Characterization of sludge from the Fez wastewater treatment plant

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Abstract. The Fès wastewater treatment plant is of the activated sludge type. It has been in service since 2014, and receives 155,400 cubic meters per day of domestic wastewater from numerous urban and rural communities: Fès, Ras El Ma, Oulad Tayeb and Ain Chkef. On the one hand, this WWTP generates clean, purified water which is discharged into the receiving environment without any harm to the environment, and on the other, it produces huge quantities of residual sludge, i.e. 5,100 t/year. The aim of this study is to characterize the sludge from the Fez wastewater treatment plant, following sludge treatability tests by monitoring the various analytical parameters. To be able to choose the right technique for the type of sludge to be treated. In our case, for sludge from the Fez wastewater treatment plant, physico-chemical characteristics were carried out for COD, BOD5, TSS, total nitrogen and phosphorus, showing the sludge's richness in nutrients. The characterization of the sludge from the Fez wastewater treatment plant showed the potential of this product to be valorized.

1 Introduction

The development of Morocco's infrastructure includes the creation of numerous wastewater treatment facilities, which not only produce clean, safe water ready for release back into the environment or for reuse but also generate significant amounts of sludge, seen as a byproduct [1-7]. There is a need for environmental and public health officials to incorporate the handling of this sludge into their management strategies, as untreated sludge poses risks to both human health and the environment. It's essential to accurately measure and analyze the sludge produced [8-16].

On the domestic or industrial front, water usage invariably leads to waste production. This wastewater is collected and processed at treatment centers before it can be safely returned to the natural world [17-23]. The process at these centers separates clean water from sludge, the latter being a potential organic fertilizer rich in nutrients and trace minerals. The Fez treatment facility, positioned 3 km northeast of the city and spanning 14 hectares, has been operational since 2014, processing 155,400 cubic meters of wastewater daily from a wide range of urban and rural areas [1, 6, 8, 24-36].

This facility successfully purifies water, ensuring its safe return to the ecosystem, and also produces a substantial amount of sludge. The management of this sludge, whether from municipal or industrial sources, requires specific treatments to minimize its volume and mitigate any potential smell or microbiological hazards. Initial steps involve identifying the sludge based on its source and physical or chemical properties [16, 28, 37-51].

Our research aims to categorize residual sludge by conducting a comprehensive physico-chemical and biological analysis. This classification will aid in selecting the most appropriate treatment method for the specific type of sludge. By linking sludge types with their ideal treatment methods, we can identify the most efficient ways to treat and repurpose these byproducts based on their unique characteristics.

2 Materials and methods

2.1 Study area

Fez, situated at 387 meters above sea level, lies at a crucial intersection of four natural regions in Morocco: flanked by the Middle Atlas mountains to its south and east, the Fès-Meknès plains to the west, and the Rif mountains to the north. Positioned at the foothills of the Tghat (837 meters) and Zalagh (900 meters) mountains, the city oversees the Fès river's journey through the Saïss plain before it converges with the Sebou river [39, 52-57].

Fès experiences a semi-continental climate with cold, rainy winters and hot, dry summers, featuring a rainy season from October to April and a dry spell from May to September. The region sees an average rainfall of 450 mm and an average temperature of 17.7°C.

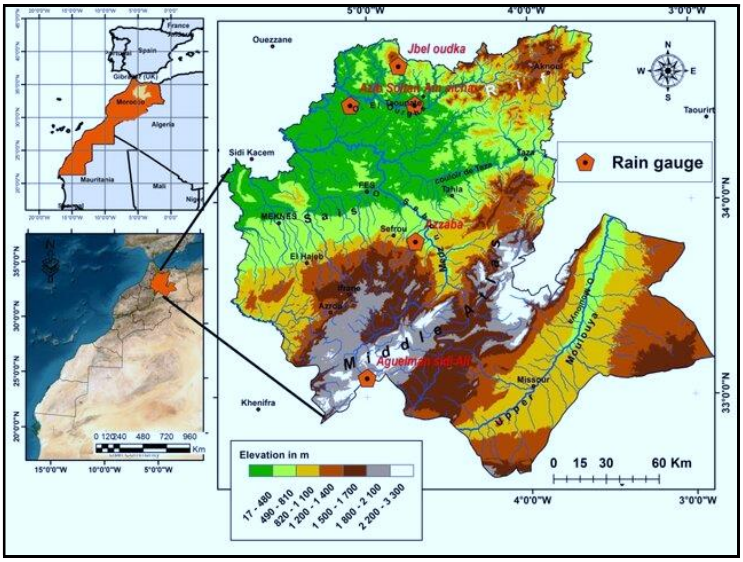

Fig. 1. Geographical location of Fez.

2.2 Description of the Fez wastewater treatment plant

The Fez wastewater treatment plant, located 3 km northeast of Fès and spanning 14 hectares, has been operational since 2014. Processing 155,400 cubic meters of wastewater daily from Fès and surrounding areas, the facility, managed by RADEEF, supports roughly 1.2 million people. Its comprehensive treatment process includes pre-treatment (screening, and removing oil and sand), medium-load activated sludge biological treatment (with steps like primary settling, aeration, and clarification), and sludge management (encompassing thickening, digestion, dewatering, liming, and storage). Annually, it handles a peak organic load of 72,000 kgBOD5/day, leading to an average BOD5 of 582 mg/l and produces around 5,100 tons of sludge.

