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INVESTIGATION USE IRRADIATION TO TREAT SOIL CONTAMINATE WITH OIL

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Abstract

the utilization of gamma rays with a high energy is common in the treatment of water contaminated with organic matter. Although it is an effective method for treating water contamination with biological contaminants. The effect of these rays on soil contamination with oil has not been investigated. In light of this, the impact of radiation on soil contaminated with oil was studied the effects of these rays on the physical and chemical properties of oil in the treated soil after being exposed to gamma rays at various dosages was studied. The nuclear lab of the Physics Department, Faculty of Science, University of Kufa, Iraq processed three samples of oil-contaminated soil. The International Atomic Energy Agency (IAEA) in a close setup, all samples may be radioactively irradiated concurrently at dosages of 0, 11, 30, and 70 krad. The area of experimentation in the Kufa University, Faculty of Science, Ecology Departments for 30 days. The main results have been reduction in TOC, DO, COD, in contaminate soil with oil for all radiation doses. This demonstrates the utility of radiation technology in contaminate soil with oil treatment and the possibility of using irradiation technology in the biological treatment in such kind of contaminate soil. This is an effective, new, and fast method of treatment.

Keywords: *Irradiation; TU, DO, BOD5; TOC; COD.*

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Introduction

The strongest type of electromagnetic radiation is called a gamma ray. It has a 10 keV (kilo-electron-volt) power level for several hundred keV. When compared to other sources of radiation like alpha and beta rays, it is thought to be the most penetrating, also it more dangerous than alpha and beta with compare [1]. Since its discovery, researchers have been scrambling to develop fresh methods for handling tainted water, particularly sewage. This innovative technology was envisioned as a tool for plant development projects [2, 3]. mutations in the plant caused by the use of radioactive fertilizers or by light radiation applied to seeds or plants, [4]. Ionizing radiation includes gamma rays, which interact with atoms or molecules to create free radicals in cells that, depending on the radiation exposure amount, can either kill or cause mutations or changes in plant cell components. These impacts include modifications to the antioxidant system, an increase in phenolic chemicals, and alterations in photosynthesis, as well as changes in the structure and metabolism of plant cells [5]. These impacts include modifications to the antioxidant system, an increase in phenolic chemicals, and alterations in photosynthesis, as well as changes in the structure and metabolism of plant cells [6]. Soil polluted with petroleum hydrocarbons has been successfully cleansed using irradiation heating in place for the first time after being used in its complete configuration at a genuine location. Economically, a network of separate antennas driven by a single low power irradiation generator would be the idea behind the irradiation energy delivery to the soil. This investigation's success paved the way for a second, much larger field test employing irradiation heating to cure soil tainted with petroleum hydrocarbons. A irradiation heating system with low power generators has great flexibility, is inexpensive, and places no limitations on the quantity or configuration of antennas.

Material and Methods

2.1 Soil sample collection

On October 15, 2022, soil samples were taken from three polluted locations at an oil-refining complex Najaf in the Iraqi . Water lay around ten meters below the field's surface. Due to previous uses of the land, petroleum hydrocarbon compounds from leaking storage tanks were present in the soil.

2.2 Soil irradiation

In the nuclear lab of the Physics Department, Faculty of Science, University of Kufa, three soil samples were processed. The International Atomic Energy Agency's (IAEA) Cs137 source was used in a closed system to administer radiation to the first group (G1) at a dose of 11 krad, the second group (G2) at a dose of 30 krad, and the third group (G3) at a dose of 70 krad. A Canadian-made cell that uses the radioactive source Cs 137 to determine the dose rate of two Mrad/hr and radioactivity of 50 kCi and this device was used since January 1985.

To ensure that each sample received a uniform dosage of radiation, the samples were put in a cylinder that was 16 cm in diameter and 20 cm high[7].

2.3 Physical and chemical measurements of Soil samples

A multi photometer was used to measure the pH, EC, salinity, and dissolved oxygen (DO), while a turbo meter was used to measure turbidity. Prior to beginning the measurements, all of the aforementioned instruments were calibrated. The American Public Health Association (APHA) (2003) describes the techniques used to test total TDS, total TSS, total organic carbonate (TOC), and carbon dioxide (COD).

