POLICY BRIEF

A summary for decision making of key research findings

Sustainable management of sewage sludge: valorization for textile effluents treatment

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Summary

"Sustainable management of sewage sludge is crucial for environment preservation and socio-economic development. The purpose of this work was to demonstrate that sewage sludge can be effectively used to treat and manage textile effluents in a circular economy context."

Huge quantities of sewage sludge (SS) are produced in Oman by both industrial and urban wastewater treatment plants (WWTPs). Until now, SS was considered a dangerous waste that must be handled to avoid negative impacts on human health and the environment.

In this policy brief, we propose a circular economy-based approach for managing SS and textile effluent. Indeed, SS is used without treatment for effective dye removal from textile effluents. This dye-loaded SS can be regenerated and reused for another adsorption cycle. Through decantation, dye (methylene blue: MB) can be recovered and reused in related factories' processes. The remaining dissolved MB in the desorbing solution can be completely oxidized permitting the reuse of the treated water for factories needs. The proposed approach is in line with Oman's vision 2040. It also fulfills the requirements of other national and international initiatives such as the United Nations Sustainable Development Goals (UN-SDGs). As a result, sustainable development, circular economy, and environmental preservation will be directly promoted.

Key messages

- ***Large amounts of sewage sludge are produced in urban and industrial WWTPs in Oman.***
- ***Sewage sludge represents a serious threat to the environment and human health.***
- ***Sewage sludge efficiently remove dyes (methylene blue: MB) from effluents under both static and dynamic conditions.***
- ***MB could be efficiently desorbed from the sewage sludge by using salty solutions.***
- ***MB can be recovered (as solid phase) from the desorbing solution and reused in the related factories.***
- ***The remaining MB in the desorbing solution can be oxidized by advanced oxidation processes and the related treated water can be reused by the factories***
- ***This approach preserves the environment and is economically beneficial for textile industry.***

Background

Oman, like other countries, is facing a range of environmental challenges related to the management of produced SS in WWTPs. Nowadays, most SS is kept onsite or dumped in landfills. At the same time, the textile industries produce huge amounts of effluents rich in dyes and other minerals. Sustainable management of solid and liquid wastes is a priority in Oman to avoid negative effects on the environment and human health.

Owing to their physico-chemical properties, SS may be useful adsorbents for various organic and mineral pollutants, including dyes. However, these dye-loaded SS should be sustainably managed to avoid negative impacts on the environment.

Therefore, in this work, we aim to find-out and test an innovative strategy based on decentralized management of both SS and textile effluents. As part of this approach, circular economy, sustainability, and the 4Rs (Reduce, Recycle, Reuse, and Recover) will be promoted.

Methods

The SS was collected from an industrial estate in Oman. It was air-dried for a week, then grinded before use. The dye-rich effluent was prepared by dissolving methylene blue (MB) in distilled water.

The *MB removal* efficiency by the SS was carried out using:

* Batch assays under different experimental conditions (time, pH, dose, initial MB concentration, temperature, etc.)

* Column assays by continuous injection of MB through a SS bed by using a peristatic pump. The effect of various parameters (SS's bed height, initial MB concentration, and flow rates) was assessed.

The *MB desorption* from the dye-loaded SS was carried out under column mode using salty solutions. The recovery of MB from this desorbing solution was performed through decantation. The degradation of the remaining dissolved MB solution in the desorbing solution was performed through oxidation by persulfate after activation with a nano-magnetite.

Key findings

SS properties

The SS appears to be a heterogeneous material with significant contents of organic matter conglomerates on its surface. It is mainly constituted by oxygen and carbon. It also contains relatively high contents of iron (8%) along with other alkaline earth metals.

Dye adsorption

In batch mode, MB removal by the SS is a time-dependent process with an equilibrium state observed after 3 h (Figure 1).

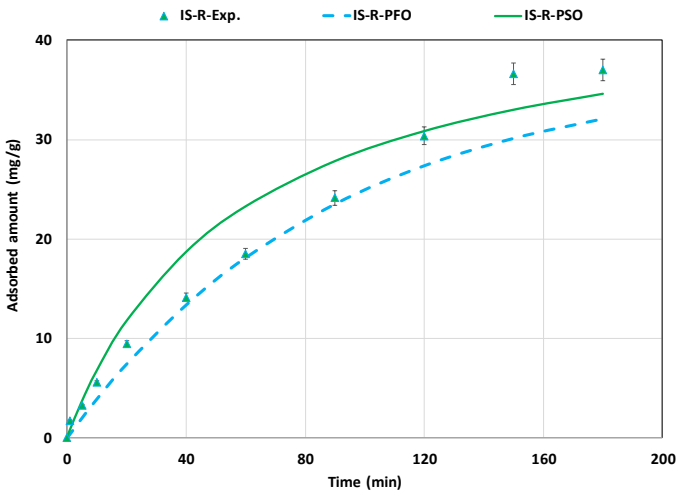

Figure 1: MB kinetic adsorption by the SS and its fitting with the pseudo-first order (PFO) and pseudo-second order (PSO) kinetic models (IS-R: raw industrial sludge; PFO: pseudo-first order; PSO: pseudo-second order; C0= 50 mg/L; adsorbent dose= 1 g/L; natural pH; T = 20 ± 2 °C).

