

Sand Encroachment on Railway Operations in Naama:

Challenges Hindering Train Movement due to Sand

زحف الرمال على حركة السكة الحديدية في النعامة تحديات عرقله حركة القطارات بسبب الرمال.

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Abstract (English): The Algerian railway network has undergone significant changes throughout its history, with the Mechria-Ain Sefra-Beni Ounif line playing a crucial role during the colonial era. Despite retaining its importance post-independence, sand accumulation, particularly in the Naama region, has severely hampered railway operations, leading to immense economic losses and decreased public confidence. This study investigates the factors contributing to sand encroachment, emphasizing the impact of desertification, climate change, and human activities. The Oran-Bechara railway line, experiencing frequent service disruptions, serves as the focal point for testing the innovative "Draa" technique—an effective solution incorporating local resources to mitigate sand accumulation. Field assessments revealed that sand from beyond Naama has exacerbated the problem, and the "Draa" technique has shown promising preliminary results in preventing train derailments. Despite challenges, such as material quality and logistical issues, the effectiveness of this method suggests a practical approach for other regions facing similar threats. This study underscores the railway's significance for local populations and highlights the urgent need for sustainable interventions to stabilize railway infrastructure against environmental challenges.

1- Research objectives and originality: This research is original and has only been conducted over the past two years. Its aim is to understand the causes of sand accumulation on the railway and to attempt a solution to combat this phenomenon.

Keywords: railway; sand accumulation; disruptions; solution; climate change

ملخص باللغة العربية :

شهدت شبكة السكك الحديدية الجزائرية تغييرات كبيرة عبر تاريخها، حيث لعب خط مشرية-عين الصفراء-بني ونيف دوراً حيوياً خلال الحقبة الاستعمارية. وعلى الرغم من احتفاظه بأهميته بعد الاستقلال، فإن تراكم الرمال، خاصة في منطقة

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النعامة، قد أعاق بشدة نشاط السكك الحديدية، مما أدى إلى خسائر اقتصادية وانخفاض ثقة الركاب والتجار. تبحث هذه الدراسة في العوامل المتسببة في زحف الرمال على السكة الحديدية، مع التركيز على تأثير التصحر وتغير المناخ والأنشطة البشرية. يعتبر خط سكة حديد وهران-بشار، الذي يعاني من انقطاعات متكررة في عدة نقاط، نقطة التركيز لاختبار تقنية "دراع" المبتكرة—وهي حل فعال ينجز بالموارد المحلية للتخفيف من تراكم الرمال. كشفت التقييمات الميدانية أن الرمال القادمة من وراء النعامة قد فاقمت المشكلة، وأظهرت تقنية "دراع" نتائج أولية واعدة في التقليل من انحراف القطارات عن مساره. على الرغم من التحديات، مثل رداءة جودة المواد ودعم اللوجستي، فإن فعالية هذه الطريقة تشير إلى نهج عملي للمناطق الأخرى التي تواجه تهديدات مماثلة. تؤكد هذه الدراسة على أهمية السكك الحديدية للسكان المحليين وتبرز الحاجة الملحة لتدخلات مستدامة لتثبيت البنية التحتية للسكك الحديدية ضد التحديات البيئية. أهداف البحث وأصالته: هذا البحث أصلي وتم خلال السنتين الأخيرتين فقط، الهدف منه معرفة أسباب زحف الرمال على السكة الحديدية وتجريب حل للمكافحة الظاهرة. كلمات مفتاحية: سكة الحديدية؛ تراكم الرمال؛ اضطرابات؛ حل؛ تغير المناخ.

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1- Introduction

The history of the Algerian railway network is marked by periods of development and decline. The colonial period saw the construction of several railway lines, notably the Mechria-Ain Sefra-Beni Ounif line, completed between 1886 and 1901, which played a crucial role in transporting goods, raw materials, passengers, and livestock from southern Algeria to the port and to France. ("Gallica," n.d.)