2.4 Statistical investigation

Measurable investigations were calculated using the measurable program SPSS (Ver. 17), accounting for significant differences between medicines. Slightest Critical Contrasts (LSD) Test by Fisher, guaranteed for importance level.

1. Results and Discussion:

1.1 Testing of the soil both before and after radiation therapy

Due to the significant activity of gamma rays, which can alter the characteristics of contaminants soil, Table 1 demonstrated that ionizing radiation has a radical effect on total organic matter (TOC) in soil [8]. Sludge's increased soluble organic matter may be the cause of this.

Tables 1 and 2 list the fundamental characteristics of the test soil. The soil's bulk density ranged from 1.69 to 2.12 g/cm3, while its porosity ranged from 15.35 to 25.92%. The tested soil has a lower porosity than ordinary soil. It was as a result of the site's compaction and combination with material from other locations. As a result, the tested soil's bulk density might increase and its porosity might decrease. The tested soil samples had a moisture content of 7.76-22.20%.

The results showed that as radiation dose was increased, EC remained constant Table 1 . This is accurate because soil's dissolved salts are what give it its EC and hardness. In contrast to organic salts, which are not extremely conductive when dissolved in soil, inorganic salts are. Additionally, the salinity value does not change as the radiation dosage rises since radiation doses do not destroy inorganic materials. Values were constant as a result Table 1 [9]. With an increase in radiation dose, pH rose. Table 1 This suggests that soil irradiation causes pH values to generally rise. This increase was brought on by more hydroxyl radicals as a result of enhanced hydrolysis and radiation dose-related deterioration. Free hydroxyl roots are significantly more concentrated because the G value of OH (G-OH) increases in comparison to other free radicals.

The DO concentration values in Table 1 drop as the radiation dose rises. In the presence of hydrogen, free radicals like H_2O_2, HO_2, O_2, and C_6H_5OH (OH), which are potent oxygen receptors, cause these electrons to interact with the oxygen. decreased dissolved oxygen concentration.

As the radiation dose increased, the COD values became less valuable. The eradication of the bacteria in charge of oxygen consumption caused this decline. Microorganisms are well known for being extremely susceptible to radiation pulses. Additionally, chemical molecules present in biological systems can be broken down by the radiation energy Table 1 [9].

According to (Table 1), total dissolved solids (TDS) revealed a different outcome. At low radioactive doses at the beginning of the treatment, the soluble solids concentration decreased; this was followed by a rise in soluble solids concentration as the absorbed radioactive dose increased [10]. This might be as a result of dimmers or trimmers forming or dissolved organic materials being converted into simple molecular molecules. Then, in areas with high radiation levels, sediments and sludge at the bottom were melted due to the high dosage effect, raising the concentration of TDS. The values fell short of the experiment's beginning [11].

Table 1 The average values of the chemical parameters for soil samples examined before and after exposure to various doses of radiation.

Parameter	first value (mg/l)	First Affect dose (krad)	Second Affect dose (krad)	Third Affect dose (krad)	Final Value (mg/l)
TOC	1870	11			460*
			30		254*
				70	30*
EC	2.3 (mmhos/cm)	Does not affect	Does not affect	Does not affect	n
PH	6.8	11			7.3
			30		8.6*
				70	8.9*
DO	9.6	11			7.4*
			30		7.6*
				70	7.8*
COD	1676	11			85*
			30		120*
				70	130*
TDS	11250	11			1460*
			30		1780*
				70	2132*

According to Duncan Multivariate, the data with an asterisk (*) were substantially different, P≤ 0.05.

