Evaluation of the Water Retention Capacity of a Pioneering Sustainable Liquid Natural Clay

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Abstract. This study is conducted to evaluate the effectiveness of a unique product named Liquid Natural Clay (LNC), produced by Desert Control Middle East LLC, with the intent to revolutionize the war against desertification. The LNC is an innovative solution to a problem that today is more relevant than ever, enabling sandy soil to retain water, improving fertility, and strengthening resilience to drought. The process utilizes clay and natural minerals known for thousands of years to enhance soil quality and drought resilience. The LNC creates sustainable soil to support quality food production and with substantial reductions in water usage by enriching fertility capability in the desert sand. Onsite soil infiltration tests were conducted at different controlled and treated soils. The tests were performed in two different sites located in Al Rawdah in Al Ain and Khalifa Public Park in Abu Dhabi. Each site had different natural conditions and was divided into smaller zones (sub-sites) to be tested individually. The overall purpose of the investigation is to determine the infiltration rates of treated soils with the LNC and compare them with untreated soils (control without LNC) using the single-ring infiltrometer method. The trial areas were prepared, partially treated with LNC, and monitored for 11 months prior to the soil infiltration tests. The tests were conducted according to special protocol and logistics provided by the Desert Control Middle East LLC team.

Keywords: Soil Infiltration Test · LNC · Desertification · Sustainability

1 Introduction

Desertification can be defined as the process by which fertile land is transformed into desert due to multiple natural and/or man-made activities such as climate change and pollution. The process involves the degradation of soil quality, loss of vegetation, and a decline in biodiversity, leading to an increase in aridity and the formation of desert-like conditions [1]. Examples of human activities that may lead to desertification are overgrazing, deforestation, agricultural practices that deplete soil nutrients, and excessive

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water use. Climate change can also contribute to desertification by altering rainfall patterns and increasing temperatures, which further exacerbate the loss of soil moisture and vegetation. The consequences of desertification can be severe, including food and water shortages [2] as well as increased vulnerability to erosion [3]. Vegetation helps to stabilize soil and prevent erosion, but as it declines, the risk of soil erosion and landslides increases. This can further worsen the loss of plant cover and lead to further soil degradation, displacement of communities, and increased poverty [4]. Efforts to combat desertification often involve sustainable land management practices, such as conservation agriculture, afforestation, and soil treatment, as well as policies to reduce greenhouse gas emissions and address the causes of environmental degradation [5].

Liquid Natural Clay (LNC), refers to a suspension of very small clay particles in water or another liquid. The small size of the clay particles gives the LNC unique properties, such as a very high surface area, high cation exchange capacity, and the ability to form strong bonds with other materials thanks to the negative charge on the surface of the clay platelets [6–8]. The LNC produced by Desert Control is designed to combat desertification by improving soil quality and increasing soil's water retention in arid regions. LNC is produced using a patented process (Ref to patent: WO 2007/081219 A1 "Inorganic, Static Electric Binder Composition, Use Thereof and Method for the Preparation of Said Binder Composition") to exfoliate or delaminate (separate) the clay into a massive number of tiny individual platelets and air mixed into a liquid state with unique properties to avoid the risk of creating concrete-like impermeable layers [9]. Splitting the clay into tiny platelets further reduces the amount needed per m^2 from 100 kg to less than 1 kg. In short, LNC is a homogeneous suspension of clay, natural minerals, water, and air; processed into a liquid state without using chemicals, making it a 100% nature-based solution. LNC applied to the land surface will percolate into the ground and form a soil structure that retains water and nutrients, just like a sponge. A one-time LNC application is a soil upgrade proven effective over five years of validation and field trials.

