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EFFECT OF DIFFERENT ORGANIC REGULATOR APPLICATION TO PROBLEMATIC AREAS ON SOIL ERODIBILITY PARAMETERS (SERPENTINE SOIL SAMPLE)

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Abstract: In the study, the changes in the structural stability and erodibility properties of the organic regulators (TG, TAGG and SG) applications to serpentine soils were investigated. In line with the study's objective, organic amendments based on oven dry weight were applied to the soils in different dose combinations. The study, designed according to a completely randomized design (CRD) was conducted in plastic pots maintained under greenhouse conditions. Six months after the experiment was established, the pots deteriorate pots were and the necessary measurements were made. WAS, DO, EO, SSI, OM values were measured to evaluate the change in the erosive and structural stability of the soils. As a result of the study, the OM values of the soils increased with the organic regulator applications (TAGG, TG, SG). The highest increase was observed in pots where TG and TAGG were applied. The erodibility parameters of the soils, DO and EO, showed a decrease with increasing dosage applications. WAS and SSI parameters, which are soil erosive variables, increased with increasing application dose. These increases (WAS, OM, SSI) and decreases (DO and EO) depending on the applications were statistically significant ($P<0.05$). This positive improvement in soil variables (WAS, SSI, DO and EO) was attributed to the increase in soil organic matter.

Keywords: Serpentine soil, Organic regulators, Erosion, Improvement

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1. Introduction

Serpentine soils are formed as a result of the weathering and disintegration of a series of ultramafic rocks (peridotite: dunite, lherzolite, harzburgite) consisting of ferromagnesian (Fe, Mg or Fe-Mg) silicates. These soils are generally less fertile compared to other normal soils (low in N, P, K, and Ca) and are rich in heavy metals (Ni, Co, Cr) (Kara, 2019). Moreover, they contain asbestos minerals (chrysotile, lizardite, antigorite) that pose a threat to human health. In addition to these unfavorable conditions, the susceptibility of serpentine soils to erosion has gained global significance (Kara et al., 2023). Soil erosion is a significant problem environmentally, economically, and socially. It leads to severe land degradation and soil loss (Jing et al., 2005), and the transport of problematic areas like serpentine soils from one point to another threatens public health (Kara et al., 2018a). Many studies have reported abnormal concentrations of heavy metals (Ni, Cr, Fe, Co, Mn) in serpentine soils (Kara et al., 2018b; Kara, 2019; Altunbaş, 2023).

To prevent the entry of heavy metals into terrestrial, atmospheric, and aquatic environments, and to mitigate contaminated land, improvement measures need to be taken (Hasan et al., 2019). The importance of adding organic matter to soils has been mentioned to prevent heavy metals from being transported to other places through erosion and mixing with drinking water (Solak, 2020; Kara, 2023; Saltalı et al., 2023). Organic matter positively improves soil aggregate stability. It has been reported in many studies that organic matter (organic regulators: worm manure, leonardite, gyttja, olive pomace, cattle and sheep waste) reduces the resistance of soils to erosion (Spaccini et al., 2004; Kavdır and Killi, 2008; Turgut and Aksakal, 2010; Kara et al., 2022).

In this study, different organic amendments (poultry litter used as poultry litter ash (TAGG), cattle manure (SG), and chicken manure (TG)) were applied to serpentinite soils that have the potential to negatively impact human health, the environment, and ecology. The study investigated their effects on soil erodibility (dispersion ratio, erosion rate, aggregate stability, structural stability index).

2. Materials and Methods

Serpentine soils were used in the experiment. The map representation of the serpentine soil taken (37S X: 322068 Y: 4153161) is given in Figure 1.

Soil samples taken from the field were dried under appropriate conditions and passed through 2 mm sieves. 1 kg of soil sample was weighed for each pot. Except for the pots designated as control treatments, different organic regulators (TAGG, TG and SG) were applied to the other pots in different amounts (1%, 2%, 4%, 6% and 8%) and mixed homogeneously. The homogenized soil + organic regulator (TAGG, TG and SG) mixture was brought to field capacity with tap water. The prepared soil + organic regulator mixtures were incubated under greenhouse conditions for 6 months, and as the soil + TAGG, soil + TG and soil + SG mixtures in the pot dried, they were watered with tap water until they reached field capacity. When the treatment period (6 months) was completed, the samples in the pots were disrupted and made ready for analysis. Soil samples prepared for analysis were determined according to appropriate methods. Some properties of the organic fertilizers used as materials in the study are given in Table 1, and some properties of the tap water applied to bring the soil in the pots to field capacity are given in Table 2.

