ISSN(O): 2320-5407 | ISSN(P): 3107-4928

ISSN NO. 2320-5407

International Journal of Advanced Research

Publisher's Name: Jana Publication and Research LLP

www.journalijar.com

REVIEWER'S REPORT

Manuscript No.: IJAR-57488

Title: Pharmaceutical Industrial Effluents: Sources, Characteristics, Environmental Risks, and Advanced Treatment Strategies

Recommendation:
Accept as it is .....
Accept after minor revision.....
Accept after major revision .....YES
Do not accept (*Reasons below*) .....

Rating	Excel.	Good	Fair	Poor
Originality			√	
Techn. Quality		√		
Clarity		√		
Significance		√		

Reviewer's ID: JPR-094

Detailed Reviewer's Report

****"Pharmaceutical Industrial Effluents: Sources, Characteristics, Environmental Risks, and Advanced Treatment Strategies"****

 # Overall Evaluation

The manuscript addresses an important and globally relevant environmental issue related to pharmaceutical industrial wastewater and its ecological consequences. The review summarizes major sources of pharmaceutical pollutants, environmental impacts, antimicrobial resistance concerns, and conventional as well as advanced treatment technologies. The topic is timely and suitable for environmental science and wastewater management journals. However, the manuscript currently remains descriptive and lacks sufficient novelty, critical analysis, recent literature integration, and comparative technical evaluation expected for publication in a high-quality journal.

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 # Strengths

1. **Relevant and Timely Topic**

*** Pharmaceutical wastewater and antimicrobial resistance are highly significant environmental concerns worldwide.**

2. **Logical Organization**

*** The manuscript follows a clear structure from introduction to treatment technologies and future perspectives.**

3. **Broad Coverage**

*** Multiple aspects are discussed including:**

*** pharmaceutical pollutants,**
*** environmental risks,**
*** AMR,**
*** conventional treatment,**
*** advanced oxidation,**
*** membrane technologies,**
*** hybrid systems.**

4. **Good Introductory Review**

*** The paper provides a useful overview for readers new to the field.**

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5. **Use of Established References**

*** Important foundational studies are cited appropriately.**

 # Weaknesses

1. **Limited Novelty**

*** The review is largely descriptive and summarizes already well-established knowledge without presenting new interpretations or analytical insights.**

2. **Outdated References**

*** Most references are between 1999–2017.**
*** Very few recent studies (2022–2026) are included.**

3. **Lack of Critical Analysis**

*** The manuscript mainly describes technologies but does not critically compare:**

*** efficiency,**
*** operational cost,**
*** scalability,**
*** sustainability,**
*** energy consumption.**

4. **Absence of Quantitative Data**

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*** No comparative tables, removal efficiency data, or performance metrics are included.**

5. **No Methodology for Literature Review**

*** The manuscript does not explain:**

*** literature search strategy,**
*** databases used,**
*** inclusion/exclusion criteria.**

6. **Insufficient Figures and Diagrams**

*** No schematic illustrations, flowcharts, or graphical summaries are provided.**

7. **Language and Presentation Issues**

*** Several sections read like textbook summaries rather than a critical scientific review.**
*** Some references are incomplete or inconsistently formatted.**

8. **Limited Discussion on Regulations**

*** International environmental regulations and discharge standards are not adequately discussed.**

 # Key Points Raised by Reviewer

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Major Points

1. Add recent literature from 2022–2026.

2. Include comparative tables for treatment technologies.

3. Add critical evaluation rather than descriptive summaries.

4. Include removal efficiencies and operational limitations of each treatment method.

5. Add figures/flowcharts for:

*** pharmaceutical effluent pathways,**

*** treatment technologies,**

*** AMR dissemination.**

6. Clarify whether this is a narrative review or systematic review.

7. Improve discussion on sustainability and circular economy approaches.

8. Expand future perspectives with AI-based monitoring and smart wastewater treatment systems.

Minor Points

1. Correct formatting inconsistencies in references.

2. Improve grammar and sentence flow in some sections.

3. Define abbreviations consistently at first appearance.

4. Add DOI information in references if required by journal style.

 # Significance of the Study

The manuscript addresses a highly important environmental and public health issue associated with pharmaceutical industrial discharges and antimicrobial resistance.

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The review has educational value and may serve as a useful introductory resource for researchers, environmental engineers, and policymakers. The discussion of advanced treatment technologies is relevant for sustainable wastewater management research.