When applied to dry or barren soils, the LNC is absorbed into the soil, (1) increasing soil surface area, (2) increasing soil surface charge, and (3) creating clay bridges that form soil aggregates by binding sand particles together and creating micropores and macropores for air and water storage. The soil geology is upgraded by changing these properties, creating a more stable soil ecosystem that retains water and nutrients in the root zone. This structure helps to prevent erosion and dust mitigation and increases water retention, allowing plants to grow in areas where they previously could not [9]. Desert Control LNC was used successfully in a number of arid regions around the world, including the UAE, USA, Egypt, Pakistan, and China. It has been shown to reduce water usage by 35% to 50%, increase crop yields and quality, and help mitigate soil erosion and dust.

Overall, Desert Control LNC is a promising solution for combating desertification and improving water management in arid regions, potentially enabling agriculture, green landscapes, reforestation, afforestation, and regeneration of desert plant growth in previously considered unsuitable areas for such activities. In the company's mission of continuous research and development of the LNC product, this study is conducted in collaboration with Al Ain University to compare the water-retention capabilities of treated and untreated areas at various locations in the UAE using onsite standard soil-infiltration tests.

2 Soil-Infiltration Test Protocol

The single-ring infiltrometer method was performed using a 6 in. (150 mm) long PVC pipe with an inner diameter of 4 in. (100 mm). Figure 1 shows the components of the soil infiltration test setup. Four inches (100 mm) of pipe was carefully inserted inside the soil to minimize the soil disturbance and inner stresses. After driving the pipe into the soil, a bubble level was used to ensure a leveled surface of the pipe. A 200 ml measured volume of distilled water was added inside the pipe to infiltrate the soil. A stopwatch was used to measure the duration for the water to fully infiltrated inside the soil. The time was taken after excessive water was no longer visible on the surface of the soil inside the pipe. This process was fixed and repeated several times in each location. After the infiltration was complete, the pipe was removed, and the site was cleared.

Fig. 1. Onsite soil infiltration test.

3 Test Locations and Sites Description

3.1 Al Rawdah Site

The first investigated site was in Al Rawdah area, which is part of Abu Dhabi region and specifically to the west of Al Ain city. The rural area is approximately 120 km away from Abu Dhabi coastline toward inland. After visually inspecting the site, the soil was found to be sandy soil with a nonuniform distribution of small to medium size gravel and stones (1–3 cm). Some dry vegetation roots and organic matter were also visually detected on the site. Parts of the soil surface were not leveled compared to other parts of the study area, as shown in Fig. 2; however, the surface of the soil was completely dry throughout the site.

Fig. 2. Site-view at Al Rawdah area of treated and untreated sand.

3.2 Khalifa Park Site

The second testing location was in Khalifa Public Park, Abu Dhabi city. The park is about 500 m away from the sea (Khor Al Baghal). The infiltration test was performed on two vegetated strips approximately 5–7 m wide, located within the middle area of the park. The two vegetation strips were separated by curbs and white decorative stones, as shown in Fig. 3. From visual inspection of the site; it can be clearly noticed that the two vegetation strips were different in color, the density of the grass, and the soil moisture observed byfeel and appearance method. The area called $LF2_{control}$ presented dry patches. Several environmental sensor devices were installed at specific locations along each vegetation strip by Desert Control for monitoring purposes. The area was regularly irrigated on daily bases by the automatic sprinkler system.

Fig. 3. View at Khalifa Park site of treated and untreated regions.

4 Results and Discussion

After measuring the duration in which the distilled water completely infiltrated the soil inside the pipe in each test, the infiltration rates were calculated. Soil infiltration refers to the ability of the soil to allow water to move into and through the soil profile. Infiltration allows the soil to temporarily store water, making it available for use by plants and soil organisms. The infiltration rate is a measure of how fast water enters the soil. In sandy texture soil, the infiltration rate is high because the soil cannot slow down water movement toward gravitational force. Tables 1 and 2 show the results obtained for both Al Rawdah and Khalifa Park areas, respectively. All the durations were converted from seconds to hours by dividing them by 3600 s. The amount of distilled water used each time was 200 ml, and the inner pipe diameter was 4″ (~100 mm). The depth of the water to be infiltrated equals the volume of water (200,000 mm^3) over the cross-section area of the pipe (8,203 mm^2), equals to 0.96″ (24.4 mm).