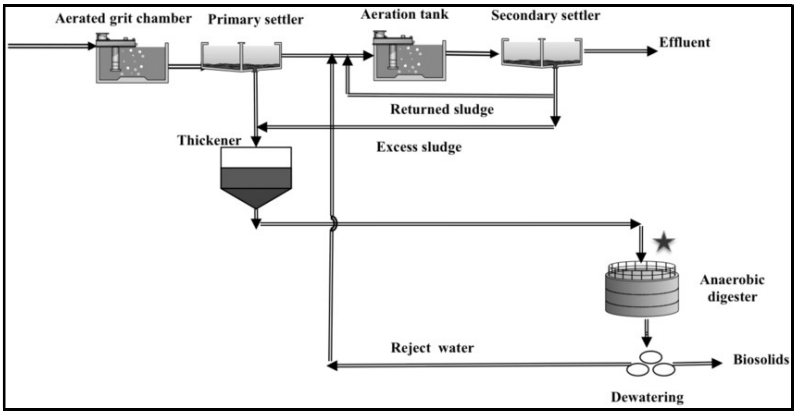

Fig. 2. Schematic diagram of the Fez wastewater treatment plant.

2.3 Sampling and analysis

To investigate the physico-chemical and bacteriological qualities of waste sludge from the Fez wastewater treatment plant, we first collected and combined sludge samples from various depths within the anaerobic basins, selecting a representative 5 kg sample for analysis. These samples were then prepared according to standard protocols for preservation and processing. The analyses, conducted at the Al-Hoceima National School of Applied Sciences, included measurements of pH, temperature, and electrical conductivity, as well as the assessment of dry and mineral residues through evaporation, drying, and calcination processes. The organic carbon content was determined using the Anne method, and essential nutrients like potassium, nitrogen, and phosphorus were quantified.

For detecting fecal pollution, we used lactose broth with bromocresol purple for total and fecal coliforms and Rothe medium for total and fecal streptococci, with positive samples confirmed through further incubation and specific media. This comprehensive approach allowed for a detailed characterization of the sludge's physico-chemical and bacteriological properties.

3 Results and discussion

The analysis of sewage sludge from the Fez wastewater treatment facility reveals a pH level that is near neutral at 7.72, indicating a relatively balanced environment. Notably, the sludge exhibits significant dryness and conductivity levels (1741 ms/cm and 28.74%, respectively), suggesting a concentrated composition. A standout feature of this sludge is its high organic carbon content, at 46%, which underscores its potential utility.

Given the substantial presence of essential nutrients for plant growth—namely nitrogen (N), phosphorus (P), and potassium (K), with their concentrations being notably high (K = 1.41%, P = 9%, NH4 = 212.8%, NO3 = 14.62%)—this sludge emerges as a promising candidate for agricultural fertilizer. Such nutrient-rich sludge could play a pivotal role in enhancing soil fertility and supporting crop production.

Moreover, the sludge's organic matter content is impressively high at 52.21%, further reinforcing its suitability for agricultural use. The fecal coliform (FC) and fecal streptococci (FS) concentrations, at 72.104 CFU/100ml and 24.104 SFU/100ml respectively, alongside the FC/FS ratio, point to a human origin of the pollution. These findings not only confirm the human source of the waste but also highlight the effectiveness of the biological treatment process at the plant in multiplying bacteria that break down this waste. Thus, the conversion of such waste into a beneficial agricultural resource illustrates a sustainable approach to managing wastewater treatment byproducts, turning potential pollutants into valuable inputs for farming.

Table 1. Characterization of sludge from Fez WWTP.

Parameters	Results
pH	7,72
Conductivity (mS/cm)	1741
Dryness (%)	28,74
Organic carbon (%)	46
Organic matter (%)	51
Mineral matter (%)	21,17
Dry residue (%)	44,9
Potassium (%)	1,41
Phosphorus (%)	9
NH (ppm)	212,8
NO (ppm)	14,62
T°C	17

4 Conclusion

To ensure the sustainable management and valorization of residual sludge from the Fès wastewater treatment plant, while safeguarding human health and environmental integrity, a comprehensive approach begins with its detailed characterization and, if needed, selection of an appropriate treatment process. The physico-chemical analysis, including measures of dryness, conductivity, organic carbon, and pH, indicated that the sludge contains high concentrations of these parameters, suggesting a potent composition.

Moreover, the sludge is notably rich in essential agricultural nutrients such as nitrogen (N), phosphorus (P), and potassium (K). These findings open the possibility of its application as a fertilizer, provided it meets the specific content standards essential for plant growth. The feasibility of such a practice hinges on ensuring that the sludge's nutrient content aligns with agronomic requirements, potentially turning it into a valuable resource for farming.

The bacteriological analysis of the sludge has also highlighted fecal coliform (FC) and fecal streptococci (FS) concentrations comparable to those typically found in wastewater, underscoring the need for meticulous handling and processing to mitigate health risks. Given the increasing volumes of domestic sewage sludge, its recycling emerges as a critical strategy not only for managing this waste but also for contributing to environmental conservation. By transforming what is traditionally considered waste into a resource, particularly for agricultural use, we can simultaneously address the challenges of waste management and support sustainable agricultural practices. This approach reflects a broader commitment to recycling and resource recovery, with the dual aims of reducing sludge volumes and promoting environmental stewardship.

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