After independence, the train retained its economic and public importance but faced a major issue: sand accumulation on the railway, particularly in the Naama region. This phenomenon has led to enormous material and moral losses, causing the train to lose its commercial and public significance. Citizens are afraid to travel by train due to sudden interruptions in the railway caused by sand.

The factors contributing to sand accumulation in the Naama region are numerous. The most significant is the desertification that has affected the area, along with drought and climate change. Additionally, human factors such as intensive grazing, erratic heat, and wood collection have exacerbated this phenomenon. (Bouarfa, Derdour, et al., 2022a)

It is essential to take measures to address this problem and restore the importance of the train in the region. This could involve implementing measures to prevent sand accumulation, such as creating barriers to stop sand from covering the railway, or establishing irrigation systems to maintain soil moisture. Furthermore, it is important to raise awareness among local populations about the significance of environmental preservation and combating desertification. (Derdour et al., 2022)

Finally, it is crucial to emphasize the importance of the train in the region, not only for economic and commercial needs but also for the needs of local populations who heavily rely on this mode of transport. The renovation and maintenance of the railway network are therefore major issues for the development of the region and the improvement of the quality of life for local populations. (Said, Ahmed, & Nadir, 2018).

The Algerian railway network has seen ups and downs throughout its existence. Numerous railway lines were built during the colonial era. Of particular note is the Mechria-Ain Sefra-Beni Ounif line,

which was finished between 1886 and 1901 and was essential for moving raw resources, cargo, people, and animals from southern Algeria to the sea and France. ("Gallica," n.d.)

Sand accumulation on the railway, especially in the Naama region, was a significant problem that the train had to deal with after independence but it still maintained its economic and societal significance. The train has lost its commercial and social significance as a result of this phenomena, which has resulted in tremendous material and moral losses. People fear riding the train because of the frequent disruptions brought on by sand in the tracks.

Numerous causes are involved in the deposition of sand in the Naama region. The most important ones are the effects of drought, climate change, and desertification on the region. This problem has also been made worse by human activities including wood collecting, variable temperatures, and heavy grazing. (Bouarfa, Farhi, et al., 2022)

It is imperative that action be taken to resolve this issue and reinstate the train's significance in the area. This can entail setting up irrigation systems to keep the soil moist or putting in place barriers to prohibit sand from covering the railroad in order to prevent sand accumulation. Additionally, it's critical to educate the local populace about the value of preserving the environment and halting desertification.

Lastly, it is critical to stress the train's significance for the area's economy and commerce, as well as for the needs of the local populace, who primarily depend on it for transportation. Therefore, maintaining and upgrading the railway network is crucial to the growth of the area and raising the standard of living for the local populace. (Bouarfa, Derdour, et al., 2022b)

2- Methods

Study area:

The wilaya of Naâma, which is situated in Algeria's high western plains, is a critical frontier in the fight against desertification. Sadly, this region, which spans a sizable 29 819,30 km² of surface, is facing significant repercussions from climate change. The wilaya has a diversified geography that is split into three main zones. The northern region, which makes up 74% of the overall area, is dominated by a plateau-like landscape. Conversely, the south, which makes about 14% of the region, exhibits pre-Saharan characteristics. Based on these two regions, a mountainous region that makes up 12% of the land is a part of the Saharan Atlas.

The diversified geography of Naâma makes it particularly vulnerable to the effects of climate change. The spread of desertification threatens communities' means of subsistence.