The MB adsorption increase with the increase of pH with a maximal adsorbed amount of 41.1 mg/g at pH=10. Likewise, the MB adsorbed quantity increased with the increase of SS amount with an approximate removal rate of 89% for a SS dose of only 2 g/L (Figure 2).

The used SS appears to be very efficient in removing MB in column mode. Among the studied parameters, the applied flow rate as well as the SS bed height seem to have the most important effect on MB removal efficiency (Figure 3). The highest adsorbed amount (more than 51 mg/g) was found for the lowest flow rate of 15 mL/min.

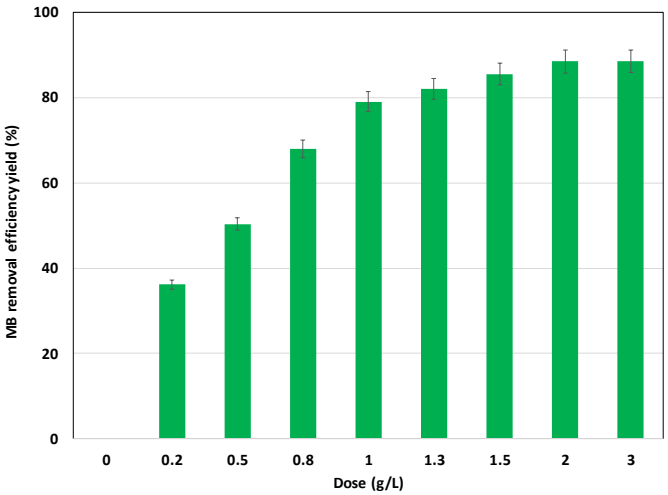

Figure 2: Effect of SS dose on MB removal yield in batch mode (C0= 50 mg/L; adsorbent dose= 1 g/L; natural pH; T = 20 ±2 °C).

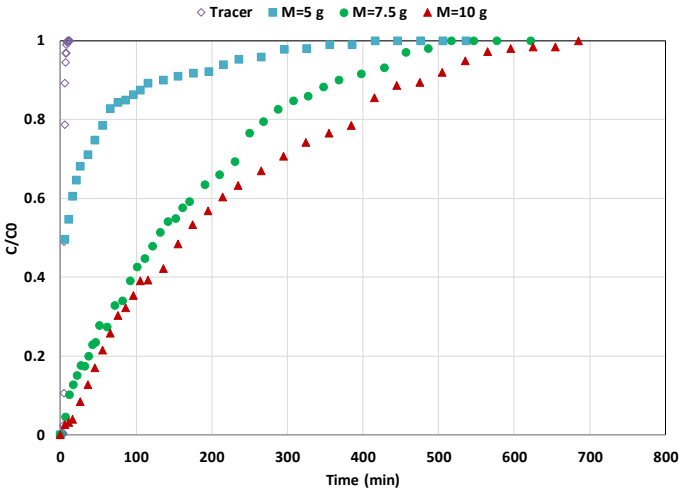

Figure 3: Effect of the SS mass on MB removal under dynamic conditions (C0= 75 mg/L; Flow rate= 25 mL/min; natural pH; T = 20 ± 2 °C).

Dye desorption

The MB desorption from the loaded-SS was efficiently achieved with salty solutions even under dynamic conditions. Desorption with highly concentrated salty solutions permits obtaining high MB concentrations peaks (>1.4 g/L) (Figure 4). This has allowed the recovery of MB as a solid phase. The analysis of this recovered MB by spectroscopic methods showed that it has a purity of about 92%. This finding has an exceptional environmental and economic added value since the recovered MB can be reused again in the textile industry activities.