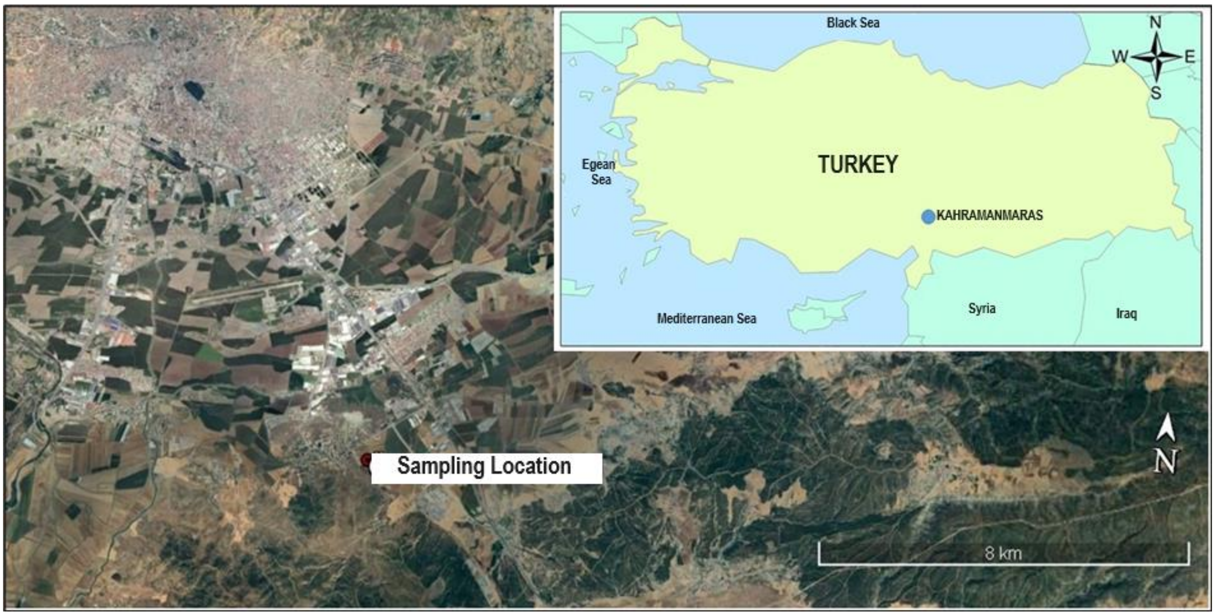

Figure 1. Display of the soil sample taken on Google Earth.

Table 1. Some properties of organic fertilizers used as materials in the study

AF	N (%)	Ca (ppm)	Mg (ppm)	K (ppm)	P (ppm)	Fe (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
TAGG	1.86	110500	3401	14610	2647	1393	4,03	103.1	132
SG	1.31	42940	6463	10510	3357	2691	14.2	80.13	207.7
TG	2.81	5425	2173	12280	2669	173.3	19.18	142.9	198

AF= application fertilizer, TAGG= gyttja manure used as chicken bedding, SG= cattle manure, TG= chicken manure

Table 2. Some characteristics of tap water applied to bring the soil in pots to field capacity

pH	Ec	Ca	Mg	Na	Klorür	Sülfat
	mikroS/cm	ppm	ppm	ppm	ppm	ppm
7.9	490	47.28	17.82	2.32	6.86	11.34

2.1. Chemical Analysis

Soil organic matter content was determined according to the wet combustion method (Nelson and Sommers, 1996). Total N content of organic regulators (TAGG, TG and SG) was determined according to the Kjeldahl method (Bremner, 1996). Total macro (Ca, Mg, P, K) and micro (Fe, Zn, Mn, Cu) element contents were determined based on the Hossner (1996) method.