Table 1. Infiltration test results at Al Rawdah site, dry soil.

Zone	Test No.	Duration (s)	Infiltration Rate (in/hr)	Average Infiltration Rate (in/hr)	Enhancement of infiltration rates
PF1treated	1	49.1	70.4	69.4	32% 1.5 times
	2	50.5	68.4		
PF2control	1	33.1	104.4	102.2	
	2	34.6	99.9		
AF3treated	1	64.7	53.4	55.9	Minimal difference
	2	59.3	58.3		
AF4control	1	70.0	49.4	57.9	
	2	52.0	66.5		

Table 2. Infiltration test results at Khalifa Park site, soil covered with vegetation.

Zone	Test No.	Duration (s)	Infiltration Rate (in/hour)	Average Infiltration Rate (in/hr)	Enhancement of infiltration rates
$LF1_{treated}$	1	2114.9	1.6	1.8	88% 8.5 times
	2	1702.0	2.0		
LF2control	1	210.2	16.4	15.3	
	2	244.4	14.1		

4.1 Al Rawdah Site Results

The trial at Al Rawdah was divided into Panicum and Alfalfa production areas between September 2021 and February 2022. The production area was separated by the fence as shown in Fig. 4 and the sections were further divided into $PF1_{treated}$, $PF2_{control}$ in the Panicum production area, and $AF3_{treated}$ and $AF4_{control}$ for the Alfalfa production area. Two tests were performed in each subsection, and the approximate location of the tests was identified by a star symbol in Fig. 5. The infiltration rates presented in Table 1 range between 68.4 to 104.4 in/hr for the previously produced Panicum area. In contrast, in the area that previously produced Alfalfa, the range was relatively lower, scoring between 53.4 to 66.5 in/hr. The average infiltration rates were calculated to estimate the overall performance of each subsection. Figure 6 shows the difference in percentage between these averages, pointing out that the average infiltration of $PF2_{control}$ was 1.5 times higher than $PF1_{treated}$. However, the difference observed in rates between $AF3_{treated}$ and $AF4_{control}$ was much lower and almost negligible. This is probably due to the water not being fully drained; thus, the soil below the study depth might be saturated, which causes lower overall infiltration rates. Furthermore, vegetation roots and organic materials bond the soil particles and densify the soil. It led to a reduction of the water movement and therefore impacted the infiltration test result.

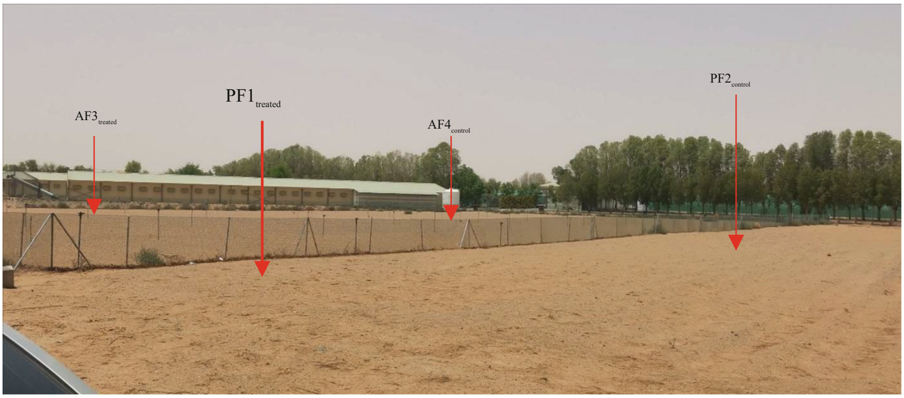

Fig. 4. Locations of the subsections at Al Rawdah site.