To remove soil-borne volatile and semi-volatile hydrocarbons, irradiation heating is a very successful method, and it works particularly well for polar molecules [11]. Comparatively straightforward to implement and reliable in use, this strategy. 3.0 hours of the decontamination process were spent using a steady irradiation power without the use of water. In general, the main impacts seen throughout the irradiation warming procedure were the same throughout the laboratory tests, despite the increased soil pollutant concentration and heating inhomogeneities caused by the larger soil volume [13]. The amounts of BTEX (benzene, toluene, ethylbenzene, and xylene), as well as C6-C9, are listed in Tables 3 through 7. It is obvious that hydrocarbons in the C6–C9 range significantly polluted the soil. Additionally, 0.57 mg/kg of BTEX was found in the soil. Most treated samples exhibit noticeably lower concentrations of hydrocarbons than untreated samples. Numerous hydrocarbons' concentrations were found to have significant decrease. The volatilization of BTEX by irradiation heating may be the cause of its elimination. Due to sampling restrictions, soil might differ at the two sampling points. As a result, in certain instances, after the irradiation procedure, the pollutant concentrations increased. The disadvantage will be overcome by either increasing the irradiation time or supplying irradiation energy to the soil through a network of separate antennas [14].

The remediation of contaminants, however, may be combined with degradation and evaporation in tables 3–6 as well as co-evaporation. The development of steam by the irradiation energy caused contaminants to be co-evaporated from the soil for the C10-C40 organic compounds without decomposing them. The wetness in damp soil acts as a good irradiation absorber, allowing the evaporated steam to trap pollutants and remove them from the soil while also absorbing irradiation radiation. The wetness might have a significant impact on the duration of the irradiation heating operation, the recorded soil temperature was between 30 and 35 C. Due to soil's transparency, this is the case [15] to heat up energy. The majority of energy is transferred straight to moisture and hydrocarbon molecules, which warm up electrically. Energy savings in the remediation process are an advantage. According to Dauer-Man et al., decontaminating one ton of soil using irradiation heating can reduce operating expenses by 77% compared to using a conventional incineration technique [14].

On the other hand, a quick reorientation of molecular dipoles in the rapidly varying external electromagnetic field is what causes the molecules' temperature to rise. However, irradiation heating, which is crucial for in situ cleanup techniques, may achieve significantly greater penetration depths in the meter-range. Heat is generated inside the soil volume when using irradiation. The installed power affects the heating rates that can be achieved [15]. Because the remediation of soil by irradiation heating is dependent on the use of high-grade electrical energy, the efficiency of heat generation in the soil is a critical parameter for measuring the economic side of this technique [16]. It is important to maximize how irradiation energy is converted into heat in the required soil volume [17]. The length of the antenna is also influenced by the depth of the contaminated soil layer that needs to be treated. a system of separate antennas, each powered by a single irradiation would be the most feasible solution for the irradiation energy delivery to the soil.

Table (2) the tested soil's physical and granular characteristics.

Depth (cm)	Bulk density (g/cm^3)	Particle density (g/cm^3)	Porosity (%)	Sand (%)	Clay (%)	Silt (%)
0–35	1.57	2.32	26.92	69.86	10.38	13.97
35–85	1.91	2.34	22.41	69.27	11.71	14.22
85–135	1.95	2.36	16.74	45.50	30.37	29.23
135–165	1.52	2.21	20.54	43.52	28.36	42.82
165–195	1.81	2.41	23.87	70.94	25.83	8.82
195–245	2.52	2.47	16.91	69.34	16.21	19.21
245–360	1.95	2.28	15.32	82.57	7.39	7.08

Clay (particle size: 0.002 mm), silt (particle size: 0.05–0.002 mm), and sand (particle size: 1-0.05 mm).

Table (3) The tested soil s moisture content.

Depth	Distance 0.4 m (%)		0.55 m (%)		1.0 m (%)	
0.5–1.0 m	8.56a	8.23b	8.26 a	16.45b	5.45a	7.67b
1.5–2.0 m	15.44a	15.43b	14.95a	6.96b	13.56a	15.56b
2.5–3.0 m	16.71a	15.28b	15.67a	14.73b	18.73a	32.20b
3.5–4.0 m	14.19a	13.24b	15.36a	14.96b	16.63a	16.57b

Moisture content of the tested soil in brackets: (a) before irradiation; (b) after irradiation.

Table (4) Toluene concentrations at different depths and starting points in soil heated by irradiation.

