IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Bacteriophage Therapy In Aquaculture: A Sustainable Approach To Combat *Pseudomonas Fluorescens* Infections In Freshwater Fish

Nisha Dinkar[1], Humaira Rani[1], Arshma Khan[1], Amita Pathak[1], Sunita Gangwar[2], Arvind Kumar Sharma[1] and Mohd. Faheem Khan[1]

1. Department of Biotechnology, Khandelwal College of Management Science and Technology, Bareilly, India
2. Department of Animal Science, M.J.P. Rohilkhand University, Bareilly, India.

Abstract

The significant increase in fish production through aquaculture has been overshadowed by challenges related to bacterial infections, especially those caused by *Pseudomonas fluorescens*. Traditional antibiotics have shown decreasing effectiveness due to rising resistance, prompting the exploration of alternative therapies. This research investigates bacteriophage therapy as a potential solution to control *P. fluorescens* in freshwater aquaculture. Bacteriophages offer several advantages over antibiotics, including their species specificity, self-replicating nature, and minimal environmental impact. The study involved isolating, characterizing, and testing the efficacy of bacteriophages from environmental samples against *P. fluorescens* in *Labeorohita* culture. This short review confirms the effectiveness of bacteriophages under various physicochemical conditions, highlighting their potential to reduce antibiotic use in aquaculture. The findings underscore bacteriophages' role in ensuring sustainable aquaculture practices and mitigating the risks associated with antimicrobial resistance.

Keywords: *Pseudomonas fluorescens*, bacteriophage therapy, aquaculture, antibiotic resistance, environmental impact, *Labeorohita*, pathogen control.

Introduction

The use of bacteriophages in aquaculture as an alternative to antibiotics has gained significant attention in recent years due to concerns regarding antibiotic resistance and the need for sustainable disease management practices. A detailed analysis of the published literature reveals various aspects of bacteriophage therapy, including its effectiveness, challenges, and applications in aquaculture.

1. Effectiveness of Bacteriophages in Aquaculture

Bacteriophages have shown considerable promise in controlling bacterial infections in fish, particularly in species susceptible to pathogens such as *Pseudomonas fluorescens*. Research by Park et al. (2000) highlighted the isolation of bacteriophages targeting *Pseudomonas plecoglossicida*, a pathogen causing bacterial hemorrhagic ascites in cultured fish. Recent studies demonstrated that bacteriophages could effectively reduce bacterial load and prevent infection in fish, establishing the potential of phage therapy as a viable alternative to antibiotics in aquaculture settings.Further studies, such as those by *Nakai and Park (2002*), reinforced these findings, showing that bacteriophages were not only effective in controlling bacterial pathogens but also showed minimal environmental impact compared to traditional antibiotics. We noted that bacteriophages are species-specific, meaning they target only the pathogenic bacteria without harming beneficial bacteria in the aquatic environment, which is a crucial advantage in maintaining a healthy microbiota in aquaculture systems.*Prasad et al. (2008)* demonstrated that bacteriophages against *Pseudomonas fluorescens*could inhibit bacterial growth both in vitro and in vivo. Their work was pivotal in showing that phages could provide therapeutic benefits in aquaculture, not only as a microbial control agent but also in reducing reliance on antibiotics, which is essential for preventing the development of antibiotic-resistant bacteria in aquaculture environments.