4.2 Khalifa Park Site Results

The two separated vegetation strips located in the Khalifa Public Park site were tested for infiltration rates. The strips were named $LF1_{treated}$ and $LF2_{control}$ as shown in Fig. 7 and the location of these tests is shown in Fig. 8. The table shows the durations and the infiltration rates of each test as well as the average rates per strip. The infiltration rate ranges between 1.6 to 16.4 in/hr in both strips. However, $LF1_{treated}$ rates were found to be significantly slower than those of $LF2_{control}$. Figure 9 shows that the average infiltration rate 1.8 in/hr for $LF1_{treated}$ is 8.5 times better in slowing down the irrigation water movement than the 15.3 in/hr average rate of $LF2_{control}$. It allows the plant to uptake water as needed and provides the capability to retain water at the target root zone.

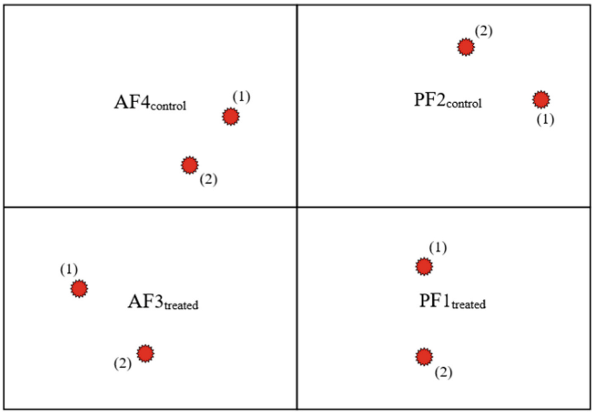

Fig. 5. Diagram showing the subsections location of each test at Al Rawdah.

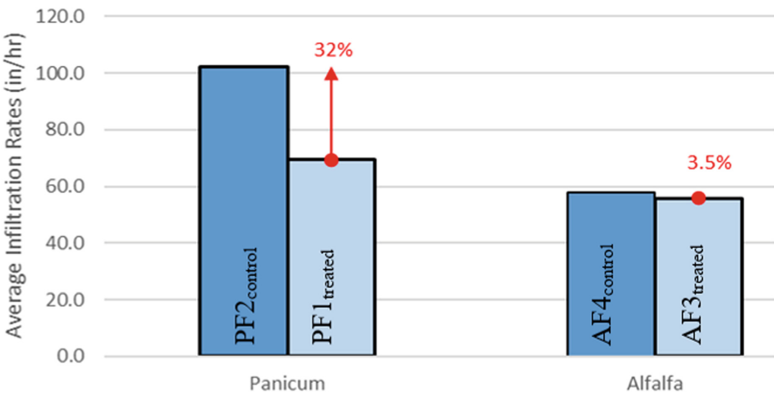

Fig. 6. The difference in infiltration rates among each subsection of Al Rawdah site.

4.3 Comparison Between Al Rawdah and Khalifa Park Sites

According to the calculated infiltration rates for both sites summarized in Tables 1 and 2, the overall infiltration rates for Al Rawdah site were significantly lower than Khalifa site. This can be explained by site condition between dry soil and irrigated soil with vegetation covered. Because of the frequent irrigation of the soil in Khalifa Park site compared to the dry soil of Al Rawdah, the moisture content is higher as confirmed by feel and appearance method during the infiltration test. This was also confirmed by the fact that the force needed to insert 4″ of the pipe in the soil was noticeably higher at Khalifa compared to Al Rawdah site.

Fig. 7. Locations of LF1 and LF2 sections in the Khalifa Public Park site.

