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Investigating the effect of Lignocellulose Mulch on Sand Shear Strength

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Extended Abstract

Introduction: As one of the most significant environmental problems in recent decades, wind erosion has caused environmental pollution throughout the world (Shojaei et al., 2019; Aliabad et al., 2019; Alipour et al., 2016).), inflicting damages to nearly 500 million hectares of land worldwide per year (equivalent to 46.4% of the world's degraded lands) (Rand et al., 2015). On the other hand, the presence of large areas of running sands, wind erosion-inflicted damages, and problems regarding the use of oil-based mulches, highlights the necessity of using nature-friendly mulches. This study, therefore, sought to investigate the effects of lignocellulosic nanomaterials and lignocellulosic micromaterials on shear strength of soft sands and to the positive and negative effects of such mulchs in that regard so that the most appropriate composition and extent of those mulchs could be identified in terms of increased shear strength of sand particles.

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Materials and methods: To conduct this study, a sample of sandy soil with 89% sand particles was collected from the Isfahan's sand dunes (Rig Boland of Kashan) in the central Iran. Bagasse paste is used to make lignocellulose materials. Using blade mills and super disk mills, bagasse paste is transformed into lignocellulosic micromaterials and nanomaterials. Moreover, the Black liqueur is a paper industry's waste that is used as an adhesive element.

To investigate the effect of lignocellulose nanomaterials and lignocellulose micromaterials on soft sands' shear strength, nano and microparticles each with 0.3% concentration at three levels (2.5, 5 and 10 g/L in 0.3 m^2 soil), Black liqueur with 1% concentration at the level of 10 g/L in 0.3 m^2 soil, a combination of Nano lignocellulose (NL) and Black liqueur (BL) in three levels (2.5, 5 and 10 g/L at 0.3 m^2 of soil), composition of Micro-lignocellulose (ML) and black liqueur at three levels (2.5, 5 and 10 g / L in 0.3 m^2 soil), the control sample and all treatments in one-later and two-layer thickness were sprayed on the surface of the sand. Furthermore, shear blades were used to measure the adhesion of the mulches under saturated and dry conditions.

Results: In saturated mode, the maximum shear strength of the double-layer microlignocellulose was found to be 10 g/0.3m^2, with the shear strength increased to 13.6 kN/m^2 compared to the control sample (zero), followed by double layer- microlignocellulose at 5 g/0.3m^2 (8 kN/m^2) level, double layer- nanolignocellulose at 10 g/0.3m^2 (7 kN/m^2) level, and the combination of single-layer microlignocellulose plus Black liqueur at 10 g/0.3m^2 level (7 kN/m^2). It was also found that the lowest shear strengths belonged to single-layer treatments of NL (at all levels), ML (2.5 and 5 g/0.3m^2), and the combination ML + BL (2.5 g/0.3m^2), as well as double-layer treatments of the combination of NL + BL (at all levels), and 2.5 g/0.3m^2 ML + BL.

In the dry mode, the maximum shear strength belonged to double- layer NL + BL mulch at 10 g/0.3m^2 level, with its shear strength increased by 39 kN/m^2 compared to the control sample (zero), followed by double-layer ML at 10 g/0.3m^2 (36.33 kN/m^2), and a combination of double- layer ML + BL (33.33 kN/m^2), respectively. The study's findings indicated that there was no significant difference between these three types of mulches in terms of shear strength at 5% confidence level, while the results of the mean comparison between these three types of mulches and the control sample showed a significant difference in terms of shear strength (P <0.05).

Table (7): Shear strength of different mulches in both saturated and dry conditions

control (water)	Black Liqueur		Double Layer						One Layer							
			lignocellulose + Black Liqueur			lignocellulose			lignocellulose + Black Liqueur			lignocellulose				
	Double Layer	One Layer	10	5	2.5	10	5	2.5	10	5	2.5	10	5	2.5	level	Saturation
			0	0	0	7	6	1	3	4	1	0	0	0	Nano	
0	0.3	3.3	6	3.6	0	13.6	8	1.33	7	3	0	0.66	0	0	Micro	
			39	7	0	26	16	1	22	4	1	26	5	0	Nano	
0	0	1	33	15	2	36	14	1	13	1	0	5	0	0	Micro	Dry

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Discussion and Conclusion: As mentioned above, the amount of shear strength increased in the dry mode compared to the saturation one. Therefore, it seems that the passage of time and dryness of the sandy bed have increased the efficiency and strength of the mulch. While the findings of some studies have indicated a significant correlation between the soil's shear strength and time, other studies have proven the opposite. Moreover, this study found that the paper layer created by the spray of NL on the sand's surface increased the resistance to sand retardation as well as surface resistance to sinking. Therefore, it appears that the morphologic structure of NL which is comprised of long hole-less nano strings increased both abrasion and strengths.

According to the study's findings, the minimum amounts of shear strength belonged to the treatments of 2.5 gr/0.3m^2 NL, ML, ML+BL, 5 gr/0.3m^2 of single-layer ML, the combination of NL+BL, and double-layer BL, with the results of the mean comparison between these treatments (minimum shear strength) and the control sample proving no significant difference between them in terms of shear strength ($P < 0.05$). The results of the study also showed that while a seemingly integrated layer had been created on the sand surface via the addition of those mulchs, limited suspensions may have prevented proper adhesion of the sand particles, leading to the easy disintegration of the particles. Therefore, it is recommended that these types of mulches be tested in the natural field first, and should they produced favorable results, be used for the stabilization of the running sands.

Keywords: Desertification, Mulch, Wind erosion, Shear strength, Micro-lignocellulose, Nano-lignocellulose.