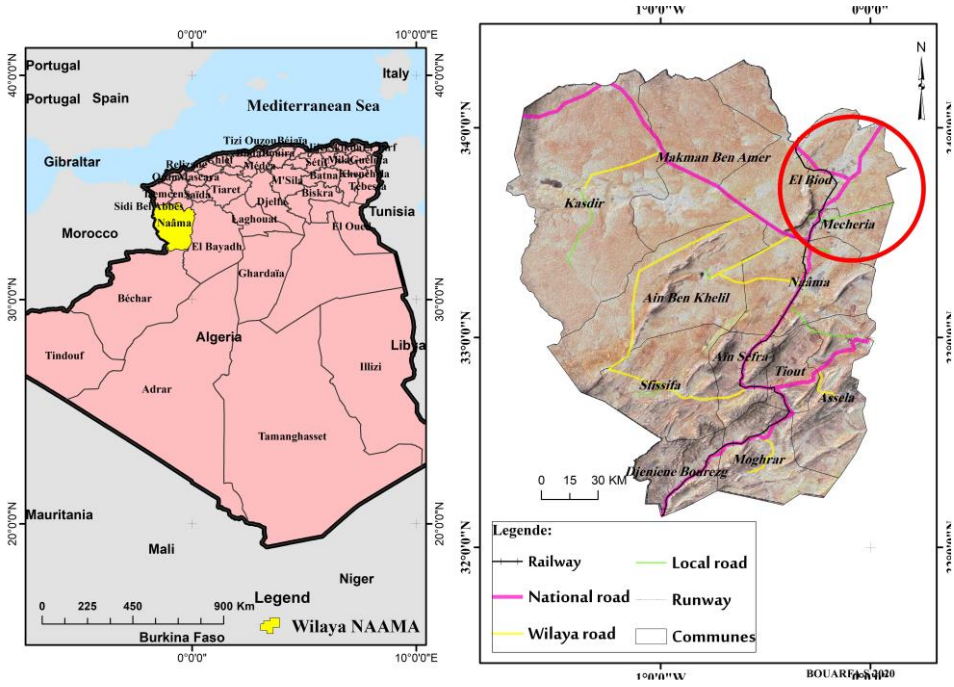


Fig.1. Study area location, source: own study

Field Outputs and Inventory:

The Oran-Bechara railway line is one of the three main longitudinal lines in the Algerian railway network, known as "cross-cutting lines," which connect northern Algeria with the northern desert regions. The line extends over 648 kilometers and was fully modernized in 2010, linking the Wadi Tlat station in Oran Province to the Bechara station.

This new line is designated for transporting approximately 600,000 passengers and 750,000 tons of freight annually, and it includes several stations, including Ain Sefra, Naama, Mcheria, Beni Ounif, and Bechara.

These railway lines face significant challenges related to sand, with over 200 days a year experiencing strong winds that carry large amounts of sand. This issue leads to costly service interruptions, as sand-related problems account for about 30% of railway delays, affecting the punctuality and reliability of the network. Additionally, the high annual maintenance costs associated with sand pose a challenge, while sand-related incidents represent approximately 15% of all railway accidents.

During the months of June and July 2023, several field visits were conducted by researchers from the Scientific and Technical Center on Arid Regions (Naama Biophysics Experimental Station) and representatives from the Algerian National Railway Company, including the regional coordinator and the Head of the Mecheria Division. The aim was to assess a section of the railway affected by sand

encroachment, which spans from kilometer point 170 in the Rasfa area to kilometer point 115 in the Huita and Rasfa areas, located in the Biyoud municipality in Naama province.



Fig.2. Train Accidents and Derailments Due to Sand August 2024. source: own study

A review of train derailment incidents in this region reveals a concerning pattern. Specifically, derailments have occurred on August 13, 2017, November 29, 2018, August 12, 2021, May 26, 2022, and most recently on August 5, 2024. This recurring issue highlights the need for further investigation into the causes and consequences of such incidents to ensure the safety of passengers and prevent future occurrences.



Fig.3. Sand blocked railway. source: own study

Through the visits, it became clear to us that the soil is suffering from erosion due to wind erosion, as a result of many years of continuous drought, leading to land degradation. Furthermore, the area is severely affected by desertification and is in an advanced stage of it. These factors have created a suitable environment for sand encroachment by the prevailing winds. However, after a careful analysis of the sand grains, it is evident that they originate from a distant source (outside the Naama province, originating from Morocco). It is important to note that there are two significant directions of the prevailing winds: the strong winds coming from the southwest and the winds coming from the north. The elevation of the railway itself forms a major obstacle to the movement of the sand, making it the primary reason for the accumulation of sand along the railway.