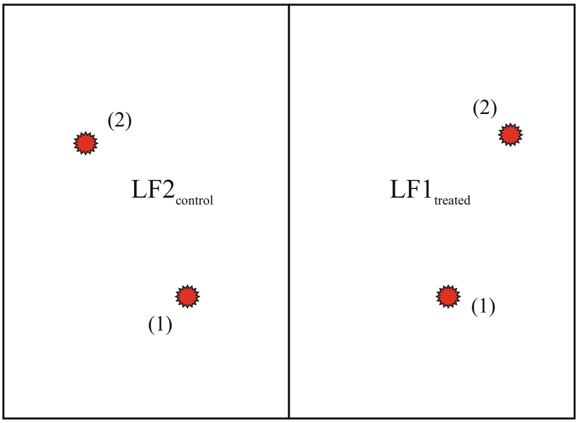

Fig. 8. Diagram showing the subsection's location of each test at Khalifa Park.

In contact with soil moisture, the clay platelets are swelling, improving the infiltration rate and lateral movement of water. However, when the soil is dry, like in Al Rahdah, the clay platelets lose their absorbed water content, reducing the LNC effect on infiltration rate as confirmed by our results. Figure 10 shows the difference in the calculated average infiltration rates for all the treated soils among both locations; the infiltration rate of Khalifa's treated soil (LF1treated) is approximately 97% better than both of the treated soils in the Panicum ($PF1_{treated}$) and Alfalfa ($AF3_{treated}$) sites in Al Rawdah.

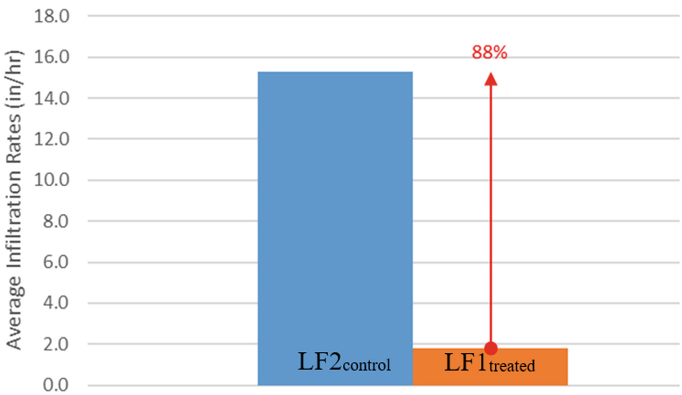

Fig. 9. The difference in infiltration rates among each section of the Khalifa Park site.

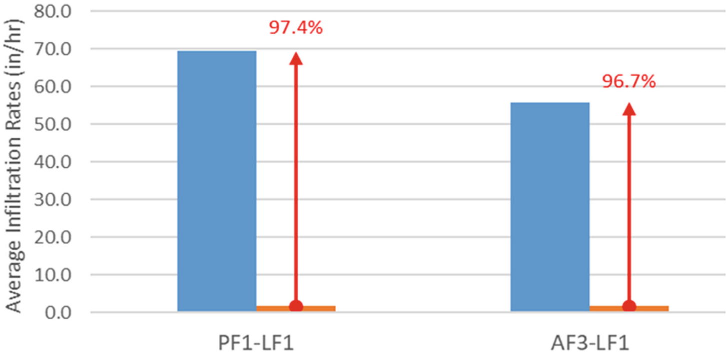

Fig. 10. Comparisons between all treated soils with LNC in Al Rawdah site ($PF1_{treated}$ and $AF3_{treated}$) with Khalifa site ($LF1_{treated}$).

5 Conclusion

A total of 6 different soil sites were tested for the determination of the infiltration rate using the single-ring infiltration method. The LNC was applied to improve water retention and slow down the water movement in the soil profile. The results indicate a significant improvement in soil infiltration rates within each site, reflecting the ability of LNC. The 1.5 and 8.5 times slow-down of water movement in the soil as shown from the respective result of the infiltration rates within Al Rawdah and Khalifa Park, confirm the effectiveness of the LNC product and its efficacy as soil conditioner. The effect of the LNC treatment in the soil improves when water is sufficiently present in the soil.

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