19th International Conference on Environmental Science and Technology

Kos, Greece, 3 to 6 September 2025

Odour monitoring as an unconventional tool for sewage sludge management in wastewater treatment plants

GIAQUINTO P.[1], DELLA ROCCA M.R.[2], BELGIORNO V.[1], NADDEO V.[1], ZARRA T.[1*]

[1] SEED – Sanitary Environmental Engineering Division, Department of Civil Engineering, University of Salerno, via G. Paolo II, 132 - 84084 Fisciano, SA, Italy

[2] Campania Region, Directorate General for Soil Protection and Ecosystem, Operational Unit for Sustainable Development, Acoustics, Air Quality, and Radiation – Environmental Criticalities Related to Human Health, via R. Bracco, 15/A - 80113 Naples, NA, Italy

*corresponding author
e-mail: tzarra@unisa.it

Abstract The management of sewage sludge generated by wastewater treatment plants (WWTPs) must comply with stringent regulations to prevent adverse impacts. Selecting appropriate sludge treatment is highly dependent on accurate sludge characterization, which traditionally involves comprehensive laboratory analyses of physical, chemical, and biological parameters. These analyses are time-consuming, costly, and do not allow for real-time decision-making. Furthermore, sewage sludge represents one of the main odour emission sources, posing potential nuisances.
This research explores the use of odour emission monitoring as a rapid, non-conventional approach for supporting sewage sludge management decisions. To validate the methodology, experimental analyses were conducted on a full-scale WWTP. Sludge samples were characterized through conventional parameters, including chemical oxygen demand (COD) and biochemical oxygen demand (BOD_5). Simultaneously, odorous emissions were quantified in terms of odour concentration, according to EN 13725:2022.
The comparison between chemical and sensorial analyses demonstrate statistically significant correlations between odour concentration and key COD and BOD5 of sewage sludge. The findings suggest that odour monitoring can serve as a practical, rapid, and cost-effective proxy indicator for sludge stability assessment, offering a complementary tool to conventional laboratory analyses. This approach can facilitate timely management decisions, optimize sludge treatment processes, and mitigate odour related impacts.
Keywords: Dynamic olfactometry, Total suspended solids, Odour impact, Biological stability, Environment protection

1. Introduction

Odours released by facilities with multiple emission sources, such as wastewater treatment plants, have become a significant issue for local authorities, as they tend to cause nuisance in surrounding communities (Naddeo et.al. 2012).
Sewage sludge in wastewater treatment plants (WWTPs) is produced at first by primary and secondary sedimentation. The composition of sewage sludge varies widely and depends on the quality of the incoming wastewater and the specific technologies used in the treatment process (Salva et.al. 2025).
A key aspect for the management of the sewage sludge is the characterization of their stability, which is based on the determination of a large number of parameters including chemical oxygen demand (COD) and biochemical oxygen demand (BOD) (Talero et.al.2022). The biological stability is currently determined by applying the respirometric method, which measure the oxygen consumption and carbon dioxide production.
However, conventional approaches for sludge stability characterization are inherently resource-intensive, requiring specialized laboratory equipment, highly trained personnel, and extended processing times. Consequently, these methods are often impractical for supporting immediate operational decisions within WWTPs.
This research proposes and evaluates an alternative, rapid approach, for assessing sludge biological stability, based on the monitoring of odorous emissions. This methodology offers the potential for real-time, low-cost assessments, enabling WWTP operators to implement timely management strategies.
In fact, a biologically stable sludge has low residual microbial activity, resulting in reduced production of malodorous gases and volatile compounds. While, unstabilized sludge tends to decompose rapidly, releasing foul odours, active pathogens, and emissions of ammonia, sulphur compounds, and VOCs (Zhu et.al. 2023).
To validate the proposed approach, the research has investigated the relationship between biochemical sludge parameters (COD) and odour emissions, with the aim of assessing the possibility to use odour concentration as an unconventional, yet effective, indicator of sludge stability. The experimental activities were conducted at full scale WWTPs, providing practical insights into the applicability of the proposed methodology.

2. Material and methods

Research activities were carried out at a full-scale wastewater treatment plant (WWTP) located in the municipality of Salerno. A quantitative characterization of sewage sludge was performed. Sludge samples were taken at the thickening unit of the WWTP sludge line. The collected samples were characterized and analyzed in terms of COD, BOD5 and odour concentration, according to standardized methods.

Currently, odour emissions in wastewater treatment plants (WWTPs) are typically assessed using sampling techniques that collect samples directly from the gaseous phase (Zarra et.al. 2021) .

The selection of an odour sampling device and relative materials may influence the composition of the resulting odour sample (Zarra et.al. 2012).

In the study, a cylindrical reactor with a volume of 50 liters and a diameter of 40 centimeters, equipped with a sampling tap, was used to collect sludge at the sampling points. From this reactor, 5-litre sludge samples were transferred into amber bottles and transported to the laboratory analyses. For air sampling, an Ecoma EP.163 static sampler and Nalophan sampling bags with a volume of 7 liters were used.

