6 and an EC of 750 mS/cm.

Table 4. Results of the physical and chemical properties of the soil after treatment

Code	Time (Minutes)	pH	EC (µS)	T (°C)
MT-1	30	6.3	534.25	19.2
MT-2	60	6.6	750	19.2
MT-3	90	6.8	565.65	19.2

The table shows that the higher the oil concentration, the greater the apparent density of the soil and the lower the concentration, the lower the value, as in the case of sample 1, which has 1.74 gr/cm3.

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Table 5. Apparent soil density after treatment

Code	Time (Minutes)	Apparent density (gr/cm^3)
MT- 1	30	1.74
MT- 2	60	1.76
MT- 3	90	1.90

4. Conclusions

From the results obtained in the present investigation, the following conclusion was reached:

- The physical properties of fuller soil contaminated with dielectric oil such as: the temperature remained constant at the beginning with 19.5°C and at the end 19.2°C only by treated sample 1 was the same at the beginning. The apparent density of the treated samples was analyzed where the increasing variation according to the concentration of the oil was noticed.
- The chemical properties of the sample treated as: pH remained constant MT1 (7.4), MT2 (7.8), MT3 (7.7). In the case of electrical conductivity the results obtained were M1 (3.30 mS/cm at 534.25 uS/cm), M2 (4.14 mS/cm at 750 µS/cm), M3 (4.52 mS/cm at 565.65 µS/cm).
- The use of micro-nanobubbles allowed the reduction of the presence of dielectric oil in fuller ground, since favorable results were obtained and it was possible to maintain a constant pH and reduce the electrical conductivity in units of measurement from mS/cm to µS/cm.

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