However, the scientific significance is currently reduced by:

*** limited originality,**
*** lack of updated literature,**
*** absence of comparative technical analysis,**
*** insufficient critical discussion.**

With substantial revision and deeper analytical content, the manuscript could become a valuable review article in the field of environmental pollution and wastewater treatment.

 # Recommendation

Decision: Major Revision

Reason for Recommendation

The manuscript has a relevant topic and acceptable structural organization, but substantial improvements are required before it can be considered for publication. In particular, the authors should strengthen:

*** originality,**
*** analytical depth,**

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*** recent literature coverage,**

*** comparative evaluation,**

*** graphical presentation,**

*** methodological rigor.**

Publication may be reconsidered after major revision and careful improvement of scientific quality.

Major Revision Justification with Issues and Reasons

Manuscript Title

"Pharmaceutical Industrial Effluents: Sources, Characteristics, Environmental Risks, and Advanced Treatment Strategies"

Reviewers Decision: MAJOR REVISION

Line No.	Issue Identified	Reason for Major Revision
1 – 2	Title is broad and generic.	The title does not clearly indicate novelty, specific focus, or unique analytical contribution. Similar review titles already exist in environmental literature.
5 – 14	Abstract is descriptive rather than analytical.	The abstract summarizes topics but does not provide critical findings, comparative insights, or clear scientific contribution.
9 – 14	Lack of novelty statement in abstract.	Readers cannot identify how this review differs from previously published reviews on pharmaceutical wastewater treatment.
11 – 13	"Critically discussed" is overstated.	The manuscript mainly summarizes literature without sufficient critical comparison of technologies, efficiencies, or limitations.
15 – 16	Keywords are too broad.	Broad keywords reduce indexing efficiency and discoverability in scientific databases.
18 – 23	Introduction relies on outdated references.	Most cited references are old (1999 – 2016), which weakens the manuscript's

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Line No.	Issue Identified	Reason for Major Revision
		scientific currency and relevance.
20 – 22	No recent global statistics on pharmaceutical pollutants.	Updated quantitative data are necessary to support the environmental importance of the topic.
24 – 28	Sources of effluents are described generally.	Industrial examples, regional case studies, and discharge profiles are absent, reducing scientific depth.
29 – 34	Ecological persistence discussion lacks mechanistic detail.	The manuscript does not explain molecular persistence, degradation resistance, or environmental transport pathways sufficiently.
32 – 34	AMR discussion is limited.	Current developments in antimicrobial resistance, resistant genes, and global AMR dissemination pathways are insufficiently covered.
35 – 38	Review objective is unclear.	The manuscript does not define whether it is a narrative review, systematic review, or critical review.
35 – 38	No review methodology included.	Absence of literature search strategy, database selection, and inclusion criteria reduces scientific rigor.
40 – 52	Chemical composition section lacks quantitative characterization.	Important wastewater parameters such as COD, BOD, TOC, TDS, and concentration ranges are missing.
42 – 46	Pharmaceutical classes are only listed descriptively.	Comparative occurrence frequencies and contamination levels are not discussed.
47 – 52	Persistence examples lack technical analysis.	Removal efficiencies, degradation pathways, and environmental half-life information are absent.
53 – 59	Operational variability discussion is superficial.	Engineering implications for reactor design and process optimization are not adequately analyzed.
55 – 56	COD and pH fluctuations are not quantified.	Numerical operational data would improve scientific reliability.
60 – 68	Emerging contaminants section is too short.	The section lacks detailed discussion of metabolites, transformation products, and modern monitoring approaches.
61 – 62	Regulatory discussion is inadequate.	International wastewater discharge standards and environmental regulations are not compared.

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Line No.	Issue Identified	Reason for Major Revision
65 – 68	Toxicity mechanisms are not sufficiently explained.	Synergistic and bioaccumulative effects require deeper ecotoxicological analysis.
70 – 78	Environmental contamination section lacks recent monitoring data.	Geographic contamination trends and updated environmental surveillance studies are absent.
72 – 75	Wastewater treatment inefficiency claims lack quantitative support.	Removal percentages and treatment performance data are necessary for scientific validation.
76 – 78	Industrial contamination examples are incomplete.	Concentration ranges and comparative contamination levels are not provided.
79 – 85	Ecotoxicological effects are oversimplified.	Molecular toxicity pathways, biomarker studies, and chronic exposure data are missing.
81 – 82	Endocrine disruption discussion lacks recent evidence.	More current toxicological studies and regulatory implications should be included.
83 – 85	Physiological effects on aquatic organisms are not critically analyzed.	Mechanistic explanation and experimental evidence are insufficient.
86 – 92	AMR section lacks scientific depth.	Resistant genes, horizontal gene transfer, ARG monitoring, and genomic surveillance are absent.
90 – 92	Wastewater treatment plants are identified as hotspots without detailed explanation.	The manuscript should explain microbial selection pressure and dissemination mechanisms.
93 – 97	Human health risk section is generalized.	Toxicological exposure assessment and epidemiological evidence are lacking.
100 – 113	Conventional treatment technologies are oversimplified.	Engineering limitations, operational performance, and pharmaceutical-specific treatment behavior are insufficiently discussed.
101 – 105	Biological treatment discussion lacks biodegradation analysis.	Microbial degradation pathways and treatment kinetics are absent.
106 – 109	Physicochemical methods section is too brief.	Coagulation mechanisms, adsorption behavior, and comparative efficiencies are not analyzed.
110 – 113	Transformation product toxicity discussion is incomplete.	Toxic intermediates formed during treatment should be critically evaluated.

