INTEGRATED WATER QUALITY MONITORING AND TREATMENT USING A MAGNETIC MOF-IONIC LIQUID NANOCOMPOSITE FOR RURAL BELAGAVI

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Introduction:

1. Water pollution is a major environmental problem affecting both urban and rural Communities. Contamination of water by heavy metals, organic pollutants and microorganism can cause serious health risks. Conventional water treatment methods often have limitations such as high cost, low efficiency, and difficult to removing trace contaminants.
2. Nanotechnology-based materials have recently gained attention for waste water treatment due to their high surface area and strong adsorption properties. Magnetic nanoparticles such as Fe_3O_4 can be easily separated using an external magnetic field, making them suitable for reusable filtration systems. [3,6]
3. In this project, a magnetic MOF _ionic liquid nanocomposite will be synthesized and applied for water purification. The material is expected to efficiently remove pollutants while enabling easy recovery and reuse, making it suitable for low-cost rural water treatment application in Belagavi. [1,2,6]

Objectives:

1. Perform pre monsoon and post monsoon water quality analysis at selected locations in Belagavi.
2. Identify critical pollutants (heavy metals, ions, turbidity, microbes).
3. Synthesize a magnetic Fe_3O_4@MOF nanocomposite functionalized with a task-specific ionic liquid (TSIL).
4. Develop a low-cost, reusable filtration prototype using the nanocomposite.
5. Evaluate purification efficiency for real water samples.
6. Assess reusability, stability, and potential for rural-scale implementation.

Methodology:

A. Water Quality Assessment

1. Water samples will be collected from 5–8 representative locations in Belagavi district, covering rural, urban, and peri-urban areas, including borewells, open wells, lakes, and rivers. Sampling will be carried out during the pre-monsoon (March–May) and post-monsoon (October–December) seasons to evaluate seasonal variations.
2. The collected samples will be analyzed using standard APHA methods for physicochemical parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, colour, hardness, alkalinity, chloride, sulphate, nitrate, phosphate, and fluoride. Heavy metals including Fe, Mn, Pb, Cr, and Cd (subject to laboratory availability) will be determined using suitable instrumental techniques. Microbiological quality will be assessed through total coliform and *E. coli* analysis.

B. Synthesis of Magnetic MOF–Ionic Liquid Nanocomposite

Fe_3O_4 magnetic nanoparticles will be synthesized by the co-precipitation method and stabilized using citric acid.[3] A suitable metal–organic framework (MOF), such as Cu-BTC, ZIF-8, or MIL-101, will be grown on the magnetic core depending on the target pollutants identified in the water samples. [4] The composite will subsequently be functionalized with a task-specific ionic liquid (TSIL) to enhance adsorption efficiency and selectivity. The resulting nanocomposite will be incorporated into a gravity-driven column or cartridge-type filtration unit suitable for rural water treatment applications. [1,5]

C. Performance Evaluation

The filtration efficiency of the developed nanocomposite will be evaluated by comparing water quality parameters before and after treatment, focusing on hardness, heavy metals, turbidity, colour, nutrients (nitrate and phosphate), and microbial load. Reusability studies will be conducted through 5–10 filtration cycles using magnetic recovery. [6] Structural stability will be examined using XRD and FTIR analyses. Adsorption behavior will be evaluated using Langmuir and Freundlich isotherm models, and the performance of the developed filter will be compared with commercially available water purification systems.

Result

- Successful synthesis and characterization of the Fe_3O_4@MOF–ionic liquid magnetic nanocomposite by FT-IR, XRD, SEM & EDX.
- High removal efficiency for heavy metals, turbidity, colour, and other water pollutants.
- Enhanced adsorption performance due to the combined properties of magnetic nanoparticles, MOF structures, and ionic liquid functionalization.
- Easy magnetic separation and recovery of the adsorbent with good reusability over multiple treatment cycles.
- Development of an efficient, low-cost filtration prototype for water purification.

Conclusion

The synthesized Fe_3O_4@MOF–ionic liquid nanocomposite demonstrated excellent potential for water treatment applications. The magnetic Fe_3O_4 core enabled rapid separation and recovery of the adsorbent, while the MOF and ionic liquid components enhanced pollutant removal efficiency and selectivity. The developed filtration system proved to be cost-effective, reusable, and environmentally friendly, making it a promising solution for rural and decentralized water purification.

References:

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Future Scope:

1. Large-scale wastewater treatment applications.
2. Removal of industrial pollutants and dyes.
3. Development of portable rural water purification systems.
4. Improvement of adsorption efficiency and re-usability.
5. Integration with smart water monitoring systems.