Heavy metal characterization of dewatered sludge from the Kenitra wastewater treatment plant (Morocco) for agricultural use

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Abstract. The wastewater treatment plant (WWTP) of the city of Kenitra treats urban wastewater, this said treatment produces significant quantities of dehydrated sludge which are then placed in the public dump. The valorization of the dehydrated sludge of the WWTP-Kenitra became a priority, seen the enormous quantities produced of their complex and heterogeneous composition. Objective: It is in this present work which aims at following the fate of the dehydrated sludge of the WWTP-Kenitra after their dehydration as well as their characterization by the analysis of the heavy metals in order to study the possibility of their valorization with one of the dies answering the protection of the environment. Results: The results of the analyses of the composition of the dehydrated sludge in Metallic Traces Element is in conformity with the standards AFNOR and the directive 86/278/CEE of the European Commission and does not reflect any danger in their use for the agriculture. Conclusion: The valorization of the sludge of the WWTP of the city of Kenitra is encouraged.

1 Introduction

The construction of wastewater treatment plants (WWTP) [1] has led to a significant raise in the production of municipal sewage sludge in recent years [2]. The increase in the production of large quantities of sludge [3] is directly linked to growing urbanization and rapid industrialization, which has led to a continuous increase in wastewater production [4].The wastewater treatment process, also generates by-products, such as treated effluent and sewage sludge [5].

At present in Morocco, the country has over 131 WWTPs using a variety of wastewater treatment processes, including natural lagooning, activated sludge [6] and aerated lagooning [7].

Dewatered sludge is a great advantage for agricultural soils, because it is rich in nutrients such as phosphorus and nitrogen, which are essential for plant growth [8].

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The aim of this project is to monitor the fate of dewatered sludge from Kenitra's wastewater treatment plant before it is disposed of in landfill [9], sites, and to characterize it by analyzing heavy metals, in order to decide whether it should be recycled through one of the channels designed to protect the environment and minimize pollution.

2 Materials and methods

In this section, we will describe the geographical location of the Kenitra–WWTP and methods physicochemical of sludge wastewater and heavy metal analysis.

2.1 Description and Geographical location of the Kenitra-WWTP in Morocco

To respect the environment, protect the receiving environment, preserve the water table and improve the quality of life for the people of Kenitra and Mehdia, RAK (water, electricity and liquid sewerage distribution company for the province of kenitra,Morocco) has put a great deal of effort into its wastewater treatment plant and facilities.
This medium-load activated sludge plant will have a treatment capacity equivalent to 700000 EH (Equivalent habitat) by 2020 and 1050000 EH by 2030.

2.1.1 Location of the Kenitra wastewater treatment plant

The WWTP is located to the northeast of the city of Kenitra, close to the scrap metal and thermal power plant in the Kenitra industrial zone, Morocco.

Fig. 1.Geographical location of the Kenitra WWTP

2.1.2 Technical Description

Kenitra's medium-load activated sludge wastewater treatment plant has the following main characteristics (Table 1)

Table 1. The principal characteristics of the Kénitra wastewater treatment plan

Purification process	Medium-load activated sludge
Treatment capacity	700 000HE (30g)

Average annual flow	19.6 Million m^3/ year
Average annual pollutant load	7 655 Tons / year

The following figure 2 describes the three sectors of the treatment plant - water, sludge, and biogas:

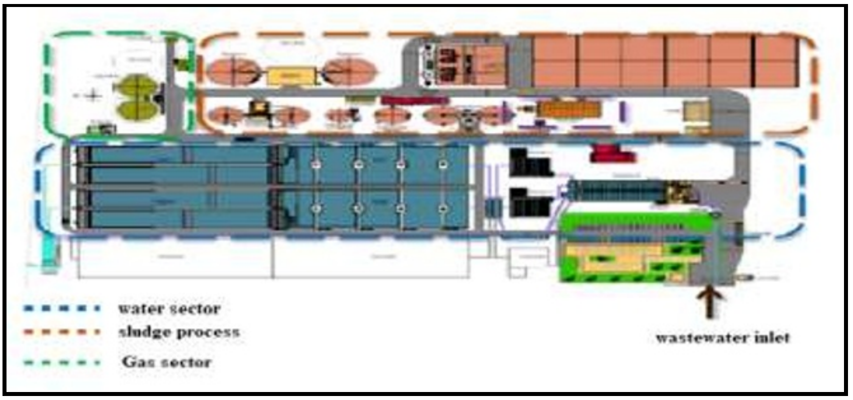

Fig. 2. The three lines of the wastewater treatment plant-water, sludge, biogas

2.2 Pre-treatment of dewatered sludge samples for physico-chemical analysis according to ISO 11464:1994

•Principle:

Pre-treatment of dewatered sludge samples is generally carried out as follows:
Drying Sludge samples can be air-dried or oven-dried at temperatures not exceeding 40°C. Another option is freeze-drying, in which moisture is removed by vacuum sublimation at low temperature. Grinding, if necessary, the sludge sample can be ground. This can be done while the sample is still wet and crumbly, as well as after drying. Grinding ensures a homogeneous consistency and facilitates subsequent handling of the sample. The dried and possibly ground sludge is sieved to separate the fraction smaller than 2 mm. This can be done using mechanical or manual means. Sieving produces a specific granulometric fraction to obtain a representative sub-sample for analysis.