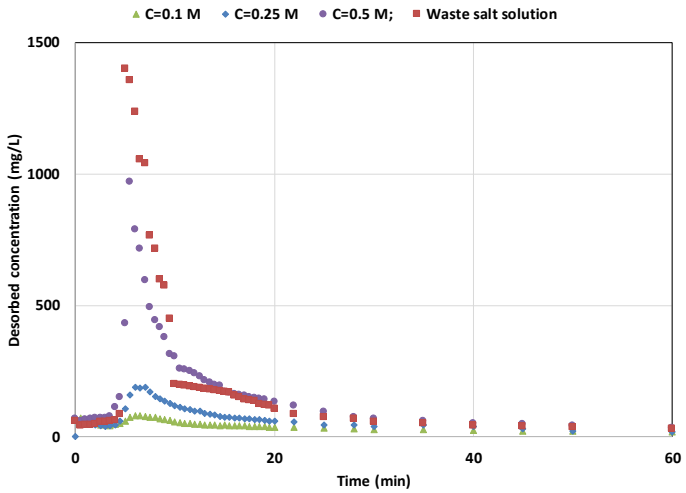

Figure 4: Effect of salt solution concentration on MB desorption from SS in column mode.

The recovery of MB permitted a net decrease of the desorbing solution MB concentration. This solution can be efficiently treated and reused as a water source in the same industry. Indeed, about 98% of remaining MB was oxidized with a persulfate concentration of 5 mM. The activation of persulfate was ensured by using a relatively low dose of magnetite (1 g/L) (Figure 5).

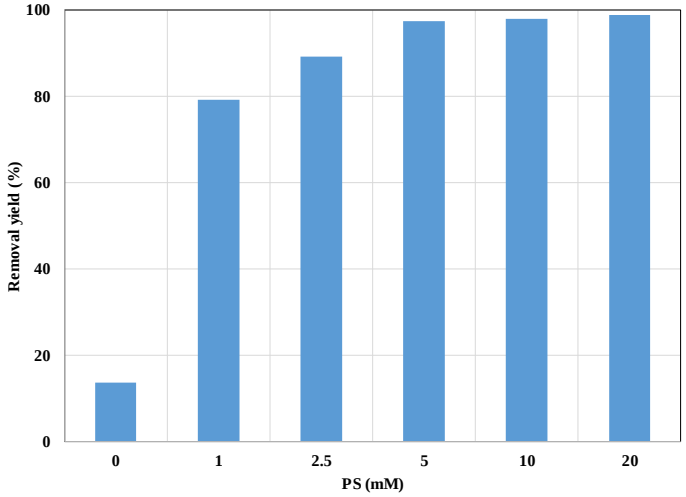

Figure 5: Desorbed MB oxidation with persulfate activated with magnetite

The treated desorbing effluent can be reused in the textile factories to partially cover their needs. This is important for textile factories to reduce water consumption. This is also beneficial to the environment since the produced and discharged wastewater will be significantly reduced.

Proposed approach

Our proposed approach permits a sustainable management of both industrial sludge and textile effluents and also promotes the concept of circular economy (Figure 6).

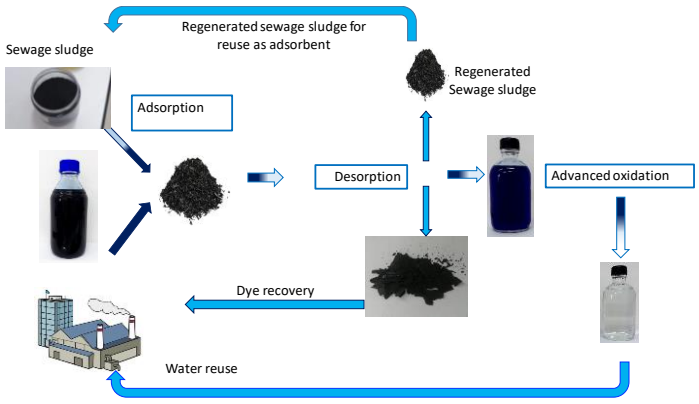

Figure 6: Proposed approach for sewage sludge and textile effluents sustainable management

The produced industrial sludge can be turned into high added value material (efficient adsorbent) for the treatment of textile industrial effluents. This material can be regenerated by another liquid waste (brine solutions) and reused again for another adsorption cycle. From the desorbing solution, dyes can be recovered and reused again in the industry process. The remaining desorbing solution can be treated by using an advanced oxidation process and reused in the same industry as an additional water source.

Conclusions

In this work, we show that SS can be valorized as an efficient adsorbent for typical dyes of textile effluents (MB). SS can be easily regenerated by salty solutions and reused again for other adsorption cycles. This operation permits the recovery of MB as a solid phase that can be reused in the industrial process. Moreover, the remaining MB in the desorbing solution can be completely oxidized with persulfates and reused for covering the textile factory water needs.

The real application of our proposed approach in the textile sector is economically interesting and environmentally beneficial. However, a precise cost benefit analysis of this approach, taking into account technical; social; environmental; and economic constraints, is required.

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