Depth	Distance								
	0.4 m (mg/kg)			0.55 m (mg/kg)			1.0 m (mg/kg)		
0.5–1.0 m	MGn	0.29d	–R	MGn	0.19d	–R	0.18n	MGd	100r
1.5–2.0 m	MGn	MGd	–R	MGn	0.29d	–R	MGn	MGd	–R
2.5–3.0 m	MGn	MGd	–R	MGn	MGd	–R	0.26n	0.14d	46.2r
3.5–4.0 m	0.57n	0.23d	59.6r	MGn	MGd	–R	0.29n	0.37d	–R

n Initial concentrations., d Residual concentrations., r Removal efficiency.

Table (5) M-xylene and p-xylene initial and residual concentrations after microwave heating at various distances and depths.

Depth	Distance								
	0.4 m (mg/kg)			0.55 m (mg/kg)			1.0 m (mg/kg)		
0.5–1.0 m	MGn	MGd	–R	MGn	MGd	–R	MGn	MGd	
1.5–2.0 m	0.20n	MGd	100r	0.14n	MGd	100r	0.13n	0.31d	–R
2.5–3.0 m	MGn	MGd	–R	MGn	MGd	–R	MGn	MGd	
3.5–4.0 m	0.20n	MGd	100r	0.14n	MGd	100r	0.13n	0.31d	–R

n Initial concentrations., d Residual concentrations., r Removal efficiency.

Table (6) O-xylene initial and residual concentrations in soil heated by irradiation at various distances and depths.

Depth	Distance								
	0.4 m (mg/kg)			0.55 m (mg/kg)			1.0 m (mg/kg)		
0.5–1.0 m	MGn	MGd	–R	MGn	MGd	–R	MGn	MGd	
1.5–2.0 m	0.50n	MGd	100c	MGn	MGd	–R	0.23n	0.25d	–R
2.5–3.0 m	MGn	MGd	–R	MGn	MGd	–R	MGn	MGd	
3.5–4.0 m	0.50n	MGd	100c	MGn	MGd	–R	0.23n	0.25d	–R

n Initial concentrations., d Residual concentrations., r Removal efficiency.

Table (7) C6-C9 initial and residual concentrations after microwave heating at various distances and depths..

Depth	Distance								
	0.4 m (mg/kg)			0.55 m (mg/kg)			1.0 m (mg/kg)		
0.5–1.0 m	MGn	22.5d	>	MGn	38.2d	–R	MGn	MGd	–R
1.5–2.0 m	MGn	MGd	–R	MGn	32.7d	–R	MGn	MGd	–R
2.5–3.0 m	76.7n	18.6d	75.0c	36.2n	MGd	100c	1056n	65.0d	90.3c
3.5–4.0 m	16.70n	72.3d	96.2c	904n	MGd	100c	1803n	1394d	25.1c

n Initial concentrations., d Residual concentrations., r Removal efficiency.

2. Discussion

The most powerful effect of radiation irradiation on the treatment of soil was the elimination of organic materials. The current work demonstrates that irradiation heating is a time- and cost-efficient method for cleaning up soil that has been contaminated with petroleum hydrocarbons and volatile organic chemicals. Irradiation heating can remove the contaminated soil without disturbing it or excavating it. There is very little exposure of the general public and staff to the contaminated site, and the remediation is permanent. The irradiation heating system is rather straightforward and is easily created. In order to stimulate the direct volatilization of pollutants out of the soil, this procedure entails infusing irradiation into the site[18]. The reactor created for this investigation has proven to be capable of successfully removing organic chemicals from contaminated soil. The results show that irradiation energy may safely clean up even polluted soils. Irradiation heating can be thought of as the adaptive technology for remediating hydrocarbon-contaminated soil because different types of soil can be treated. The remediation process can also be completed in a limited amount of time. A lot of information on the engineering, physical, and chemical aspects of irradiation application was made available by the successful testing[19]. General conclusions are formed regarding the appropriateness, competitiveness, and preferred application domains of irradiation heating. These findings, in our opinion, promote additional study into irradiation heating systems for the treatment of polluted soil. This innovative method offers the chance for on-site, large-scale industrial in situ treatment of hydrocarbon-contaminated soil.

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