If analyses require a smaller sub-sample, typically below 2 g, it is necessary to further reduce the particles in the fraction below 2 mm. This can be done using special equipment to obtain the quantity of sample required for specific analyses.

2.3 Analytical methods for trace metals in dewatered sludge from the wastewater treatment plant

The following table shows the heavy metal analysis method:

Table 2. Analytical methods for trace metals

Elements	Method of extraction and preparation	Analysis method
Metallic trace elements	Regal water extraction: NF EN 16174	Inductively coupled argon plasma mass spectrometry (ICPEMS) NF EN 16171

2.4 Limits for metal micropollutants in sludge

The table gives limits for metal micropollutants in sludge

Table 3.limits for metal micropollutants in sludge for agricultural use (mg/kg of dry matter)

Parameters	Limit values mg/kg MS Directive C.E.E	French standard AFNOR	
		Limits	**References**
Cadmium	20 à 40	40	20
Copper	1000 à 1750	2000	1000
Nickel	300 à 400	400	200
Lead	750 à 1200	1600	800
Zinc	2500 à 4000	6000	3000
Chromium	1000	2000	1000

3 Results and discussion

The results of heavy metal analyses of dewatered sludge over a one-year period (2022-2023) and the interpretation of each result.

3.1 Results of heavy metal analyses of dewatered sludge from the Kenitra city wastewater treatment plant for 1 year of the year 2022-2023

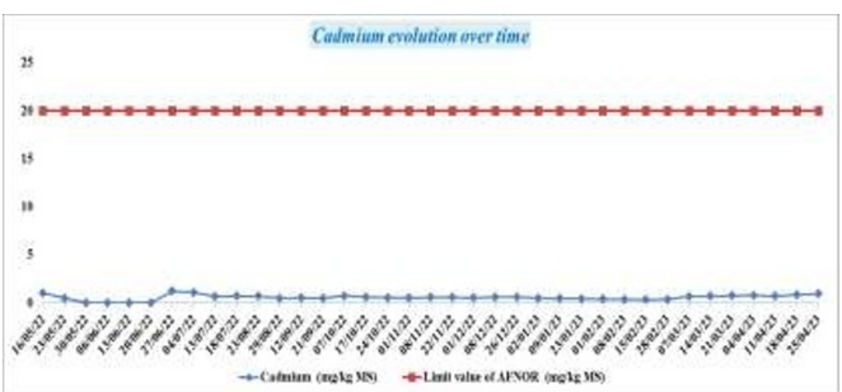

Fig.3.Cadmium evolution over time

According to the results of Cadmium analyses (Figure 3) over a one-year period, concentrations are conform and respect the limit values defined by French standard AFNOR and European Commission Directive 86/278/EEC for agronomic use (Table 3).

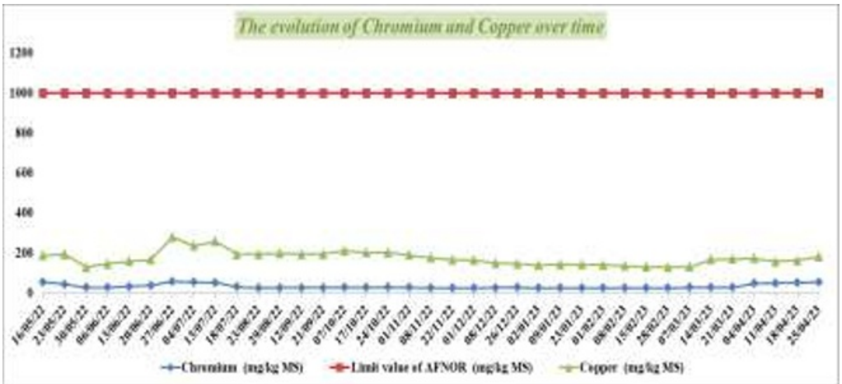

Fig.4.The evolution of Chromium and Copper over time

According to the results of Chromium and Copper analyses (Figure 4) over a one-year period, concentrations are conform and respect the limit values defined by French standard AFNOR and European Commission Directive 86/278/EEC for agronomic use (Table 3).