In April 2024, the Scientific and Technical Research Center for Arid Areas conducted a study addressing the issue of desertification and sand encroachment in Naama Province. The study, summarized with updated digital maps from satellite imagery for April 2024 (attached), revealed that 47% of the province's total area has turned into sand-covered lands or sand dunes, compared to the year 2000 when the sand coverage was 26%. This indicates an annual sand encroachment rate of 1% on the province's land, necessitating urgent action and collaboration between technical sectors, research centers, and universities to combat this phenomenon.

The study also addressed the areas of sand encroachment expansion and movement, particularly due to prevailing sand-laden winds, namely the southwesterly and northwesterly winds coming from the Moroccan deserts of Kcht Tigri and the Tindouf Desert.

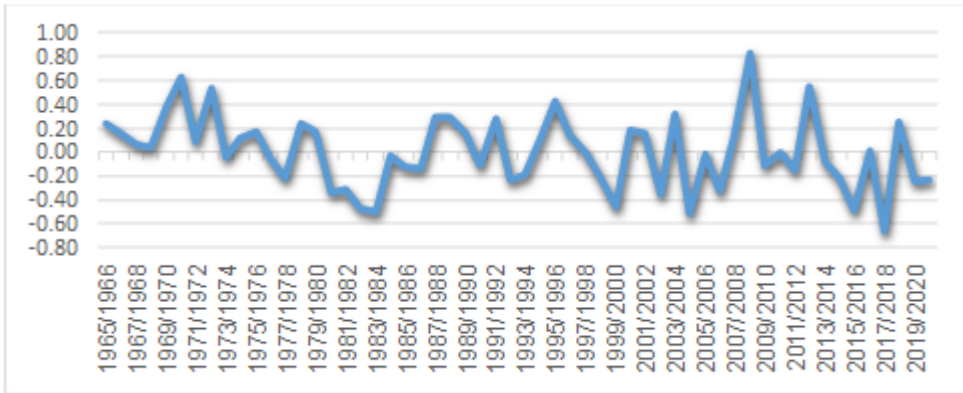


Fig.4. Drought Precipitation Index for Méchria, source: own study

3- Results and Discussion

Testing the "DRAA " Technique and Results

After a comprehensive analysis of climate indicators, physical characteristics, and the morphology of the terrain in the concerned area, a decision was made to designate a railway track extending from kilometer point PK115 to 170 km, located in an area called Al-Rasfa. This region has experienced issues with train derailments or stoppages due to sand, leading to service disruptions or rerouting of trains, as occurred in 2022. Therefore, this section was chosen as a suitable area for the pilot testing of the "Daraa" technology. The "Draâ" Technique it is a patented invention (c.r.s.t.r.a) ("Guide-des-techniques-de-lutte-contre-l-ensablement-au-sahara-algerien.pdf," 2015.)

The "Draa" method can offer a more effective solution than other known methods, such as inclined walls and barriers, for combating sand accumulation on roads and railways. By harnessing the power of the wind and utilizing local coarse materials, this method does not require massive investments and can be mastered through training courses for project managers. Therefore, it can be easily developed in all sectors threatened by the advancement of sand dunes, as the risks will extend over the coming decades with the increase of human activities in arid and desertification-prone areas.

We selected three points to test three different types of arm technology under the same environmental, temporal, and spatial conditions.



Fig.5. The process of completing the arm in August 2023, source: own study

Preliminary results are very satisfactory in a route that experienced train derailments due to sand.