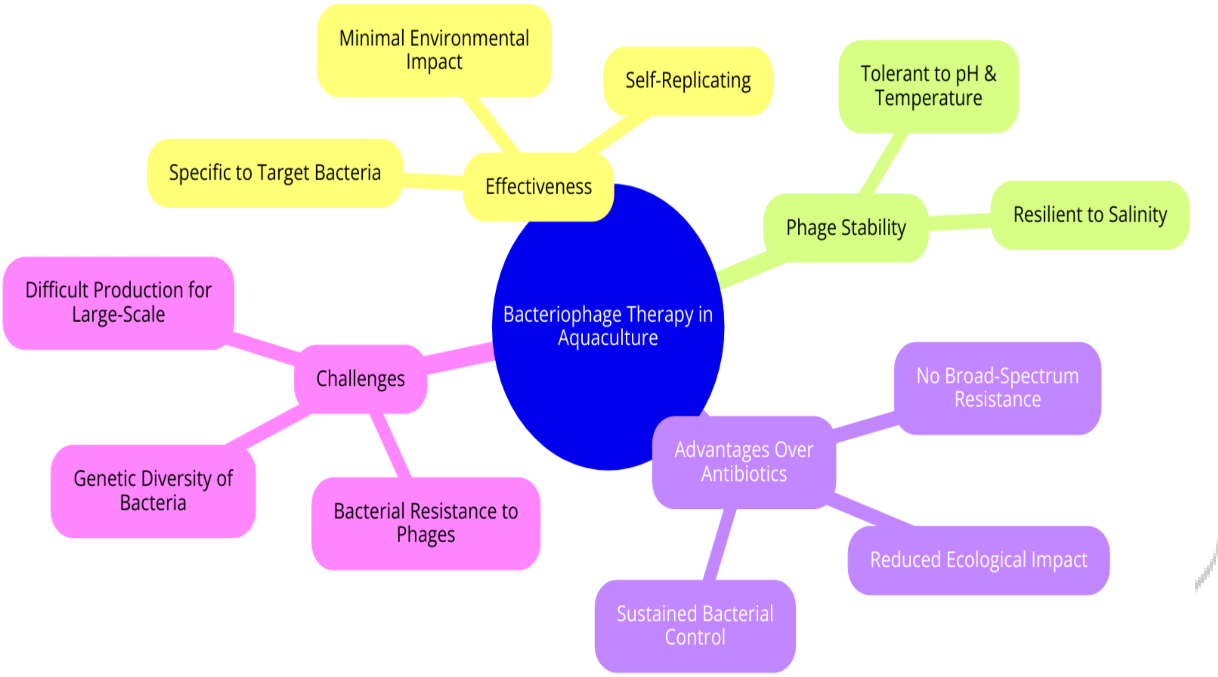
2. Phage Stability and Adaptability

One of the key factors determining the success of bacteriophage therapy is the stability of phages under different environmental conditions. Several studies, including the work of *Sillankorva et al. (2008)*, have evaluated the physicochemical properties of bacteriophages, focusing on their tolerance to variations in temperature, pH, and salinity. Phage stability is essential for ensuring that the bacteriophages remain effective when introduced into the dynamic and often harsh conditions of aquatic environments.*Sillankorva et al. (2008)* highlighted that phage isolated from aquatic environments, such as sewage and water, tend to exhibit a high degree of resilience to varying temperatures and salinities, making them suitable for use in aquaculture. We canconclude that bacteriophages could survive in a wide range of environmental conditions, ensuring their potential as a reliable therapeutic agent for fish farming.In contrast, studies by *Imbeault et al. (2006)* suggested that while phages can be quite stable, their efficacy could decrease over time if not properly stored or if they are exposed to extreme conditions. They emphasized the need for ongoing research into improving phage formulation and application techniques to enhance the longevity and performance of bacteriophage-based treatments in aquaculture.

3. Advantages Over Antibiotics

The potential of bacteriophage therapy as an alternative to antibiotics is a major reason for its increasing popularity in aquaculture. Traditional antibiotic treatments, while effective in controlling bacterial diseases, have several drawbacks, including the development of resistance in pathogenic bacteria, environmental contamination, and harm to non-target microorganisms. The literature clearly indicates that bacteriophages offer several advantages over antibiotics.

Figure 1: Workflow of presented short review for Bacteriophages therapy in Aqua culture



According to research by ***Austin and Austin (1999)***, the use of antibiotics in aquaculture has led to the emergence of resistant bacterial strains, which poses a serious threat to both animal health and public safety. In contrast, bacteriophages are highly specific to their host bacteria, reducing the risk of resistance development and minimizing the ecological impact. The self-perpetuating nature of phages also provides a long-lasting solution, as phages continue to replicate in the presence of their target bacteria, providing sustained bacterial control.*Levin and Bull (2004)* discussed the advantages of phage therapy, noting that phages could potentially be used to target specific pathogens in aquaculture without the broad-spectrum effects associated with antibiotics. This specificity is particularly crucial in aquaculture, where maintaining the balance of microbial communities is essential for the overall health of fish and the environment.