2.2. Physical Analysis

Soil structure was determined according to the Bouyoucus hydrometer method (Gee and Bauder, 1986). Aggregate stability was determined with a wet sieving device (Kemper and Rosenau, 1986). The dispersion rate of soil wear parameters was determined based on the Bryan (1968) method. Structure stability index (Leo, 1963) and erosion rate (Lal, 1988) were determined according to generally accepted methods.

2.3. Statistical Analysis

Multiple comparison analysis (Tukey Test) of the findings was determined with the JMP 7.0 package program (JMP, 2007).

3. Results and Discussion

According to the findings, the effects of different organic regulators and applications on the amount of soil organic matter are given in Figure 2. Accordingly, compared to the control treatment (1.61%), the application of TAGG, SG and TG organic regulators increased the amount of soil organic matter due to the increase in dose (Figure 2). While the highest organic matter increase was achieved in the TG-8% (2.89%) application, they were listed as TAGG-8% (2.81%) and SG-8% (2.65%), respectively. It has been reported in many studies that organic regulators (such as leonardite, gyttja, worm manure, pomace, cattle and sheep waste, pigeon and quail waste) increase the amount of soil organic matter (Ece et al., 2007; Durmuş and Özdemir, 2020; İlay et al., 2021; Kara et al., 2022; Kara, 2023). The change of soil organic matter depending on the applications was found to be statistically significant ($P<0.05$) (Table 3).

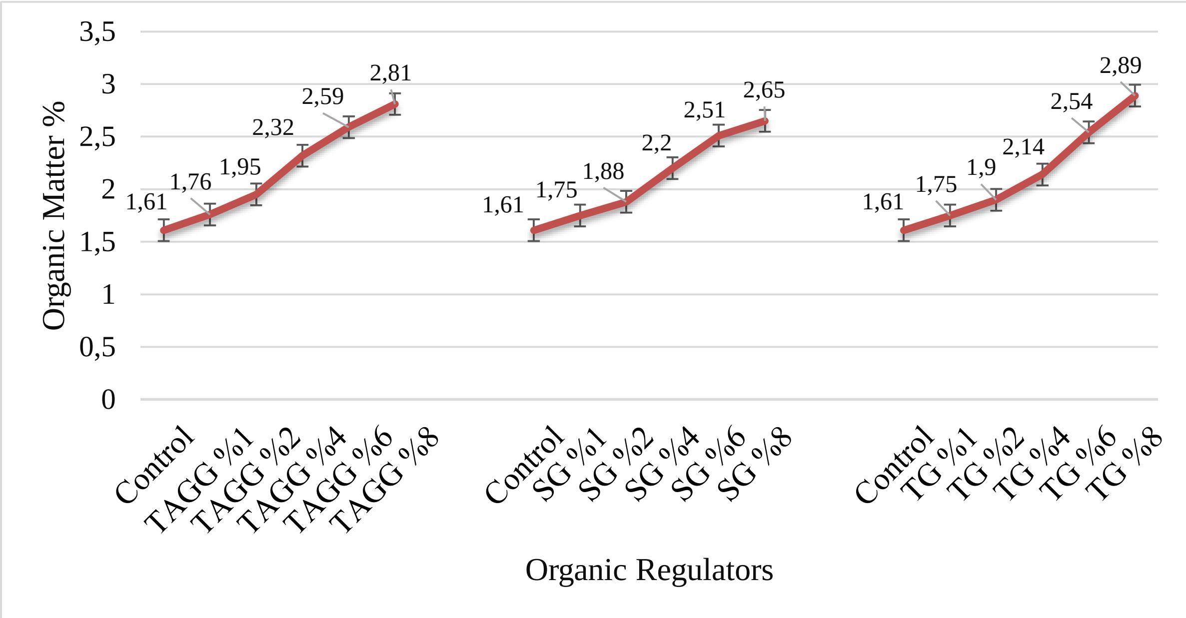

Figure 2. Effect of different organic regulators and applications on soil organic matter

Table 3. Effect of organic regulators (TAGG, SG, TG) applied to soils on soil properties (TUKEY Analysis)