The effectiveness of the "Dara'a" technique achieved at the first point

During the implementation of the "Draa" technique, several obstacles were encountered, including interruptions in water supply due to the site's isolation. These interruptions led to delays in the execution of the work. However, it is important to note that this issue has been resolved. Additionally, there was another problem related to the poor quality of the raw material "Tif," which resulted in negative outcomes when applying the technique. Nevertheless, corrective measures were taken to improve the quality of the material or to adapt the technique accordingly, with the aim of ensuring the success of the technique.

Although the construction of "Draa" was not completed according to the required standards, appropriate quality, and necessary quantity for its success, the preliminary results were very satisfactory. Despite the area being affected by severe sandstorms, all coming from the south and southwest, the wind speeds were as follows: from September 3 to 4: 70 km/h or 19.44 m/s; from September 15 to 18: 40 km/h or 11.3 m/s; October 20: 50 km/h or 13.5 m/s; October 22: 45 km/h or 12.5 m/s; October 23: 74 km/h or 20.5 m/s; October 31: 40 km/h or 11.1 m/s.

No accumulation of sand has been recorded at these points, nor has there been any train stoppage or derailment since the implementation of the technology up to now, even with a thin layer of sand. This is due to the winds that blew from the south only during the recent storms, as previously mentioned.



Fig.5.

Preliminary results source: own study

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5- Conclusion

In conclusion, the railway is a lifeline, especially in inland and desert areas. The train is exposed to sand accumulation, which hinders its movement and negatively affects its operation. Long periods of drought have intensified sandstorms, leading to increased sand encroachment on the railway, particularly. These preliminary results at the point where the "Draa" technique was tested have been accepted by the national railway company. They acknowledged that there was no significant intervention at this point, which was known for blockage whenever the wind blew. The company officials have adopted this technique along the line connecting "Mecheria" and "Rgeme Damoush," despite the poor execution and lack of consultation with the technical team at the center.

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6- The bibliography

- Bouarfa, S., Derdour, A., Okkacha, Y., Almaliki, A. H., Jodar-Abellan, A., & Hussein, E. E. (2022a). Sedimentological investigation of the potential origin and provenance of sand deposits in an arid area: A case study of the Ksour Mountains Region in Algeria. *Arabian Journal of Geosciences*, 15(17), 1460.
- Bouarfa, S., Derdour, A., Okkacha, Y., Almaliki, A. H., Jodar-Abellan, A., & Hussein, E. E. (2022b). Aeolian Sand Deposit Assessment in an Arid Area, Case Study: The Region of Ksour Mountains (SW of Algeria). Retrieved March 28, 2024, from <https://www.researchsquare.com/article/rs-1234507/latest>
- Bouarfa, S., Farhi, Y., Youb, O., Boultf, M., Djoudi, W., & Faci, M. (2022). Spatio-temporal assessment of drought in the semi-arid region of Algerian steppe through index and remote sensing. *Journal of Water and Land Development*, 210–218. Polish Academy of Sciences; Institute of Technology and Life Sciences
- Derdour, A., Bouarfa, S., Kaid, N., Baili, J., Al-Bahrani, M., Menni, Y., & Ahmad, H. (2022). Assessment of the impacts of climate change on drought in an arid area using drought indices and Landsat remote sensing data. *International Journal of Low-Carbon Technologies*, 17, 1459–1469. Oxford University Press.
- Gallica. (n.d.). Retrieved September 1, 2024, from <https://gallica.bnf.fr/accueil/fr/content/accueil-fr?mode=desktop>
- Guide-des-techniques-de-lutte-contre-l-ensablement-au-sahara-algerien.pdf. (n.d.). Retrieved November 3, 2024, from <https://www.crstra.dz/telechargement/ouvrages/guide-des-techniques-de-lutte-contre-l-ensablement-au-sahara-algerien.pdf>
- Said, B., Ahmed, B. S., & Nadir, B. M. (2018). The Phenomenon of Sand Encroachment in the Region of Ain Sefra in the Saharan Atlas (South-Western of Algeria) Conditions and Factors.