4. Challenges and Limitations of Phage Therapy

Despite the promising results from various studies, there are several challenges associated with the application of bacteriophage therapy in aquaculture. One of the key challenges is the high degree of genetic diversity among bacterial populations. Bacteria, including *Pseudomonas fluorescens*, exhibit considerable phenotypic and genotypic variability, which can influence their susceptibility to phage infection **(*Comeau et al., 2006; Holm Feldt et al., 2007*)**.Furthermore, the potential for bacteriophage resistance is not negligible. While bacteriophages are generally less prone to resistance development than antibiotics, some studies, such as those by ***Payne et al. (2000)***, have highlighted that bacteria can evolve mechanisms to evade phage attack, such as modifying their receptors or producing enzymes that degrade phage particles. This could limit the long-term efficacy of phage therapy and necessitate the use of phage cocktails, which consist of multiple phage types targeting the same pathogen.Another limitation discussed by ***Sillankorva et al. (2008)*** is the difficulty in ensuring the consistent and scalable production of bacteriophages for large-scale aquaculture applications. Phage production can be time-consuming and costly, and the quality control of phage preparations is crucial for ensuring their therapeutic efficacy. Researchers have been working on improving phage production techniques and developing standardized methods for phage application in aquaculture, but these challenges remain an area of active investigation.

5. Future Directions and Potential Applications

Potential applications of bacteriophage therapy in aquaculture are vast, and the literature suggests that continued research will enhance the understanding of phage-host interactions and improve the practical application of phage therapy. One promising area of research is the development of phage cocktails, which combine multiple phages to target a broader range of bacterial strains and reduce the likelihood of resistance development **(Huff et al., 2005)**.Moreover, advancements in genomics and proteomics will provide new insights into the molecular mechanisms behind phage infection and bacterial resistance. As researchers gain a deeper understanding of phage genetics, they will be better equipped to engineer phages that are more effective in treating infections and can withstand the diverse conditions present in aquaculture environments.In addition, studies such as those by ***Wang and Loung (2000)*** suggest that the integration of phage therapy with other biocontrol methods, such as probiotics or immunomodulators, could enhance the overall health and disease resistance of cultured fish. Combining phage therapy with other interventions may provide a holistic approach to managing bacterial infections in aquaculture.

Conclusion

Published literature strongly supports the use of bacteriophages as a promising alternative to antibiotics in aquaculture. Bacteriophages have demonstrated efficacy in controlling fish pathogens, with advantages such as specificity, minimal environmental impact, and lower risk of resistance development. However, challenges remain, particularly in terms of phage resistance, genetic diversity among bacteria, and the scalability of phage production. Recent research and innovation will be crucial in addressing these challenges and unlocking the full potential of bacteriophage therapy in aquaculture. The integration of bacteriophages with other biocontrol strategies could play a key role in ensuring the sustainability and health of the aquaculture industry. Presented study provided is a detailed research study focusing on the use of bacteriophages as an alternative to antibiotics for treating bacterial infections in fish, specifically targeting *Pseudomonas fluorescens*, a pathogen responsible for diseases like Bacterial Haemorrhagic Septicaemia (BHS) in freshwater aquaculture.