Organic Regulators	AD	OM	SSI	DO	WAS	EO
Gyttja manure used as chicken bedding	TAGG %8	2.81a	34.4a	30.9d	43.96a	34.02d
	TAGG %6	2.59b	31.7a	36.03d	33.29b	40.81cd
	TAGG %4	2.32c	27.9b	43.66c	27.11c	47.55bc
	TAGG %2	1.95d	25.6bc	48.5bc	25.08c	53.77ab
	TAGG %1	1.76e	23.1c	53.64b	19.52d	55.25a
	Control	1.61f	16.4d	66.84a	18.31d	58.18a
Cattle manure	SG %8	2.65a	34.83a	34.75d	40.70a	38.10b
	SG %6	2.51a	32.05a	40.18c	35.50b	43.65b
	SG %4	2.20b	25.09b	50.82b	29.43c	54.63a
	SG %2	1.88c	23.01bc	53.64b	21.66d	57.24a
	SG %1	1.75cd	21.56c	55.57b	19.16de	59.51a
	Control	1.61d	16.45d	66.84a	18.31e	58.18a
Chicken manure	TG %8	2.89a	33.47a	32.37d	43.72a	35.74b
	TG %6	2.54b	31.75ab	36.03cd	26.87b	38.18b
	TG %4	2.14c	29.94ab	39.70cd	25.56b	41.33b
	TG %2	1.90d	28.91b	41.90c	23.06bc	41.56b
	TG %1	1.75e	23.11c	53.64b	21.63bc	55.18a
	Control	1.61e	16.45d	68.84a	18.31c	58.18a

AA= application dosage, TAGG= gyttja manure used as chicken bedding, SG= cattle manure, TG= chicken manure

The changes in soil variables such as structure stability index (SSI), dispersion rate (DO), aggregate stability (WAS) and erosion rate (EO) depending on organic regulator applications are given in Figure 3. Looking at Figure 3, SSI and WAS variables increased depending on the application dose increase of TAGG, SG and TG organic regulators (Figure 3).The highest increase in the SSI variable was at a similar level in the three organic regulators (TAGG-8%, SG-8%, TG-8%). While the lowest SSI value was seen in control pots (16.4%), the highest values were detected in SG-8% (34.83%), TAGG-8% (34.4%) and TG-8% (33.47%) applications, respectively. It is accepted that soils with SSI values below 40% are highly susceptible to erosion (Leo, 1963). Although the soil in the study showed a tendency to exhibit a more stable structure, the SSI values were determined to be below 40%.

The highest increase in the WAS parameter was provided by the TAGG-8% organic regulator (43.96%), followed by TG-8% (43.72%) and SG-8% (40.70%), respectively. The changes in SSI and WAS variables depending on the applications compared to the control treatment were found to be statistically significant (P<0.05) (Table 3). They stated that leonardite fertilizer, one of the organic regulators, increased soil aggregate stability and this increase was statistically significant (İlay et al., 2021). Other researchers reported similar results (Chaney and Swift, 1984; İlay and Kavdır, 2008; Herath et al., 2013; Kara et al., 2022). They reported that there is a positive relationship between the structure stability index and soil organic matter, which are among the soil variables (Mbagwu and Bazzoffi, 1989; Tejada et al., 2008; Erdal et al., 2010; Turgut and Aksakal, 2010). The positive improvement of SSI and WAS variables compared to the control treatment (SSI: %16.4; WAS: %18.31) was attributed to the increase in soil organic matter.