Odour emissions were evaluated in terms of odour concentration, expressed in European Odour Units per cubic metre (ouE/m³), in accordance with the EN 13725:2022 standard, which defines the dynamic olfactometry method.

Odour concentrations were determined using a TO8 olfactometer (ECOMA GmbH, Germany) based on the "yes/no" method, involving a panel of four trained assessors. A total of five air samples and liquid samples for the one (P1) sampling point were collected, every two weeks at the WWTP.

3. Results and discussions

Error! Reference source not found. shows the odour concentration, COD and BOD5 values detected at the sampling point P1 during the different campaigns.

Table 1 Odour concentration, COD and BOD5 values of sewage sludge of the investigated samples, overall the analyses

Sample	I	II	III	IV	V
Odour concentration ouE/m³	9742	10624	20536	16621	10128
COD mgO_2/L	28062	28148	29104	31000	28726
BOD5 mgO_2/L	14769	11259	14552	15500	11490

The results show how the mean values of COD and BOD_5 related to the 5 samples analyzed were 29008 mgO_2/L and 13514 mgO_2/L, respectively, confirming an untreated sludge. While the highest value of COD and BOD5 were 31000 mgO_2/L and 15500 mgO_2/L, respectively.

Focusing on odour concentration, the highest value recorded is 20536 ouE/m³, while the lowest one is 9742 ouE/m³. The mean value is 13530 ouE/m³. **Error! Reference source not found.** reports the correlation studies between COD and odour concentration.

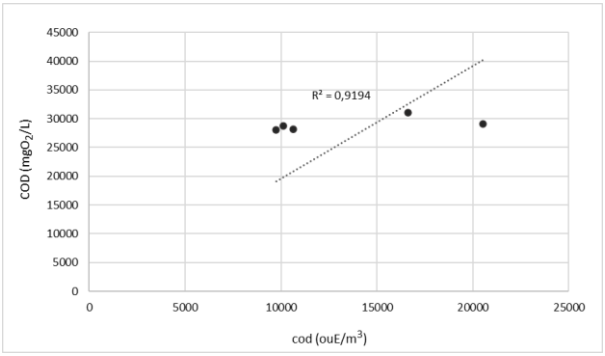

Figure 1 Scatter plot of odour concentration and COD of the investigated sewage sludge at P1.

ResultsFigure 1 shows a high linear correlation between odour concentration and COD (R^2= 0.9154). Therefore it is possible to use the odour concentration as unconventional tool for sewage sludge management in wastewater treatment plants.

Acknowledgement

This research is funded by the Agreement Program for the Protection of Air Quality MASE/Campania Region (CUP B 21122000180001)

References

Salva, Jozef, Michal Sečkár, Marián Schwarz, Dagmar Samešová, Martina Mordáčová, Juraj Poništ, e Darina Veverková. «Analysis of the current state of sewage sludge treatment from the perspective of current European directives». Environmental Sciences Europe 37, fasc. 1 (2025): 59.

Zhu, Xinmeng, Xiaofang Yang, Wei Gao, Shan Zhao, Weijun Zhang, Pingfeng Yu, e Dongsheng Wang. «Malodorous volatile organic compounds (MVOCs) formation after dewatering of wastewater sludge: Correlation with the extracellular polymeric substances (EPS) and microbial communities». Science of The Total Environment 867 (2023): 161491.

Cárdenas-Talero, José Luis, Jorge Antonio Silva-Leal, Andrea Pérez-Vidal, e Patricia Torres-Lozada. «The Influence of Municipal Wastewater Treatment Technologies on the Biological Stabilization of Sewage Sludge: A Systematic Review». Sustainability 14, fasc. 10 (2022): 1–21.

Zarra, T., M. Reiser, V. Naddeo, V. Belgiorno, e M. Kranert. «A Comparative and Critical Evaluation of Different Sampling Materials in the Measurement of Odour Concentration by Dynamic Olfactometry». Chemical Engineering Transactions 30 (2012): 307–12.

Naddeo, V., T. Zarra, S. Giuliani, e V. Belgiorno. «Odour Impact Assessment in Industrial Areas». *Chemical Engineering Transactions* 30 (2012): 85–90.

Zarra Tiziano, Cimatoribus Carla, Oliva Giuseppina, Belgiorno Vincenzo, e Naddeo Vincenzo. «Proactive Approach for Odour Emissions Characterization in Wastewater Treatment Plant by H2odour System». *Chemical Engineering Transactions* 85 (2021): 37–42.

Zarra, T., V. Naddeo, S. Giuliani, e V. Belgiorno. «Optimization of Field Inspection Method for Odour Impact Assessment». *Chemical Engineering Transactions* 23 (2011): 93–98.