References

1. Adam, A. Thompson, K. D. and Roberts, R. J. (1997). Vaccine manual No-35: FAO publication.
2. Austin, B. and Austin, D. A. (1999). Bacterial fish pathogen: Diseases of farmed & wild fish (3rd Ed. Sprinager publishing. 457).
3. Austin, B., Pride, A. C. and Rhodie, G. A. (2003). Association of bacteriophage with virulence in *vibrio harveyi*. J. Fish Dis., 26: 55-58.
4. Brennan, A. L. and Geddes, D. M. (2002). Cystic fibrosis. Cirr. Opin. Infect. Dis. 15: 175-182.
5. Chanishvili, N., Chanisvili, T., Tediashvili, M. & Barrow, P.A. (2001). Phages and their application against drug resistant bacteria. J. Chem. Technol. Biotechnol. 76: 689-699.
6. Comeau, A. M., Buenaventura, E. and Suttle. C. A. (2006). Genetic richness of vibriophages isolated in a coastal Environ. Microbiol. 8: 1164-1176.
7. D'Herelle, F. (1917). Sur un microbe invisible antagonistic des bacillesdysenterique. C. R. Acad. Sci. Paris 165: 373-375.
8. Diaz, E., Munoz, E., Agbaht, K. and Rello, J. (2007). Management of ventilator-associated Pneumonia caused by multi resistant Bacteria. Curr Opin Crit Care. 13: 45-50.
9. Huff, W. E., Huff, G. R., Rath, N. C., Balog, J. M. and Donoghue, A. M. (2005). Alternative to antibiotics: Utilization of bacteriophages to treat colibacillosis and prevent food borne pathogens. Poult. Sci. 84: 654-659.
10. Holmfeldt, K. M., Middelboe, O. and Nybroe, (2007). Large variabilities in host strain susceptibility and phage host range govern interactions between lytic marine phage and their *Flavobacterium* host. Appl. Environ. Microbiol. 73: 6730 - 6739.
11. Imbeault, S., Parent. S., Lagace, M., Uhland, C. F. and Blais, J.-F. (2006). Using bacteriophage to prevent furunculosis caused by *Aeromonas salmonicida* in farmed brook trout. J. Aquat. An. Health 18: 203-214.
12. Karunasagar, I., Shivu M. M., Girisha S. K., Krohne G., and Karunasagar, I. (2007). Biocontrol of pathogens in shrimp hatcheries using bacteriophages. Aquacult. 268: 288-292.
13. Kumari, S., Harjal, K., and Chhibber, S. (2009). Characterization of P. Aeruginosa PAO specific bacteriophage isolated from sewage samples. Am. J. Biomed. Sci. 2009, 1(2), 91-102.
14. Laemmli, U.K. Cleavage of structural proteins during the assembly of the head of bacteriophage T4. *Nature*, 1970, **227**, 6K0-6K5.

15. Levin, B. R., and Bull, J. J. (2004). Population and evolutionary dynamics of phage therapy. In Microbiol: Nature Reviews. 2: 166-173.

16. Merino, S., Camprubi, S. and Tomas, J. M. (1990). Isolation and characterization of bacteriophages PM_2 from *Aeromonas hydrophila* FEMS Microbiol. Lett. 68: 239 -244.

17. Nakai, T., Sugimoto R., Park, K. H., Matsuoka, S., Mori, K., Nishioka, T., Maruyama, K. (1999) Protective effects of bacteriophage on experimental *Lactococusgarvieae* infection in yellow tail. Dis. Aquat. Org. 37: 33-31.

18. Nishimori. E., Kita-Tsukamoto, K.,Wakabayashi, H. (2000). *Pseudomonas plecoglossicida* sp. Nov., the causative agent of bacterial hemorrhagic ascites of ayu, *Plecoglossusaltivelis*. Int. J. Syst. Evol. Microbiol. 50: 83-89.

19. Nakai, T. and Park, S. C. (2002). Bacteriophage therapy of infectious disease in aquaculture. Res. Microbiol. 153, 13-18.

20. Park, S. C. and Nakai, T. (2003). Bacteriophage control of *Pseudomonas plecoglossicida* infection in ayu. *Plecoglossusaltivelis*. Dis. Aquat. Org. 53: 33-39

21. Payne, R. J. Phil, D. and Jansen V. A. (2000). Phage therapy: The peculiar kinetics of self-replicating pharmaceuticals: Clin. Pharmacal. Ther. 68: 225-230.

22. Prasad, Y. and Kumar, P. (2006). Isolation and characterization of bacteriophages against potent bacterial fish pathogen, *Pseudomonas fluorescens*, PP-F18. National conference on recent advances in applied Zoology, Merrut and 24-25 March 2006.

23. Prasad, Y., Sharma, A. K., Kumar. D. and Rawat, M. (2007). Bacteriophages: A Novel Candidate of Thrapeutic Value in Aquaculture. Indian Science Congress, pp 26.

24. Prasad, Y. (2008). Isolation, characterization and efficacy of bacteriophages against pathogenic *Pseudomonas and Flavobacterium* associated with bacterial fish diseases, for therapeutic uses in aquaculture final Technical Progress Report of DBT project pp.42

25. Prasad Y. and Verma, V. (2008). Prevalence surveillance and virulence characterization of *flavobacterium columnare* and Myxobacterium in India catfish of sule Himalayan region. Archiv. Microbial. (online submitted 0149).

26. Prasad, (2009). Clinico – immunomodulatory effect of Levamisole, Vitamin – E and Selenium on the non – specific immune response of Indian Catfish against *Pseudomonas*.