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Line No.	Issue Identified	Reason for Major Revision
115 – 120	AOP discussion lacks comparative evaluation.	Energy demand, operational cost, mineralization efficiency, and sustainability are not compared.
119 – 120	Secondary pollutant formation is not critically assessed.	By-product toxicity and environmental implications require deeper discussion.
121 – 124	Adsorption technologies are inadequately compared.	Adsorption capacities, kinetics, and material performance comparisons are missing.
125 – 128	Membrane technologies lack engineering analysis.	Fouling mechanisms, concentrate management, and economic feasibility are insufficiently discussed.
127 – 128	Sustainability issues are only briefly mentioned.	Operational costs and environmental trade-offs require detailed evaluation.
129 – 132	Hybrid treatment systems are insufficiently analyzed.	Industrial applicability and integration strategies are not discussed thoroughly.
134 – 140	Emerging technologies section lacks technical depth.	Electrochemical oxidation and plasma treatment require mechanistic and pilot-scale discussion.
135 – 137	Advanced sustainable technologies are only introduced superficially.	Comparative advantages, disadvantages, and limitations are not critically examined.
139 – 140	Green chemistry discussion is underdeveloped.	Sustainable pharmaceutical design strategies and eco-friendly manufacturing concepts should be expanded.
142 – 146	Future perspectives section is weak.	Emerging concepts such as AI-based monitoring, IoT sensors, smart treatment systems, and circular economy approaches are absent.
143 – 145	Challenges are listed generally.	Economic feasibility and scalability challenges are not systematically evaluated.
148 – 153	Conclusion lacks strong scientific insight.	The conclusion summarizes content but does not provide strategic recommendations or future research priorities.
163 – 182	Reference list is outdated.	Most references are older than 10 years, reducing scientific relevance.
163 – 182	Limited recent literature included.	Recent high-impact studies from 2022 – 2026 are necessary for publication-quality review work.
163 – 182	Reference formatting	Some references are incomplete and not

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Line No.	Issue Identified	Reason for Major Revision
	inconsistencies observed.	fully aligned with journal formatting standards.
Entire Manuscript	No tables included.	Comparative tables for treatment technologies, efficiencies, and limitations are expected in review articles.
Entire Manuscript	No figures or schematics included.	Visual presentation is insufficient for a comprehensive review paper.
Entire Manuscript	Manuscript lacks comparative critical analysis.	The article reads more like a textbook summary rather than a high-impact analytical review.
Entire Manuscript	Novel contribution is unclear.	The manuscript does not clearly explain how it advances current knowledge beyond existing reviews.

Overall Justification for Major Revision

1. Insufficient Originality

The manuscript mainly summarizes established literature without presenting significant new analytical insights or conceptual advancement.

2. Limited Scientific Depth

Critical evaluation of treatment technologies, operational limitations, sustainability, and engineering feasibility is inadequate.

3. Outdated Literature Support

Heavy reliance on older references weakens scientific relevance and reduces the manuscript's competitiveness for modern journals.

4. Weak Critical Analysis

The manuscript is largely descriptive and lacks:

comparative analysis,

quantitative evaluation,

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technological benchmarking.

5. Missing Visual and Comparative Components

The absence of:

tables,

figures,

schematics,

process flow diagrams,
reduces readability and scientific quality.

6. Methodological Deficiency

No systematic literature review methodology or article selection process is described.

Final Recommendation

Decision: MAJOR REVISION

The manuscript addresses an important environmental issue and has potential educational value. However, substantial revision is necessary to improve originality, scientific rigor, literature currency, analytical depth, and technical presentation before the manuscript can be considered for publication.