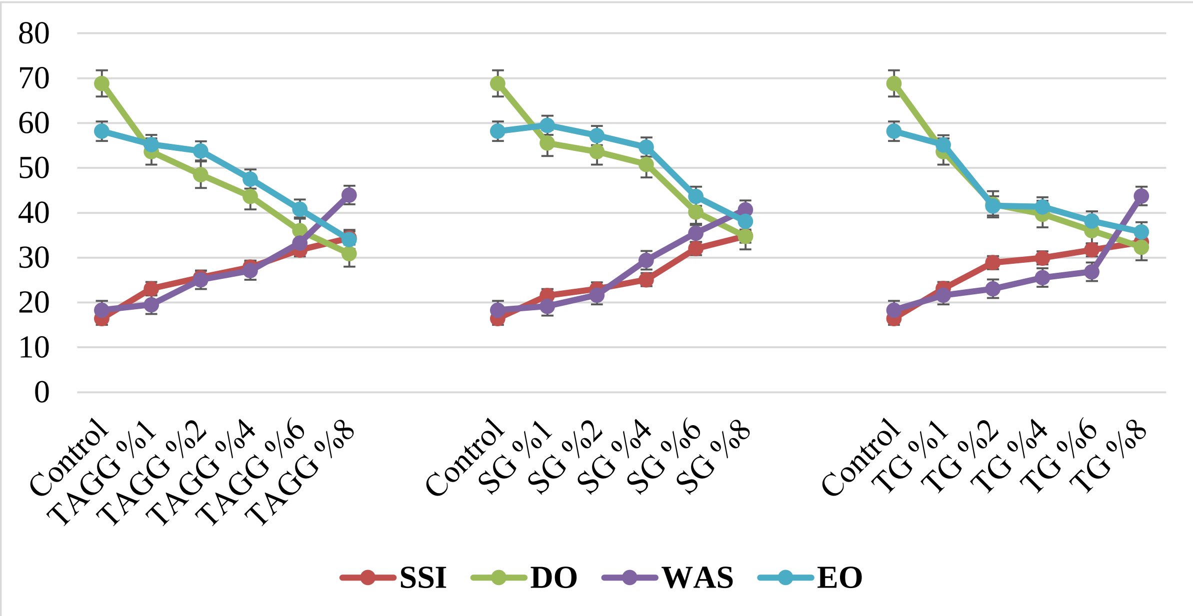

Figure 3. Effect of organic regulators on soil variables SSI, DO, WAS and EO

The changes of DO and EO, which are soil variables, depending on the applications are given in Figure 3 and Table 3. Accordingly, while the DO parameter was highest at the control treatment (66.84%), its lowest value was obtained in the pots where TAGG-8% (30.9%) was applied (Table 3). This was followed by TG-8% (32.37%) and SG-8% (34.75%), respectively. It has been reported that soils with a dispersion ratio greater than 15% are susceptible to erosion (Bryan, 1968; Lal, 1988).Accordingly, although different organic amendments and application doses reduced the sensitivity of soils to erosion compared to the control treatment, they were all greater than 15%. According to the Tukey analysis result, the dispersion rate change was found to be significant (P<0.05) (Table 3). There is an inverse relationship between soil organic matter and dispersion ratio (Saygın et al., 2019). Similar findings have been reported by other researchers (Turgut and Aksakal, 2010; Kara et al., 2022).

The erosion ratio, like the dispersion ratio, showed its highest value in the control treatment (58.18%) pots (Table 3). The erosion ratio tended to decrease depending on the applications, and the lowest values were observed in TAGG-8% (34.02%) and TG-8% (35.74%) pots. Organic regulators and application doses reduced the soil erosion ratio compared to the control treatment. It was reported that soils with a soil erosion ratio greater than 10% are erodible (Lal, 1988). Different organic practices reduced the risk of soil erosion. But it appears to be above the limit stated by Lal (1988). The change in erosion ratio depending on the applications was found to be statistically significant (P<0.05) (Table 3).

4. Conclusion

In this study, the application of TAGG, TG, and SG to the soil reduced the erodibility parameters EO and DO while increasing WAS and SSI. The organic amendments applied to the soils (TAGG, TG, and SG) significantly increased the soil organic matter content. The increase in soil organic matter positively influenced the DO, EO, SSI, and WAS parameters. The improvement effect of organic matter on soil parameters was found to be statistically significant. When comparing organic amendments to each other, the positive impact of TAGG and TG on soil structure was slightly more pronounced than that of SG. Overall, all three organic amendments restored the stability of the soil. On the other hand, the addition of organic matter to the soil improved its structural composition and reduced its susceptibility to erosion. In conclusion, considering the low Ca/Mg ratio and lime content (Kara, 2019) of serpentine soils, TAGG from organic amendments can be recommended for these areas. Additionally, for areas sensitive to erosion but with a suitable Ca/Mg ratio and lime content, the TG organic amendment may be suggested..

Author Contributions

The percentage of the author(s) contributions is presented below. All authors reviewed and approved the final version of the manuscript.

	Z.K	F.K	M.Ç	A.Ç
C	40	20	10	30
D	80			20
S	50	10		40
DCP	70	15	5	10
DAI	65	10		25
L	70	10	10	10
W	85			15
CR	40	25		35
SR	60			40
PM	60	10		30
FA	25	25	25	25

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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