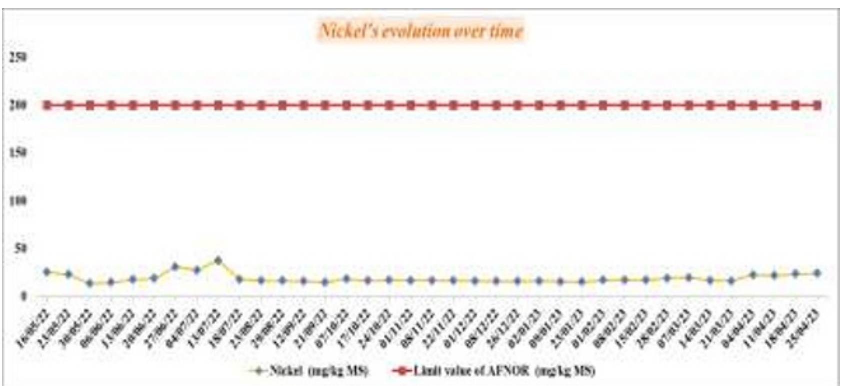

Fig.5.Nickel's evolution over time

According to the results of Nickel analyses (Figure 5) for one year, concentrations are conform and respect the limit values defined by French standard AFNOR and European Commission Directive 86/278/EEC for agronomic use (Table 3).

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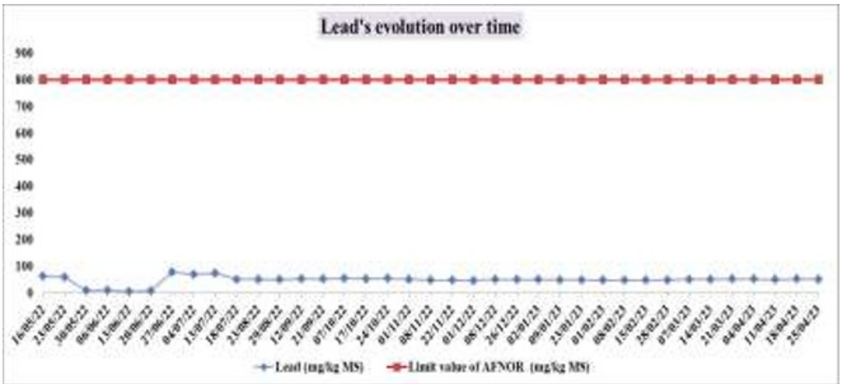

Fig.6. Lead's evolution over time

According to the results of Lead analyses (Figure 6) over a one-year period, concentrations are conform and respect the limit values defined by French standard AFNOR and European Commission Directive 86/278/EEC for agronomic use (Table 3).

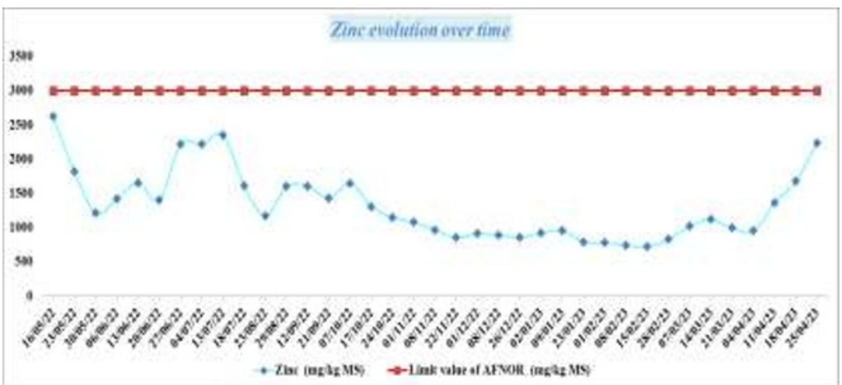

Fig.7. Zinc's evolution over time

According to the results of Zinc analyses (Figure7) over a one-year period, concentrations are conform and respect the limit values defined by French standard AFNOR and European Commission Directive 86/278/EEC for agronomic use (Table 3).

Fig.8.The evolution of Chromium + Copper + Nickel + Zinc over time

According to the results of analyses of Chromium + Copper + Nickel + Zinc (Figure 8) for one year, concentrations are conform and respect the limit values defined by French standard AFNOR and European Commission Directive 86/278/EEC for agronomic use (Table 3).

The chemical composition of dewatered sludge has shown that it carries a low metallic load.

4 Conclusion

The quantities of sludge produced are rising steadily as a result of regulations governing [10]wastewater discharge standards, which require ever more advanced treatment. At the same time, the disposal of sludge is a national issue that is facing increasingly acute problems due to changing legislation. One of the main problems is the presence of metals, which reduces elimination routes and imposes additional constraints in terms of operations and health and environmental risks. Reducing micropollutant discharges or inputs into the sewage system at source is the essential approach for preserving sludge quality and guaranteeing a reduction in the health and environmental risks associated with the various urban sludge disposal processes. The sludge produced by the Kenitra wastewater treatment plant (Kenitra-WWTP) from the treatment of domestic and industrial wastewater is characterized by a complex composition, encompassing both organic and inorganic elements. The Kenitra WWTP sends its sludge to the Kenitra city landfill. The results of heavy metal analyses of dewatered sludge over time show that concentrations respect values defined by French standard AFNOR and European Commission Directive 86/278/EEC for agronomic use (Table 3).The composition of dewatered sludge in terms of metallic trace elements complies with AFNOR standards and the specific regulation on the use of sewage sludge in agriculture 86/278/EEC, and reflects no danger for agricultural use. According to the heavy metal analyses, the reuse of sludge from the Kenitra-WWTP is encouraged for agricultural purposes.

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